The 'Solarization' of the Moon: Manipulated Knowledge at Stonehenge

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Recent archaeological research now views the northwest European Neolithic and Early Bronze Age as a period of separation from a resilient complex of traditions of Mesolithic and even Palaeolithic origin. Extending this insight to recent findings in archaeoastronomy, this article treats the sarsen monument at Stonehenge as one among a number of monuments with lunar–solar alignments which privileged night over day, winter over summer, dark moon over full. The aim of the monument builders was to juxtapose, replicate and reverse certain key horizon properties of the sun and the moon, apparently with the intention of investing the sun with the moon's former religious significance. This model is consistent with both current archaeological interpretations of burial practices associated with the monument, and with recent anthropological modelling of hunter-gatherer cultural origins.

Archaeological models of the Neolithic

Until the 1980s, the main archaeological model of European prehistory contrasted an itinerant, materially and culturally limited Mesolithic forager lifestyle with the fixed settlements of socially complex Neolithic farmers (Case 1969; Childe 1940; Runciman 2001). Social complexity and monuments were viewed as by-products of farming surpluses. This interpretation is no longer accepted. It is now argued that, from the sixth to approximately the middle of the second millennium BC, the moving frontier of farming stopped in central and eastern Europe, and so could not have been a precondition to northwest European monumental architecture. The hunter-gatherers dwelling on the Atlantic fringes of this frontier were not replaced by farmers, nor did they immediately switch to sedentary intensive farming (Edmonds 1999; Rowley-Conwy 1984; Thomas 1999; Whittle 1996; Zvelebil 1986). Instead, according to current consensus, these complex hunter-gatherers switched to pastoralism combined in a highly variable mix with the old foraging ways and new crop-growing practices. The new material culture included the polished stone axe, pottery and monuments which, for many researchers, are key signifiers of the Neolithic, all of which co-existed alongside remnants of the Mesolithic, a relatively mobile life which still included foraging. Rather than the point in prehistory when monument construction begins, the adoption of sedentary agro-pastoral farming in the Middle Bronze Age is seen as coinciding with the *ending* of that tradition. The earlier view of prehistory assumed an under-specified, ecological model of pre-historic hunter-gatherer cultures if only because it was necessary to the assumption of an institutionally formative farming Neolithic (Renfrew 2001; Runciman 2001). However, it 'is now generally accepted that Mesolithic communities were no sense [*sic*] less complex than those in the Neolithic' (Tilley 1994, 86; see also Gamble 1986; Hayden 1990; Ruggles 1999a). The new model sees the adoption of farming as long delayed by a contest with a pre-existing system of beliefs.

> The Neolithic phenomenon was not so much the creation of new worlds as the prolongation of old ones. But there were fundamental differences between different conceptual orders … Many early foragers may have seen themselves as part of an undivided, timeless world, shared by people and the animals which inhabited it … In … the Neolithic way of life … there was categorisation and separation … a new emphasis on … relationships with an otherworld. Speculatively, this shift may have been reinforced by guilt to do with the breaking of earlier bonds with nature. (Whittle 1996, 360)

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If we link Whittle's comments more precisely with Neolithic and Early Bronze Age monuments, this suggests that they can be conceptualized as devices to prolong, recapture or manufacture a sense of unity and respect for more ancient beliefs, but in ways more amenable to a Neolithic when division and estrangement are on the increase. This double purpose is seen reflected in the design of mortuary complexes and monuments. Mesolithic burials had emphasized rebirth, regeneration and fertility, with women's burials in particular associated with animals and natural materials such as antler horns. In the early Neolithic, burials become housed in mounds that mimicked the mid-European long houses of the first farmers. Accessible chambers and the re-circulation of the partial remains of the dead now emphasized the theme of an ancestral collectivism which seemed largely unnecessary in the Mesolithic. Skulls and hides of domesticated cattle accompanied or even displaced the dead in abstract representations of religious power (Bradley 1998; Hodder 1990; Thomas 1999; Whittle 1996). The same themes of juxtaposition, mimicry and estrangement of old and new symbolic motifs are repeated in later Neolithic and Early Bronze Age monument design. Circular monuments celebrated the disc-like shape of the cosmos, designed to mimic the topography of local horizons and the movement of the sun and the moon upon them (Bradley 1998). By aligning these monuments on the local encircling landscape and the rise and set positions of the sun and the moon, the builders locked their monuments to their local place. Each regional group, focused around their monuments, commanded their own 'centre of the universe'. Instead of a generalized communion with the entire natural world as sacred as, in the Mesolithic, Neolithic concepts emphasized local space as a cosmological centre, reversing earlier beliefs:

> [T]he experience of watching the sunset … depended upon the momentary coincidence of chalk from the earth, the descending sun, the dead in their barrow and the surrounding forest. This does not indicate any scientific observation of the heavens, so much as a perceived unity of earth and sky, life and death, past and present, all being referenced to bring more and more emphasis on to particular spaces and places … At the same time it would also limit access to these spaces in terms of both direction and timing, and would contribute to the way in which the space was experienced by promoting the impression that it stood at an axial point of an integrated cosmos. (Thomas 1999, 53)

The general consensus among specialists is that monument building was central to changing and sustaining the *social* relationships which came to define the Neolithic (Thomas 1999). This change in world view is seen as an achievement of the Neolithic as an historical armature in which monument design operates simultaneously on two levels — the commemoration of a past lived communalism through *imagined* collectives of ancestors. By the time of the Neolithic, there 'is a strong sense of seasonal time, fixity of place, a celebration of the local, and an abstract collectivised sense of an ancestral past' (Whittle 1996, 261). Symbolic and abstract representations of collectivism and community may well have been shadows of earlier lived forms of solidarity.

> This kind of interpretation could be taken much further, to link such [monumental] sites not only with cult or ritual but with the consecration of place, the marking of time, the presence of ancestors and the *symbolic* representation of communal cohesion. (Whittle 1996, 190; my emphasis.)

Nevertheless, from these accounts, it remains a puzzle as to what retrospective practices provided the conservative impediment that slowed the migration of farming for four millennia in exactly those areas in which monument construction flourished. A possible answer to this question comes from recent anthropological modelling of hunter-gatherer cultural origins.

Anthropological models of the Palaeolithic

There is a growing body of archaeological evidence that human symbolic culture was already established before our ancestors came out of Africa about 80,000 years ago (D'Errico *et al.* 2001; Henshilwood *et al.* 2001; Hovers *et al.* 2003; McBrearty & Brooks 2000; Oppenheimer 2003; Stringer & McKie 1996; Watts 1999; White *et al.* 2003). A recent return to fitness thinking within anthropology has assessed the fitness costs and benefits of various types of middle–late Pleistocene human coalitions, some of which may have encouraged the levels of solidarity now thought essential for first establishing the symbolic domain (Boehm 2001; Dunbar *et al.* 1999). One result is the prediction that matrilineal coalitions in particular would have accrued substantial evolutionary benefits by phase-locking their economic and ritual routines to the rhythms of the moon (Knight 1991; Knight *et al.* 1995; Power 1999; Power & Aiello 1997). More specifically, this 'sex-strike' model predicts that the seclusion of sisters and mothers would have been optimally timed to coincide with dark moon, would have marked the time of maximum ritual potency and sacred observance, and would have triggered monthly collective big game hunts as bride-service. Further elaboration of this model predicts a time-resistant syntax in the social construction of the sacred domain (Knight *et al.* 1995). Subsequent testing of this expectation has shown it to be useful in interpreting extant low-latitude hunter-gatherer practice, ritual and beliefs (Power & Watts 1997; Watts 2005). If this model is robust, we would also expect it to generate testable hypotheses for Mesolithic forager and Neolithic pastoralist cultures. By the start of the Mesolithic, European megafauna had become extinct (Martin & Klein 1984; Roberts 1989). A Palaeolithic optimum monthly alternation between dark moon seclusion and full moon completion of hunting big game, predicted by the model, would not be possible once big game plenty had come to an end. If the monument-building cultures of the Neolithic and Early Bronze Age were in some way addressing earlier hunter-gatherer rituals, which is the present understanding in archaeology, then the continued viability of ancient conceptions of time and ritual practice may well have been called into question. These models would predict that Neolithic and Early Bronze Age beliefs would display a complex logic which simultaneously respects and transcends an ancient cosmology which in its astronomical aspects had focused on the moon. By extension, this also implies that the Neolithic and Early Bronze Age introduction of solar symbolism was to modify and transcend earlier engagement with the moon. These predictions can be tested.

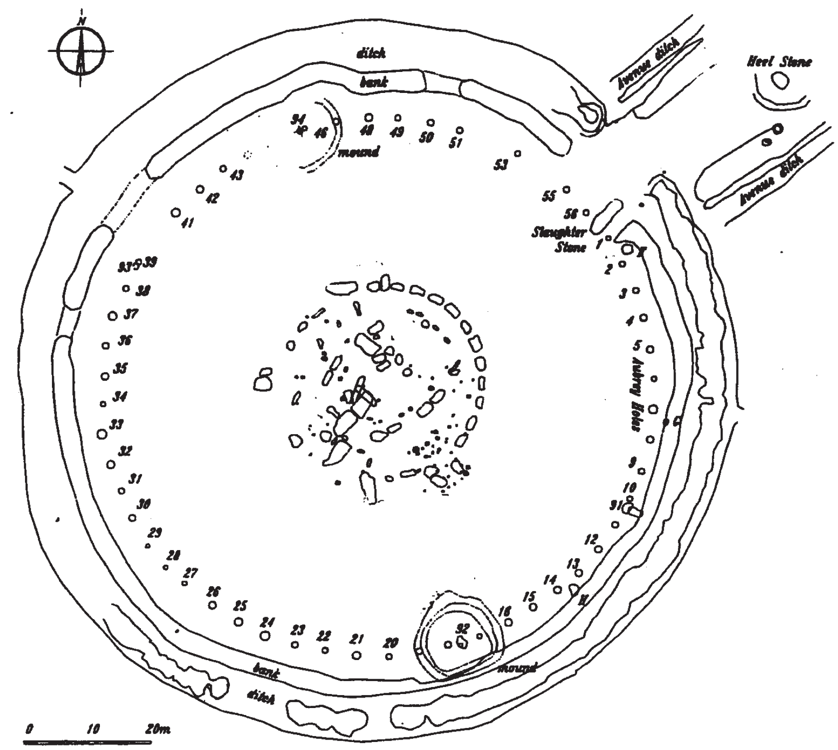
Archaeoastronomical models

For two decades or so after the mid 1960s, there was little agreement among archaeologists and archaeoastronomers on the astronomical properties of Neolithic and Early Bronze Age monuments (Ruggles 1999a). Archaeologists, then largely wedded to a version of a farming Neolithic, assumed a lack of complexity for the period and looked askance at archaeoastronomers' claims that Neolithic monuments displayed astronomical properties. Some archaeoastronomers filled the vacuum with their own models, and suggested that 'astronomer priests' were using the monuments as scientific observatories to construct calendars and predict eclipses (Hawkins & White 1970; Mackie 1977; Newham 1972; Thom 1971; Wood 1980). A more cautious note was sounded by others, who suggested a ritual rather than a 'scientific' function for prehistoric monumental astronomy (Burl 1987; Renfrew 1976). It is this second approach that has stood the test of time. A maturing archaeoastronomy now accepts a 'religionist' (North 1996, 10) or 'ethnographic' (Ruggles 2000) rather than 'astronomer' model for interpreting monumental alignments. This shift within archaeoastronomy brings it closer to the new model of a protracted religious reversal of Palaeolithic and Mesolithic forager beliefs by a 'domesticating' Neolithic. Archaeologists, in turn, have moved towards a cautious engagement with the astronomy of monuments. As Thomas and others have pointed out, these constructions point to the meeting places of sky and earth, above and below, as well as to the surrounding landscape (Hoskin 2001; Ruggles 1999a; Sims 2001; Thomas 1999) and point to 'the fundamental importance of cosmology' (Bradley 1998, 150). Testing the limits of this convergence, just as archaeologists have discerned themes of continuity and reversal of great time depth when comparing Mesolithic and Neolithic culture, we would expect similarly a rich and complex vocabulary of astronomical allusions in monument design. Over the last three decades, one finding is that the stone monuments of the late Neolithic and Early Bronze Age in the British Isles have an orientation towards the southwest which pairs alignments on the setting winter sun *and* the moon at its southern standstill moonset limits (see below for explanation of terms). In at least five regional groups of monuments of the late Neolithic and Early Bronze Age, in all accounting for 323 monuments, their main alignments focus on winter solstice sunset and the southern major or minor moonsets (Burl 1981; Ruggles 1999a). They include the Avebury stone circle and Stonehenge's Phase 1, Phase 2 and Phase 3 (North 1996). Although it may be an overly large claim best reserved for stone monuments, the 'evidence for prehistoric interest in obvious astronomical events such as midwinter sunrise and sunset is almost universally accepted' (Ashmore 1999, 28; Barnatt 1978; Burl 1976; Burl 1979; Burl 1988; Burl 1999).

This article will concentrate on the symbolism of sarsen Stonehenge, the sarsen circle and trilithons identified by Cleal as Stonehenge Phase 3ii, with an average calibrated date of 2413 BC (Cleal *et al.* 1995, 167, 204–5, table 64). The arrangement of bluestones in this period and shown in Figure 2 is Cleal's sequence 3v, dated to about 'the early second millennium' BC (Cleal 1995, 231). While the arrangement of sarsens did not change throughout this sequence from 3ii to 3v, the end stones of the bluestone horseshoe did. The main axial alignment discussed in this article relies on the sarsens only. I have used the term 'sarsen Stonehenge' for phases 3ii–3v throughout this article. We will see that sarsen Stonehenge's astronomy was the 'same' as 322 other monuments, including all of Stonehenge's earlier incarnations.

North's case against alignment on summer Solstice sunrise

Many commentators claim that, when standing at the centre of sarsen Stonehenge (Figs. 1 & 2) and looking to the northeast on summer solstice morning, the sun can be seen to rise over the Heel Stone (Atkinson 1979, 93–7). We now know that this is not just an anomalous claim for most stone monuments' main alignment in the British Isles of the late Neolithic and Early Bronze Age, but that the claim is inconsistent with the known internal properties of the monument. The findings of North (1996) and others (Burl 2002; Newham 1972) provide many details to correct this misunderstanding. First, it is unclear where the 'centre' of Stonehenge lies. It is not marked by any stone (Cleal *et al.* 1995; Ruggles 1999a), nor is the Avenue aligned on the centre of the sarsen circle (Atkinson 1979, 94–5). The absence of a precise viewing position is important, since even changing from one eye to the other alters the alignment by many solar diameters. In the absence of any criterion by which a central viewing position can be fixed, no definite alignment can be claimed. Second, standing at the centre of the sarsen circle, and looking through either eye, the summer solstice sun does not rise over the Heel Stone. It did not in the Neolithic and it never has. The sun has always risen by about three solar diameters (about 1.5°) to the left of the Heel Stone. Since other monuments of the period had higher levels of accuracy in their alignments, this is an unacceptable level of error for one of the greatest of these monuments (North 1996; Ruggles 1999a). Third, since it minimally requires two markers to establish a single alignment, the claim accounts for very few details of the monument. Stonehenge was once a complex arrangement of about 119 upright stones of graded heights, many lintelled and laid out in concentric circles and arcs, with another four 'station' stones laid out in an encompassing quadrangle; and there were additional single standing stones now known as the Heel, Slaughter and Altar Stones (North 1996). Out of a total of what was once around 160 stones, about 158 would remain to be explained by separate and additional theories to that of a single summer solstice alignment. Fourth, when the now prostrate Slaughter Stone is stood upright from its present position, it entirely obscures the view of the Heel Stone from the 'centre' of Stonehenge, blocking any view of a Heel Stone alignment on the summer sunrise (Burl 1999, 139–49; North 1996, 421–4, 427–30, 468–70). This evidence, and more to be discussed below, severely weakens the claim that Stonehenge was ever meant to align on summer solstice sunrise (Ruggles 1997; 1999a).

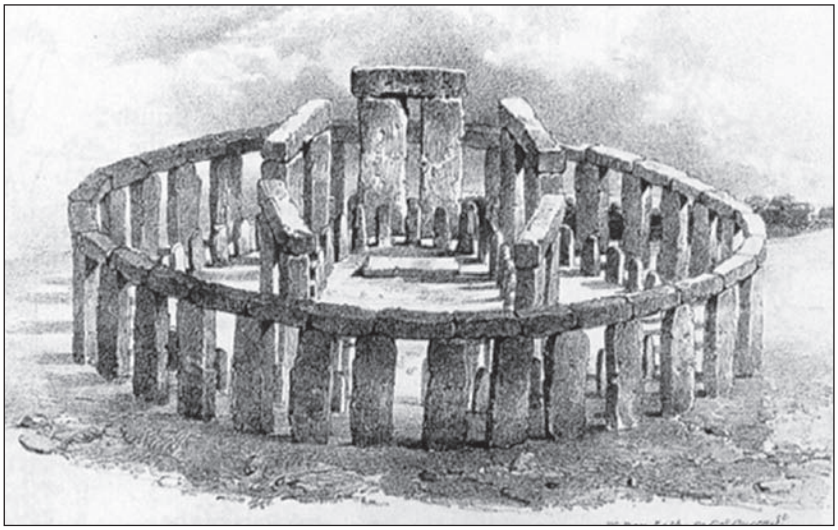


The Avenue approaches the monument uphill from the northeast. At the end of the Avenue, just before it reaches the ditched enclosure, a late Neolithic observer's eye standing beside the Heel Stone is at the level of the centre of the monument. The Slaughter Stone lies in a shallow ditch especially dug for it. The Aubrey Holes, numbered 1–56, encircle the sarsen monument. They held posts in Phase 1 of the monument and, after the posts were removed, they were used as deposition pits in Phases 2 & 3. The Station Stones, almost coincident with the Aubrey Hole circuit, are numbered 91–4. This plan gives no indication of the site's slope, or the lintels, or important individual features of many of the stones. The reader can compare this plan of the present positions of the remaining stones with the artist's recreation in Figure 2.

Figure 1. *Plan of Stonehenge Phase 3v (adapted from North 1996, 410).*

North's case for a main alignment on winter solstice sunset

North (1996) has argued that the archaeology of Stonehenge suggests that its major alignment is not towards the northeast, but towards the southwest,



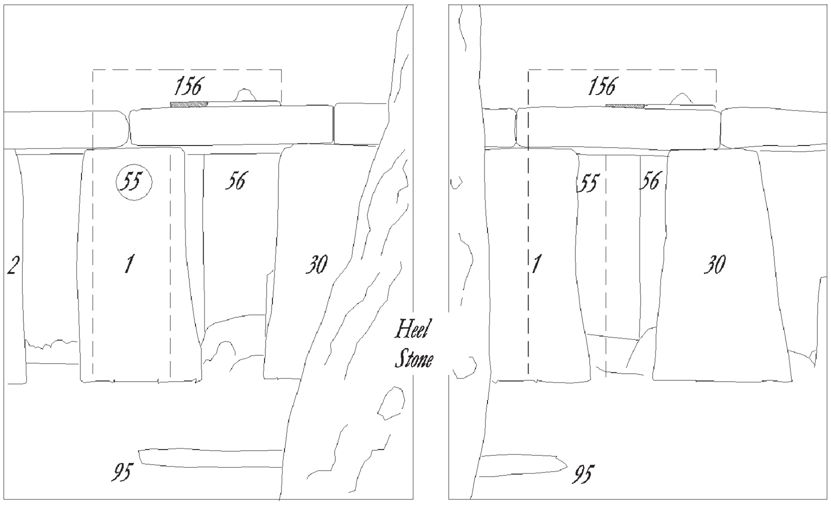
Looking along the central axis, southwestward, from above the Heel Stone and Avenue (not shown). The nearest sarsen uprights are stone number 1 to the left of the central axis, and stone number 30 to the right. Stone number 11 is incorrectly drawn as the same uniform size as all the other outer sarsen ring uprights: it is half the height, width and breadth of the standardized size shown. Opinions differ as to whether this stone was originally intended to be half-size or whether it was subsequently broken to this size. Note, then, that the lintel circle may not originally have been a complete ring of stones. The focus for the central arena in this representation is the prostrate Altar Stone. A more likely scenario, according to North, is that the Altar Stone was upright.

Within the sarsen circle there stood an estimated 59 or 60 uprights of the bluestone circle. The five trilithons are stepped in height towards the largest, the grand trilithon. Notice how the near trilithons converge symmetrically on a point. That point is the Heel Stone. Within the trilithons of Phase 3ii–vi, the 19 bluestones of Phase 3v–vi repeat the shape of the trilithon's enveloping horseshoe. The bluestones, like the trilithons, are stepped in height towards the southwest.

Figure 2. *Artist's reconstruction of Stonehenge Phase 3v (from North 1994, 340, with permission).*

onto winter solstice sunset. When today we look at a plan view of the monument, we see many stone pillars arranged in concentric series of two circles and two arcs. In this view, it appears to be gaps surrounding a space (Fig. 1). When looking at the monument outside the sarsen circle from the Heel Stone, North shows how the builders created the illusion that the monument appeared to be an almost solid block of stone (Pitts 2000, 135). They achieved this by adjusting the ratio of the width of the stones to the gap between them and by nesting the horseshoe arrangement of five trilithons within the sarsen circle. This design allowed the trilithons to block nearly all the gaps that otherwise would be seen through the sarsen ring. This paradox of an open monument appearing to be an almost solid block of stone obscuring the skyline is apparent when approaching the structure from the Avenue, as was intended, from 11 metres before the Heel Stone right up to the 'entrance' between stones 1 and 30. Stonehenge's main axis does not have this 'obscuration' property in the reverse direction, towards the northeast and summer solstice sunrise (North 1996, 451–6; Sims 2003). A further property, also not obvious in a plan view of the monument, is that Stonehenge is built on the side of a hill which rises to the southwest. This sloping location brings the observer's eye at the Heel Stone down to the level of the central area of the monument, so creating a very sharp single horizon which facilitates observation of the southwestern sky (Bender 1998, 70). This is not the case when standing in the middle of the monument looking towards the northeast, from where the land first falls away into Stonehenge Bottom, and then rises and falls in two further horizons to a distant skyline, presently etched with tree cover. Standing at the Heel Stone, this apparently near solid monument reveals through its central axis a 'window' framed between the grand trilithon uprights aligned on winter solstice sunset. Within the darkening mass of stone at winter solstice sunset, a Heel Stone observer would have seen a burst of light as the sun seemed to set into the Altar stone at the apparent centre of the monument.

Unlike viewing from the centre of the monument, many of its design principles recommend that we accept this winter sunset interpretation (Darvill (1997) interprets Stonehenge's horizons very differently but see Pollard & Ruggles (2001)). The surfaces of the monument have been engineered to present a clear-cut silhouette to an observer standing at the Heel Stone (Whittle 1997, 155). The converging inner faces of the nearest trilithons focus on the Heel Stone. The grand trilithon lintel, unlike the sarsen circle lintels, is wider at its top than at its bottom, so tipping its face forward at a right-angle to the Heel Stone line of sight (North 1996, 447). From the Heel Stone, the lintelled sarsen circle cuts out the glare of the sky without the cost of an enormously heavy superstructure, as in a passage tomb design such as at Newgrange in Ireland (O'Kelly 1982). Immediately in front of the grand trilithon, the Altar Stone provides an artificial but durable horizon into which the sun will, if viewed from the Heel Stone, appear to set (North 1996, 460–65). And while the sarsen circle stands on



Stones 55 and 156 of the grand trilithon have been reconstructed to fit the present setting of stone 56. North (1996, 443) suggests that, in 1901, Gowland may have re-set stone 56 'a hand-breadth's too deep'. I consider that it has also been twisted anti-clockwise out of alignment with the gap between stones 1 and 30. The Altar Stone is not shown but, according to North, it would probably have stood upright in front of the grand trilithon uprights, obscuring the lower portion of the bottom window.

This elevation demonstrates how the dishing of stone 1 keeps the view between the grand trilithon uprights, and therefore winter solstice sunset, open from the left hand side of the Heel Stone. If stone 1 were of 'standard' shape, this would not have been the case.

The shaded portion beneath the grand trilithon lintel, stone 156, represents the upper window aligned on the southern minor standstill moonsets. This window is enlarged by left-hand viewing from the Heel Stone.

Figure 3. *Elevation views along the main axis of Stonehenge Phase 3ii–vi, standing on the left- and right-hand sides of the (upright) Heel Stone (adapted from North 1996, fig. 170).*

ground that slopes by half a metre across its diameter, the top surfaces of its lintels are level to within an error of 17 cm across the sarsen circle diameter of about 32 m, so affording a level horizon to a viewer standing beside the Heel Stone (North 1996, 420).

Not just the engineering, but also the artistry of the monumental architecture orchestrates participants into the inner horseshoe *from* the Heel Stone. The trilithon and bluestone horseshoes are stepped in height in that direction, and towards the largest stones of the monument, the grand trilithon. These dramatic stones draw walkers along the processional avenue into the horseshoe and simultaneously entrain their gaze onto the southwestern sky, then framed by the grand trilithon uprights. The assumption that we should be looking to the northeast is an artefact of plan viewing of the monument, not three-dimensional viewing (Pollard & Ruggles 2001). A plan view gives no information about the height of the stones, severely diminishes the significance of the lintels and gives little indication of the slope of the land on which the stones stand. Nor does it allow an explanation for idiosyncratic properties of some individual stones. For example, the substantial dishing of the right side of stone 1 keeps the central axial alignment open when viewing the monument from the left side of the Heel Stone (Fig. 3). And it would be a very odd ritual centre indeed if, once having turned their backs and walked away from the rising sun along the Avenue and into the monument, participants were then expected to turn round, ignore the monument, face back towards the rising summer solstice sun, and observe it outside the monument probably emerging from behind some trees over two horizons away (Ruggles 1999a, 248).

> [I]f the Altar Stone was the focus of attention and the Heel Stone … marked the ceremonial entrance to the monument, it is certainly just as plausible, and arguably more so, that the alignment of particular symbolic value was that of the Altar Stone with the direction of mid-winter sunset in the southwest (Ruggles 1999a, 138) .

Plausibility is enhanced if we factor in the view to an observer processing uphill past the Heel Stone into the centre of the monument (North 1996, 453). When approaching the monument from the Heel Stone, walking at a sedate pace at winter solstice sunset, the artifice is created of holding the setting sun still, the upward movement of the walker's eye exactly counterbalancing the sinking motion of the sun.

North's case for a second main alignment on the southern minor standstill moonset

North shows that when Stonehenge is viewed from the Heel Stone there are in fact two 'windows', not one, that can be seen in the centre of the monument (North 1996, 454–9, 470–75). First, looking from the right side of the Heel Stone, a window can be seen framed within the grand trilithon uprights, themselves nested within the outer circle entrance stones below their lintel.[1] This lower window is aligned on winter solstice sunset. Second, looking from the left side of the Heel Stone, an upper window is framed again within the grand trilithon uprights but now between the upper surface of the closest lintel of the outer sarsen circle and the lower surface of the protruding grand trilithon lintel. This upper window, directly above the lower window, is aligned on the southern minor standstill setting moon (Fig. 3). The first alignment occurs once every year, but the second occurs only once in 19 years. Recognizing that these alignments are made from either side of the Heel Stone helps explain why its sides are parallel up to eye-level (Atkinson 1979).

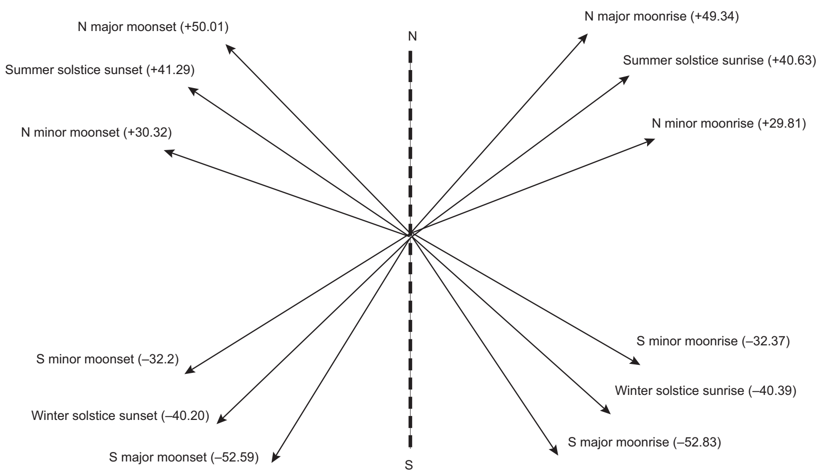
These properties are testable. For example, when checking North's claim for a double main alignment at sarsen Stonehenge against the scaled plans in Cleal *et al.* (1995), we find an azimuth of 229.5° from the right-hand side of the Heel Stone, which matches a winter sunset azimuth at an altitude of 0.5° of 229.5°, and an azimuth of 231° from the left-hand side of the Heel Stone which matches an average southern minor standstill moonset azimuth at an altitude of 4.3° of 231.2°. Opponents will have to find some more compelling explanation for these window alignments than these provided by archaeoastronomy.

The alignments derive from properties internal to the monument alone, and do not rely on any prior assumptions about distant skyline notches, or other (possibly random) external features, to fix an astronomical alignment. It is an accident of Stonehenge's location that, at 51° north, an *accurate* orientation on winter solstice sunset yields, in the reverse direction, an *approximate* orientation on summer solstice sunrise. This effect is an unintended and fortuitous consequence of the monument's geographical position, which generates nearly 180° of separation between these different solstice sunrise and sunset points. Ruggles (2000, 73) sees the central 'solstitial axis' as equivalent in both directions; but, if it comes to a choice between two precise orientations to the southwest and one approximate orientation to the northeast, it would be mistaken to choose the latter when so many properties of the monument suggest otherwise.

North's obscuration model manages to combine 28 properties of Stonehenge in a single argument. A plan diagram cannot capture the illusion that in three-dimensional view from the Heel Stone the monument appears to be an almost solid object on an eye-level horizon. Avenue, Heel Stone, sarsen circle, trilithons, and Altar Stone, all contemporary, are integrated in a single parsimonious model.[2] It is extremely improbable that this full suite of design characteristics, whose main rationale is to generate a double axial alignment on the winter solstice sunset and superior southern minor standstill moonset, can be explained away as chance. It also provides a response to the challenge of a preferential selection of sight-lines from the many offered by so many concentric pillars, since only two internal alignments are possible from the Heel Stone and both are found to fit cosmological events.[3] Furthermore, the finding that the main orientation of the monument is on the winter solstice sun brings Stonehenge back into agreement with the emerging consensus for late Neolithic and Early Bronze Age stone monuments. The evidence seems to indicate that, for these monuments, lunar-solar pairings at winter settings were emphasized (Ashmore 1999; North 1996, 489; Prendergast 1998). Any ethnographic investigation into this cosmology must therefore address why ancient monumental alignments should select not for the sun's ascent on the longest day but for its descent at the start of the longest night.

North's explanation for solar and lunar alignments at sarsen Stonehenge

However, North's claim that Stonehenge also has a main alignment on moonset at the southern minor standstill is, on first acquaintance, perplexing. While the sun takes one year to complete its cycle of horizon rise and set positions from one winter solstice to another, the moon takes just 27.3 days (Thom 1971, 117, McCluskey 1998, 9). Using a term which echoes the sun's solstice horizon movements, the moon's monthly horizon extremes are known as lunistices. Unlike the sun, the moon's extreme southern and northern horizon rise and set positions are not 'fixed'. On top of its rapid monthly alternation the moon's movements obey a cycle in which its monthly horizon extremes of rising and setting gradually but radically change over a span of 19 years. Once in this 19-year period, during what is known as a major standstill, the moon reaches the maximum of its range of monthly horizon swings. At Stonehenge this is approximately 10° further north and south of the horizon rise and set positions of the summer and winter solstice sun (Fig. 4). For about one year, the limits of the moon's northern and southern rise and set positions hover around these major standstill points. At no other time in its 19-year cycle does the moon ever reach these most widely separated sections of the horizon. Over the next nine or so years, the extreme limits of the moon's rising and setting positions gradually reduce, until again they reach a standstill when, once again for about one year, the moon's monthly horizon limits stay in this standstill area, but now about 10° *within* the sun's extreme rise and set positions. This second type is known as the minor standstill. Unlike during the major standstill, the moon can set in the region of the minor standstill throughout its 19-year cycle. 'The only particular qual-



N = north; S = south. Bracketed numbers are degrees above or below the west–east axis. Horizon alignment on upper limb of sun and moon.
Natural horizon altitudes in degrees at Stonehenge: NE 0.60 SE 0.70 SW 0.60 NW 0.30

Figure 4. *Plan view of natural horizon alignments on sun's solstices and moon's standstills at Stonehenge 2500 BC (data from North 1996, appendix 3).*

ity that can be associated with the minor standstill is that the directions … enclose the narrowest range in azimuth in which the moon rises and sets during any month' (Morrison 1980). It is for this reason that Thom (1971) labelled it the *minor* standstill. He suggests that, in general, a megalithic monument's largest stone or stones indicate a lunar alignment.

For some reason, the builders of one of the greatest monuments of the late Neolithic and Early Bronze Age went to extraordinary lengths to align the largest stones of the monument on precisely the minor standstill. If we can find an aspect to the southern minor standstill that eludes some modern astronomers, then this might strengthen our confidence in North's claims for the 'astronomy' of sarsen Stonehenge.

North's explanation for the choice

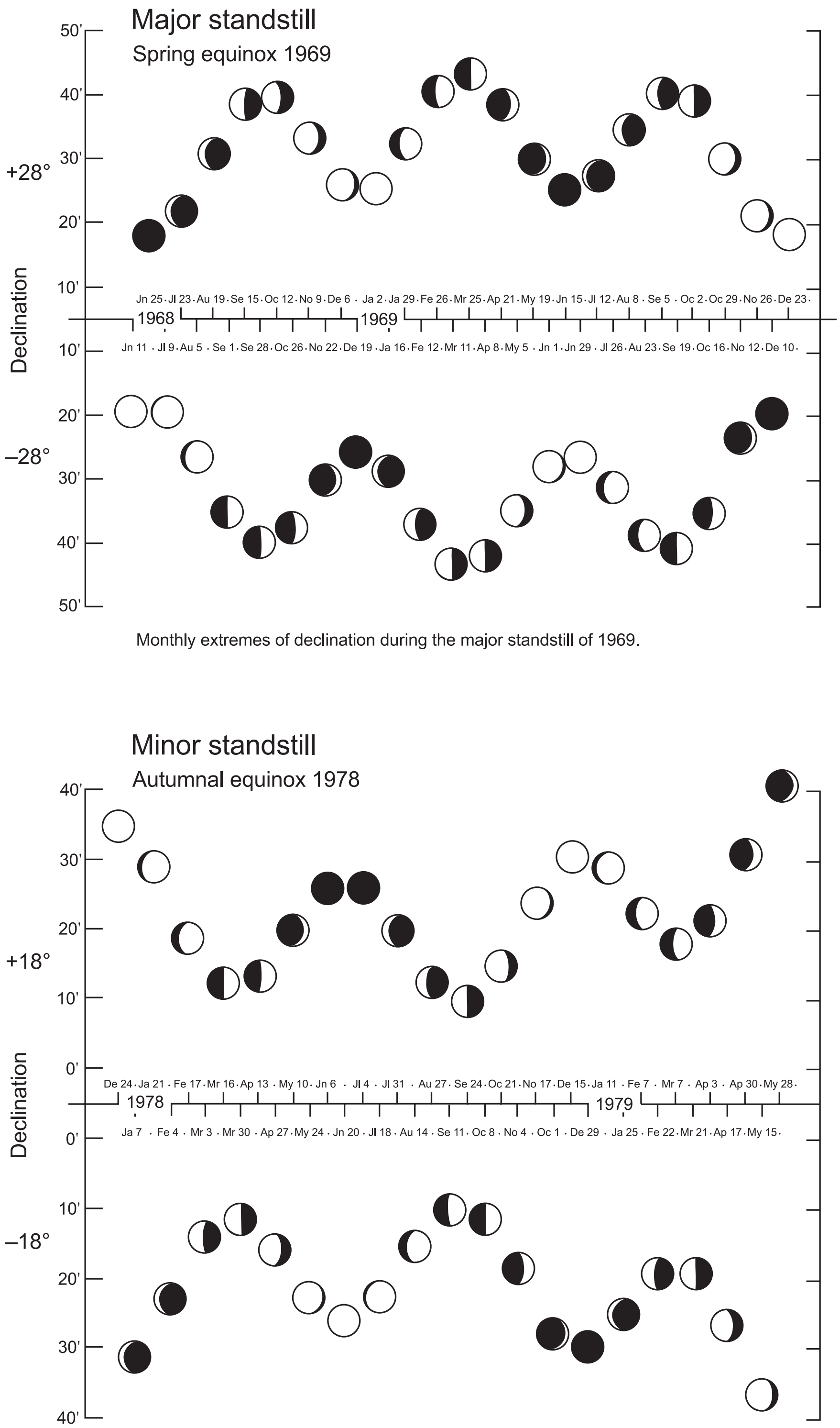
> [T]he grand trilithon was so designed as to allow for two key observations from the Heel Stone, one of the setting midwinter sun at its base, the other of the setting moon at minor southern standstill at its top … As the moon set, its last glint within the window would have gradually shifted, day by day, from the right-hand end to the left, and it would then have reversed. At other times, it would not have reversed, and would have gone on setting further and further to the south. If this second type of behaviour was regarded as 'normal', then a minor standstill has a touch of the miraculous about it, and perhaps this was the reason for paying so much attention to it. (North 1996, 474–5)

North's explanation poses as many problems as it might solve. First, if it were the case that the southern minor standstill moonset was considered 'miraculous' by Stonehenge people, why is it that North makes very different claims for the stone circle at Avebury just 20 or so miles away? For this monument, contemporary with Stonehenge, he suggests that the lunar alignment of the inner northern circle is on moonrise at its northern major standstill, and for the inner southern circle on moonrise and moonset at its southern major standstill (North 1996, 275). Why would the southern minor standstill moonset be 'miraculous' at Stonehenge but not at Avebury? Second, it may be the case that the builders of Stonehenge considered the moon's direction reversal at the southern minor standstill 'miraculous', but the small perturbations of the moon's lunistice extremes reverse their direction at *every* standstill (Morrison 1980; see also below and Ruggles 1999a, 60). Third, to judge the forestalled southern swing of the minor standstill moonset extreme as 'miraculous' suggests that North is using a solar template for judging the moon's movements. Sunsets never interrupt their progress along the western horizon to its southwestern or northwestern limits. Only by taking the sun's more pedestrian horizon movements as 'normal' could we possibly judge the moon as 'miraculous' when, unlike the winter sun, at the southern minor standstill it stops short of its full range to the southwest and temporarily reverses its direction. But if the builders of Stonehenge did perceive the southern minor standstill moonsets this way, it cannot account for why the builders of Avebury stone circle selected the southern major standstill of the moon which has an extended southern horizon swing. Fourth, if it is the case that a sense of 'magic' is created when southern minor standstill moonsets stop short of their full range, as this is equally true of the northern minor standstill moonsets, the southern minor standstill must possess some property beyond forestalled horizon swing to explain its selection by the builders of sarsen Stonehenge. To grasp these points, we need to pause awhile to compare the horizon astronomy of the sun and the moon.

Horizon properties of solstices and standstills

At the latitude of the British Isles, on summer solstice the sun rises in the northeast and sets in the northwest;

and at the winter solstice the sun rises in the southeast and sets in the southwest. Thus the sun has four solstice horizon points. At a major standstill, the moon will rise in the north-northeast and set in the north-northwest. 13 to 14 days later, the moon will rise in the south-southeast and set in the south-southwest. At a minor standstill of the moon there will be another four horizon points for the rising and setting moon, although now within the Sun's solstice horizon extremes. The moon therefore has eight, not four, horizon 'points' that mark its horizon boundaries (Fig. 4).[4] There are further differences between solstices and lunistices. The unaided eye cannot detect any change in the sun's horizon setting position for three days either side of the solstice (Allen 1992). In its pendulum-like movements before this 'stationary' period, the winter sunsets are very slowly setting further to the south, and three days after the winter solstice sunsets slowly start to set further to the north. The sun's horizon movements are therefore characterized by daily incremental change interrupted by over a week at the solstices when the sun apparently occupies a stationary position on the horizon at sunset. North (1996) seems to suggest that standstills are the lunar equivalent of the sun's solstices, for, at the southern minor standstill in the grand trilithon 'upper window' at Stonehenge, the setting moon 'would have gradually shifted, day by day, from the right-hand end to the left, and it would then have reversed' (North 1996, 474–5). This is not the case. The moon sets at its southwestern horizon limit only once every 27 nights, and does not stay at this position for a week as do the winter solstice sunsets. The very next night moonsets begin to move to their northwestern hori-



Monthly extremes of declination during the minor standstill of 1978.

Month here means sidereal month: the geocentric extreme declination occurs during the moon's mid-transit, not at the moment of horizon rise or set. Horizon movements are measured by azimuth not declination.

Figure 5. *Monthly (geocentric) extreme declinations of 1969 major standstill and 1978 minor standstill, by date and lunar phase (adapted from Morrison 1980).*

zon limit, arriving there 13 or 14 nights later to then immediately start moving southwards. Therefore, unlike the sun, the southwestern limit to the moon's horizon setting point is not characterized by a week in which the moonsets appear 'stationary'. To observe southern lunistice moonsets requires watching every twenty-seventh moonset in a time-lapsed observation exercise.

According to North, observing these monthly southern minor moonsets over a standstill year in the grand trilithon upper window reveals systematic sinusoidal perturbations in horizon lunistice positions. 'As the moon set, its last glint … shifted … from … right … left, and … then … reversed. At other times, it would … have gone on setting further and further to the south' (North 1996, 474–5). This property of the southern minor lunar standstill is represented in Figure 5.[5] Twice every 19 years, at the major and minor standstills of the moon, when the larger horizon movements of the moon have ceased for about one year, this perturbation alone accounts for the variation in the horizon limits of the moon's rise and set points. There is, however, a problem in claiming that this property can be observed on the horizon. North, in keeping with most archaeoastronomers, has assumed that the seasonal oscillation of geocentric extreme declinations[6] is repeated at moonsets on the horizon. The vertical oscillation shown in Figure 5, he suggests, would be translated as a horizontal alternation in the upper window of the grand trilithon every three or four lunistices. However, the extreme geocentric declinations of the standstill moon occur, almost invariably, during its transit in the heavens before or after the time it sets on the horizon. And as, unlike any other body in the sky, the moon is constantly changing its declination, by the time the moon sets it is no longer at its extreme declination value but almost invariably at some lower value. This substantially transforms the horizon pattern of seasonal alternation, so that the regular and seasonal wave-like motion of the extreme lunar perturbations shown in Figure 5 cannot be observed on the horizon at all. But since modern archaeoastronomy defines a lunar standstill by this single property, it is generally assumed that prehistoric sky-watchers aspired to identify these extreme declinations of the moon which they only imperfectly achieved. This assumption is a misunderstanding uncorrected since Thom's founding work on the subject and an artefact of modern astronomers' use of geocentric declination to measure the path of heavenly bodies.

Northwest European late Neolithic and Early Bronze Age monumental alignments on lunar standstills were first systematically studied by Thom in 1971. Each time the standstill moon reaches its 'geocentric extreme', it crosses or approaches very close to the plane of the sun and the earth. These are the circumstances that create an eclipse. It was Thom's view that additional structures, 'extrapolation devices', accompanied some lunar-aligned monuments to estimate an interpolated 'true' mid-transit value from the observed horizon value, and so calculate the 173.3-day cycle of geocentric extremes (Fig. 5). Knowledge of this sinusoidal perturbation of the geocentric extremes calculated from such devices, he thought, would indicate a prehistoric ability to predict eclipses. Archaeologists met these claims with extreme scepticism, so that archaeoastronomers entered a long period of field work and debate as to whether megalithic monuments were able to map these geocentric extreme movements of the lunar perturbation, or, in fact, whether they were aligned on lunar standstills at all. After two decades, the conclusion was reached that many of the monuments were aligned on lunar standstills but that there was no evidence for 'extrapolation devices' (Heggie 1981; Hoskin 2001; Morrison 1980; Ruggles 1999a). Nevertheless, horizon alignments up to levels of accuracy of about 6 minutes of arc are considered by some to have been made at some late Neolithic and Early Bronze Age monuments (Ruggles 1999a, 227). Whatever the level of accuracy achieved, we now know that the observations were on horizon alignments, not mid-transit extremes, of the moon. This poses the question as to the purpose of these alignments. It might be more useful if, instead of using the modern understanding of a lunar standstill measured and defined by its mid-transit geocentric extreme declination values, we search for other properties that may be associated with horizon azimuth alignments on a lunar standstill.

Even though he has identified the main Stonehenge lunar alignment to be on the southern minor standstill moonset, surprisingly North suggests that megalith builders in general, including those who built Stonehenge, preferred alignments on major standstills or northern minor standstills (North 1996, 563–7). This claim reflects either an imputed concern for the unusual angles of major standstill extreme horizon alignments (southern or northern), or for luminosity, since northern standstill moonsets (major or minor) generate a full moon at winter, or for both extreme alignments and luminosity, as with the northern major standstill full moonset at winter solstice (Fig. 5). These may well be the modern (and thus possibly ethnocentric) preoccupations of astronomers that, while true, do not exhaust the properties of lunar standstills (the same assumptions are shared by most researchers: see, for example, Ruggles 1999a; Thom 1967; Burl

1981). But the upper window of the grand trilithon is aligned on the southern, not northern, standstill and this generates a full moon at summer solstice, not winter solstice. When the full moon is seen to descend into this upper window at summer solstice, the 'fine slit' below the grand trilithon lintel frames just 'the upper limb of the moon' as it descends behind and 'into' the centre of the monument (North 1996, 472, fig. 170). If this was the case then the grand trilithon window box was in fact never designed to frame the full moon but just a descending sliver of the moon. On all three counts — alignment on the southern minor standstill, consistency with the winter solstice sunset, and the dimensions of the grand trilithon upper window — the builders of sarsen Stonehenge were not seeking an alignment upon full moon.

The emergent properties of lunar–solar double alignments

We have rejected the five current archaeoastronomical theories for the main alignments at Stonehenge. Selection for summer sunrise, the horizon extremes of the moon, forestalled horizon moonsets, eclipse prediction and full moon have all been found inadequate when set against the archaeological details of sarsen Stonehenge. Since the pairing of winter solstice sunset and southern minor standstill moonsets remains unexplained, let us approach the matter of lunar standstills anew. In his characterization of the 'miraculous' properties of this standstill, North does not incorporate in his interpretation all the information from his own findings. The defining design property of the monument is tiered lintelled pillars in concentric nested circles and arcs. Sarsen Stonehenge manipulated *two* horizons, one above the other, in a double alignment from one viewing position, the Heel Stone (and see North 1996, 434–502). Not to investigate the astronomical properties of this double alignment would therefore be to deny the central architectural principle of the monument. North discusses the astronomy of each alignment, winter solstice sunset and southern minor standstill moonset, as separate alignments, and does not investigate the emergent properties of their association. This is, in fact, a fruitful exercise, and allows us to test competing hypotheses for the possible cosmological motivations of the builders.

Duplication is built into the monument's design, as in the replication of the trilithon horseshoe by the bluestone horseshoe, and the sarsen circle by the bluestone circle. Each closely juxtaposed arrangement of stones mimics, in different registers, the other. To construct a binary monument that has a double alignment for both the sun and the moon suggests that some association between them is being sought. If the intended association was merely complementary, then this could have been achieved with two separate and unconnected alignments without doubling them along a single axis through the challenging architecture of concentric and nested circles and arcs of tiered lintelled pillars. As the two largest bodies in the sky also happen to be of the same apparent size, the architecture suggests that their properties are being symbolically conflated, not just combined, in a relation of identity. If other characteristics of their pairing suggest selection for identity, then this will add strength to the hypothesis of conflation. As we have discounted North's suggestion of a seasonal sinusoidal alternation in standstill lunistice moonsets, there remain three possible dimensions of the shared properties of the sun and the moon in a double alignment: the placement of the moon above or below the sun; sharing the 'same' position on the horizon; or other emergent properties from a combination of these two. Let us look at each possibility in turn.

For a double alignment to pair a lunar standstill with a solstice sunset along a single axis, as at sarsen Stonehenge, it depends on which lunar standstill is chosen whether the sun or the moon is above the other. There are eight possible double alignments of the sun and the moon along a single orientation in one direction at the solstices (W1–W4 and E1–E4 in Row 6 of Figs. 6a & 6b). What is very interesting is that, in their selection of the monument's main orientation (W2), the builders did not use the same engineering and architectural skills for the other seven possible combinations of the sun and the moon. Three of these other orientations would also have the moon above the Sun, but then bracketed either with summer solstice sunset (W4), or with winter solstice sunrise (E3), or with both summer and sunrise at summer solstice sunrise (E1). These three paired associations were rejected by the builders. One of these three paired orientations could have been the southern minor standstill moonrise with the winter solstice sunrise (E3) but, even though in this case the moon is above the sun, and it is the time of winter solstice, and it is the 'miraculous' minor standstill, the condition of impending daylight is not what the builders wanted to mark. There are four possible paired alignments with the sun above the moon (E2, E4, W1, W3), and one of these (W1) would pair winter solstice sunset with the southern major standstill moonset. This meets the chosen condition of winter solstice at sunset with the one difference that the southern major standstill places the moon below the sun. So, even though the major standstill horizon

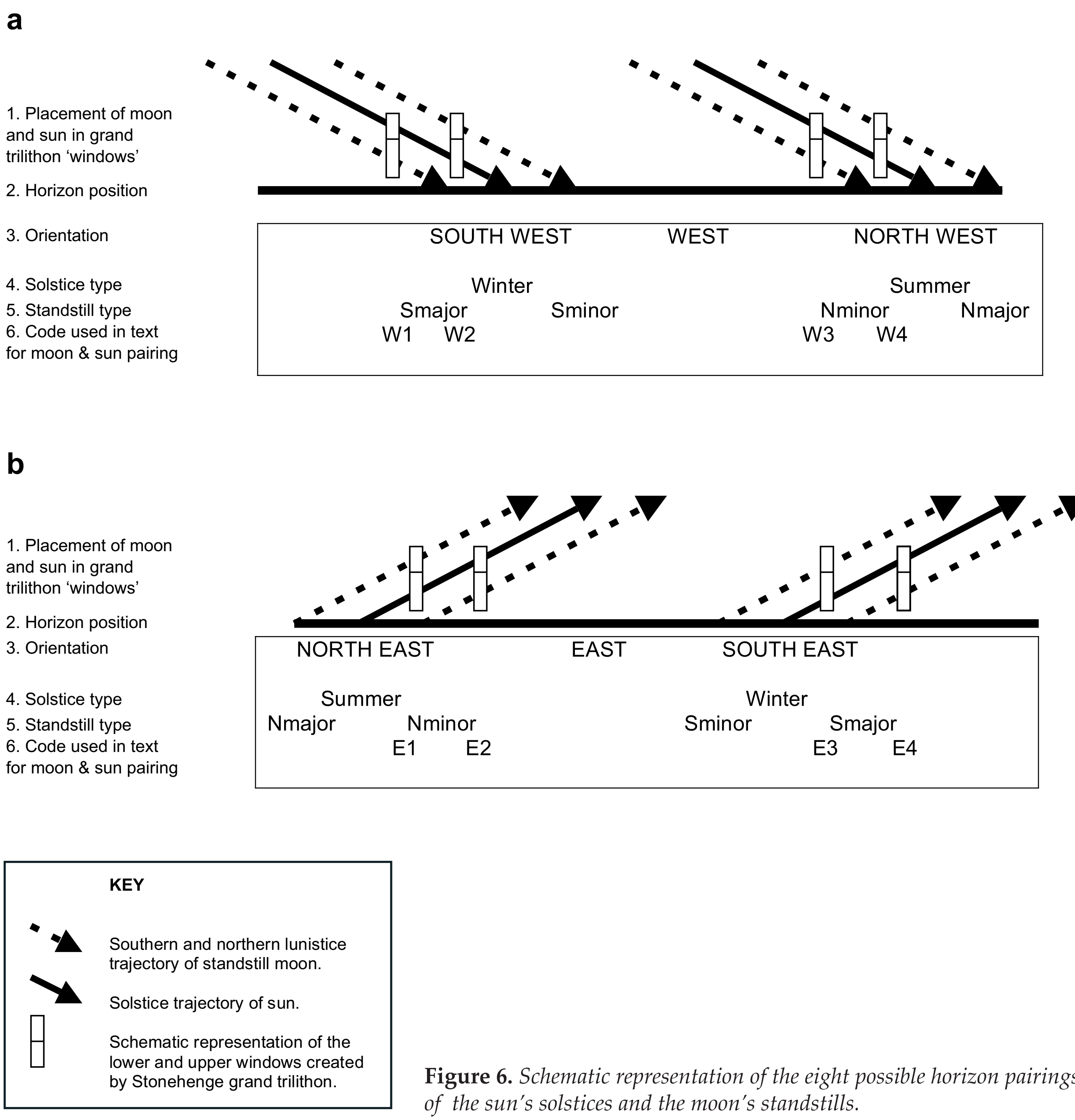


Figure 6. *Schematic representation of the eight possible horizon pairings of the sun's solstices and the moon's standstills.*

point is a particularly impressive position compared to the minor standstill horizon point, this seems to be a quite secondary consideration to the requirement that the moon should be above the sun in a paired alignment. Thus the builders have chosen, out of eight possible juxtaposed alignments, the one which brackets the setting moon with the winter solstice sunset as long as the moon is above the sun, W2 not W1. Any other pairing which brackets the moon with summer, or with the start of daylight, or in a position inferior to the sun, was rejected.

Horizon position for the longest, darkest night

For every type of standstill, not just the southern minor standstill, there is a one-year period during which dark/full moon alternation synchronizes with the binary logic of solstice alternation. It will be seen that at the solstices the southern standstills, whether major or minor, always present a full moon at the summer solstice and a dark moon at winter solstice (Fig. 5). Contrarily, at northern standstills, whether major or minor, dark moons always take place at the summer solstice and full moons at winter solstice (Fig. 5). This suggests that the rejection of the northern major or minor standstill moonsets is not just because it is bracketed with the summer solstice sun, nor that the northern minor standstill moon is rejected because it is below the sun, but because all northern standstill moonsets generate a full moon at winter solstice (Burl, North and Ruggles all assume that *full* moon was the object of interest). Therefore, at Stonehenge the winter solstice sunset is bracketed with the southern minor standstill moonset, and this will ensure that, once every 19 years, the winter solstice sunset is associated with the dark moon at the start of the longest and darkest night of the year. As we will see, if we adopt an anthropological rather than astronomical approach to a lunar scheduling of ritual, this does 'make sense' (*pace* Ruggles 1999a, n. 141). Hundreds of stone monuments, mentioned above, double the setting winter sun with the southern major or minor standstill moonsets by other architectural means, and therefore also focus their double alignments on the longest, darkest night.

This bracketing of winter solstice sunset with dark moon suggests, by extension of the principle of identity, a coding in which winter solstice sunset is invested with the property of dark moon. All that remained to be seen in the upper window at the southern minor standstill would have been the grouping of all southern lunistice moonsets, and this would only have happened during the minor standstill.

In fact, it can be seen from Figure 5 that the respective phases of each of the 13 lunistices during a standstill is appropriate to a full synodic lunar cycle, but attenuated over a year and reversed in their sequence. About 9 of the 13 southern minor standstill lunistice moons would have been observed apparently descending into the upper grand trilithon 'window box'. Morrison's (1980) rendition of the four types of lunar standstills (Fig. 5) is a computer-generated abstraction showing the phase of each lunistice moon. However, it does not account for the variable effect of the sun's glare in obscuring the crescent moons. The consequence of this effect is to make certain settings and risings of crescent moons invisible to naked eye observation. Only the full moon rises at sunset and sets at sunrise, its full transit therefore taking place through the night sky. Dark moon rises and sets with the sun and obviously cannot be seen. Between these two extremes, the moon's transit in the sky is partly during the day and partly during the night. Waxing crescent moon sets after sunset and becomes visible only with the setting sun, but cannot be observed rising in the morning sky against the glare of the already risen sun. Waning crescent moon rises before sunrise, but becomes invisible in sunlight for the rest of the day. Therefore waxing crescent moons can be observed at their settings and waning crescent moons at their risings, but not *vice versa*. The sarsen Stonehenge main alignment is on the southern minor standstill moonsets, not moonrises, allowing observation of waxing crescent moons but not waning crescent moons. About 27 days before winter solstice, the slim crescent of new moon will be seen from the Heel Stone descending in the grand trilithon upper window to be followed, in the reversed sequence of lunar phases, by dark moon at winter solstice. However, the three or four southern standstill lunistices after winter solstice, all reversed waning crescent moons up to third quarter moon, cannot be observed setting in the grand trilithon upper window. Monument alignments on southern lunar standstills will therefore allow about nine, not thirteen, sightings on moonsets from spring equinox to winter solstice, whereas monument alignments on northern lunar standstills will similarly allow nine sightings on moonsets, although now between autumn equinox and summer solstice. Sarsen Stonehenge is therefore a centre for ritual at which the main alignment standstill moon's role culminates and ends with a winter solstice dark moon.

An alignment on a lunar standstill, unlike on the solstices, is immediately a multiple alignment which theoretically identifies 13, not just one, of the lunistices. The lunistices at a standstill therefore scroll in reverse order through a full suite of phases normally associated with a lunar (synodic) month, but now taking one year to unfold. The same reverse sequencing of lunar phases takes place during the southern major standstill (as do northern major and minor standstills), although of course those moonsets take place further south on the horizon about nine years later. Special to both southern standstills is the way the phase-locking of an abstracted, attenuated and reversed lunar cycle combines dark moon with the winter solstice.[7] We can conclude that the builders selected this alignment on the moon as the main alignment at sarsen Stonehenge since it allowed them to place the moon above the sun, and associate the sun's winter solstice setting with dark moon as the culmination of an annual selected sequence of lunar phases which replicate those of a reversed synodic month, and whose grouping provide a reliable indication of a guaranteed longest, darkest night.

Conclusion

We have found that the sarsen Stonehenge main alignment which pairs the moon and the sun reveals a suite of characteristics that can be explained by a religious logic of estrangement. The onset of ritual power with the period of dark moon which, arguably, Palaeolithic and Mesolithic hunting cultures had conferred on the moon is preserved and manipulated by combining the southern minor standstill moonsets with the setting winter solstice sunset. Not only does this generate the longest darkest night possible but, by bracketing this dark moon with the setting winter sun, each mimics the other in their properties of signalling the onset of darkness. And by abstracting one dark moon from the twelve others in any one year, winter solstice provides the annual anchor for estranging ritual from a monthly to an annual cycle. Further, by creating the illusion from the Heel Stone that both moon and sun descended from the world above to the world below through the centre of the sarsen monument, the monument is constructed as an 'axial centre of the cosmos'. Earlier hunter-gatherer conceptions of a generalized sacred landscape were reversed by such artifice. The artifice is extended when processing uphill in the final Avenue approach towards a descending winter sun: the two movements cancel each other and give the appearance of a momentarily frozen sunset. Ritual leaders, through prolonging winter sunset, demonstrated the power to 'stop time'. These properties were seen from the right-hand side of the Heel Stone, bracketed with left-hand side viewing of the southern standstill moon. This 'handedness' suggests a solar symbolism invested with concepts of male power (Hertz 1960). Now, instead of the week-long mid-winter appearance of the setting sun in the lower window of the grand trilithon, within the upper window, over a minor standstill year, can be seen the complex phenomenon of an abstracted, annualized and reversed set of lunar phases culminating at winter solstice with dark moon. Considered as signals, the right-hand view of the sun is redundant while the left-hand view of the moon is cryptic. This further suggests that specialist knowledge of the lunistice moon is the preserve of some high ranking group. Techniques of juxtaposition, mimicry and reversal conflate rather than conjugate the horizon alignments of the moon and the sun.

None of this can be explained by a purely solarist interpretation for a main alignment on sunset. We would expect a sun cult to begin at sunrise rather than at sunset (but see Hoskin 2001). It would also be problematical to posit a strictly astronomical explanation for a Stonehenge double alignment on an invisible moon within a disappearing sun. '"[M]egalithic" astronomy … suggests a more complex interaction of astronomy, society, ritual, and trade than that of a simple farmers' calendar' (McCluskey 1998, 14): rather than a solar or 'scientific' function for lunar–solar alignments at sarsen Stonehenge, it is suggested that both incongruities disclose a religious substitution to mimic and estrange Palaeolithic hunters' lunar motifs into an emerging Mesolithic and Neolithic solar cosmology. Viewed this way, the lintelled architecture of sarsen Stonehenge is an elaboration of a unifying and time-resistant cosmological syntax belying and in parallel with the mosaic of economic strategies found by archaeologists to characterize Neolithic and Early Bronze Age cultures (Bradley 1991; Watts 2005; Borić 2005; Thomas 1999). Stonehenge Phase 1, Phase 2 and Phase 3i, the nearby and contemporaneous Avebury stone circle, and five other regional groups of monuments are all designed to entrain winter sunset with dark moon.

This strengthens the initial hypothesis made for sarsen Stonehenge. It may prove a useful model to interpret paired alignments found more widely: it would follow, for example, that any double main alignments at wooden monuments would be on summer sunset and northern standstill moonsets. It recommends us to re-investigate Mesolithic and early Neolithic cosmologies for earlier versions of the same complex.

This interpretation suggests that Neolithic rituals would have been drawn from a time-resistant syntax of sacred power ultimately derived from Palaeolithic hunter-gatherer cultures. In embracing and adapting this ancient rule to the logic of northwest European pastoralists at least 5000 years after optimum conditions for big-game hunters, strictly lunar scheduling to ritual could be reduced and estranged into solar cycles at lunar standstills while preserving the phase properties associated with the synodic month. The '[s]ymbolic representations of communal cohesion' (Whittle 1996, 190) through ancestral remains might also have drawn upon such manipulated knowledge. Sarsen Stonehenge, with its solar and lunar alignments, is located within a cremation cemetery (Cleal *et al*. 1995). Ancestor rituals beginning with winter sunset at dark moon might well have been timed to end with winter sunrise and possibly new moon (North 1996, 425). Dark moon seclusion in the world below may have been conceptualized as temporary or transitional when, paired with the winter sunrise and new moon that follow, horizon alignments provided a venerable vocabulary of allusions of transformation. This is consistent with other researchers' suggestions that some Neolithic monuments were designed to be the points of intersection for the conceptualized worlds below and above the surface world (Barrett 1994; Bender 1992; Bradley 1998; Edmonds 1999; Richards 1996; Sims 2001; Tilley 1994; Tilley 1999). Ancestor rituals at the monuments may have manipulated astronomical alignments to bring these 'worlds' into conjunction with the processed remains of selected individuals to signify their 'transformation'. These hypotheses fit the known archaeology of Neolithic ancestor rituals, pit burials and votive deposits (Thomas 1999; Whittle 1996) and the anthropology of dark/new moon seclusion rituals linked metaphorically to death and rebirth (Knight 1991). Unlike some earlier models in archaeoastronomy, this rigorously 'religionist' interpretation requires no prior assumption of a Neolithic 'scientific' priesthood, yet offers a motive for high-fidelity alignments in some Neolithic monuments and fits Ruggles's recommendation to adopt an anthropological approach to the astronomies of past cultures (Ruggles 2000). Models drawn from archaeology, archaeoastronomy and anthropology independently point to a convergent interpretation in which lunar–solar settings and risings govern the rhythms of some burial and wider ritual practices. This is in marked contrast to claims for a sarsen Stonehenge summer solstice sunrise alignment, which remains an aberrant finding in archaeoastronomy and finds little purchase in archaeological models of Neolithic burial practices.

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Notes

1. North's view is that the Altar Stone was upright, and if so would have provided a raised and durable horizon into which the winter sun would have set. However, there is evidence that it may have lain flat. See http://www.ualberta.ca/~gfreeman/ for an interesting finding from some recent field research.
2. *Pace* Ruggles (1999b) Cleal *et al*. (1995) shows that from Stonehenge 3ii to 3v it is the bluestones which are modified, not the sarsen pillars and lintels upon which these alignments depend.
3. This has been discussed by Ruggles (1999a), using statistics. However, before a rigorous statistical procedure begins, scaling assumptions must be made about the back sights and fore sights in ancient monuments, and these decisions are based on an interpretation of their design which is not constrained by statistics. Seeing Stonehenge as an obscuration device drastically reduces the number of sight-lines. Similarly, the obvious 'light-box' design at Newgrange is but another form of obscuration. Statistics are inappropriate for such obvious design properties.
4. The angle of azimuth (swing left or right on the horizon) of the moon's lunistice is on average about 10° either side of the sun's solstice setting positions, or approximately double the value measured by the angle of declination. Declination measures, since they assume a celestial equator girdling the planet, are consistent with a heliocentric model of the solar system. Measures of azimuth (combined with horizon altitude) are more in keeping with not just a geocentric vision of the cosmos, but of a planar earth sandwiched between the sky and the underworld. Since this is far more likely to coincide with a prehistoric view of the cosmos, azimuth measures should be preferred over declination measures. Confusingly, since archaeoastronomers use both declination and azimuth (combined with horizon altitiude) interchangeably for locating the position of the sun and moon, and since crucially different levels of meaning are implied by each, any untangling of modern from prehistoric assumptions nevertheless require us to engage with both.
5. Seven points need to be made when interpreting this representation of the moon's standstill geocentric extreme movements. First, for the southern minor standstill, shown on the bottom of Figure 5, the moon's horizon setting positions oscillate about –18° 20'±10'. It can be seen that every other standstill has a similar 20' oscillation depending on whether it is a major or a minor standstill, and whether it is at its southern or northern extreme. Second, the vertical axis is cropped in the Figure, so bringing the north and south lunistice moons into close proximity, when of course they take place at opposite horizon extremes, approaching the south and north of both the western and eastern horizons. Third, the moon's path is measured by its geocentric declination, which is a measure of the distance in degrees from the celestial equator to the centre of the lunar disc. It is agreed by all archaeoastronomers that normally Neolithic observers tracked the first and last glint of sun and moon, and therefore the upper limb, not the centre, of the moon's disc. Fourth, the lunar disc is not shown to scale. The moon actually subtends an angle of about half of one degree of arc, not the 5 minutes of arc shown on the Figure. The scale reduction of the moon in this Figure exaggerates the scale of oscillation compared to the size of the moon. Fifth, the total perturbation of the moon at a standstill is about twenty minutes of arc by declination. When instead we measure this perturbation by azimuth, the movement is about 40 minutes of arc. Sixth, since the moon's geocentric extreme takes place in mid-transit, and since the moon constantly changes position, by the time the moon reaches the horizon these values have almost always reduced. The net effect is again to underestimate the variation and imply a false sinusoidal shape to the perturbation. Seventh, it will be noticed that besides giving point estimates of the extreme declinations of the moon, Morrison (1980) has also provided the appropriate lunar phase of each lunistice by date. This categorical level information, not given elsewhere in the literature, is more amenable to ethnographic de-coding.
6. Modern positional astronomy calculates these geocentric values of the moon's perturbation at the moment of

its extreme, and on the assumption that the observer is standing at the centre of the earth. Neolithic observers, however, aligned their monuments on the moment the moon rose or set on the earth's horizon. As we will see below, this is not the moment of the moon's extreme perturbation.

7. It will be noticed that northern standstills exhibit an identical property, although one in which dark moon now synchronizes with summer solstice. North (1996, 485) shows that when standing in the southeast quadrant of Aubrey Holes, this secondary paired alignment of identity can be seen threading the nested lintels of the monument, although now the summer sun sets above the northern minor moonset.

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