Calendrical Interpretation of Spirals in Irish Megalithic Art

Marc Türler
Independent scholar; formerly at the Department of Astronomy of the University of Geneva
marc.turler@unige.ch

Abstract: The tumuli of Newgrange and Knowth in Ireland are among the most monumental heritages of the Neolithic era. The megalithic constructions date back to around 3200 BC, centuries before the completion of Stonehenge and the Egyptian pyramids. Passageways inside the mounds have been shown to be aligned such as the rising sun illuminates the interior chambers on the winter solstice at Newgrange and around the equinoaxes at Knowth. Many of the kerb and interior stones are covered with petroglyphs, in particular with spiral motifs. Despite several attempts to classify and interpret them, they remain enigmatic to visitors and archaeologists alike. Here we show that some of the most elaborated spiral designs are very likely calendrical representations. We identify in the detailed spiral motifs up to five different manifestations of the solar and lunar cycles, which could easily be observed in prehistoric Ireland. Corroborating evidence comes from adjacent motifs or a special location of the stone. The more complex spirals appear to include more celestial manifestations. It suggests that an intellectual elite of this Neolithic settlement linked the astronomical cycles to the passage of seasons, followed them over years, and represented them with increasingly elaborated symbols. This process from observations to abstract models preserved in engraved signs can be considered as a truly scientific approach.

Keywords: archaeoastronomy; calendars; cycles; gnomon; Ireland; Knowth; Neolithic; Newgrange; petroglyphs; spirals; symbols

Introduction

Newgrange and Knowth are two large megalithic mounds both located in the bend of the river Boyne nearby Dublin. Covered with grass and encircled by kerbstones, they used to be considered as graves and called passage tombs because one or several corridors lead to interior chambers. Although there is evidence for burial human remains (O’Kelly, 1982; Eogan, 1986), the astronomical orientation of the passageways suggests that these monumental constructions were not primarily tombs (e.g. Murphy, 2012). Their design aims at letting sun rays illuminate the chamber of Newgrange at sunrise on the winter solstice (Patrick, 1974; Ray, 1989) and the two corridors of Knowth at sunrise and sunset around the equinoaxes (Eogan, 1986; Ruggles, 1999; Prendergast, 2017). In this context, it would make sense that at least part of the engraved symbols on the kerb and interior stones are also related to astronomical cycles. This possibility was explored intensively by Brennan (1983) and Thomas (1988) providing interesting ideas, some of them rather convincing, others much less. Brennan identifies many fan-shape petroglyphs evoking sundials, in particular at Knowth on the flat top of kerbstone K7 and forming the central motif of kerbstone K15, sometimes called the ‘sundial stone’. The second one has however also been interpreted by Thomas (1988) and by MacKie (2009; 2013) as a representation of the prehistoric sixteen-“month” solar calendar, which was first proposed by Thom (1967) based on a statistical study of many standing stone alignments. The detailed analysis by MacKie supported by the interpretation of other archaeological artefacts makes the prehistoric subdivision of the year into halves, quarters, eighths and finally sixteenths plausible. It is however a bit disturbing that such a calendar with “months” of 21 to 23 days has no connection to the moon cycle, while most calendars are lunar or lunisolar (Richards, 1998). The most explicit representation of astronomical cycles is on kerbstone K52 at Knowth. This so called ‘calendar stone’ shows a succession of 22 crescents or horseshoes completed by 7 circles, their arrangement in an ellipsoid leaves little doubt that they represent the varying moon phases over 29 days, i.e. the synodic month (Brennan, 1983; Prendergast, 2017). The associated wavy line has further been successfully interpreted by Brennan as a count of months to synchronise the lunar and annual cycles, while Murphy & Moore (2006) tentatively extrapolate this to the full 19-year Metonic cycle. Besides those interesting examples and maybe some other less robust claims, the vast majority of the rock art could not yet be convincingly and coherently interpreted as representations of astronomical cycles, thus opening the way to radically different ideas. For instance, analogies have been found with the shape of marine fauna and flora (Doyle, 2016) or with drawings performed in a state of
altered consciousness (Dronfield, 1995; Lewis-Williams & Pearce, 2005). This might well be the case for simple motifs, but the diversity of the compositions and the complexity of some designs suggest a greater purpose. In summary, there is no unanimity on the interpretation of the petroglyphs, which remain mostly enigmatic (Stout & Stout, 2008). The objective of this paper is to reconsider the possibility of a link with astronomical observations with a new approach, which is as scientific as possible given the inherent speculative nature of a study on the interpretation of prehistoric signs.

Methods

Given the compelling arguments above, we make the hypothesis that a fraction of the megalithic art represents astronomical cycles. In order to test this hypothesis with a scientific methodology, we first need to identify: a) the characteristics of signs that are likely to represent cycles; and b) a list of astronomical manifestations observable by Neolithic people. Based on this, we can then test whether the signs likely to represent cycles could also realistically represent celestial observables. If the aim of Neolithic people was to represent astronomical manifestations with symbols, we should find evidence for this by a detailed analysis of the signs. The more matching characteristics will be found, the more likely it will be that the symbols were intentionally designed to represent astronomical cycles. Unlike modern logos, the expression of a concept with a sign kept as simple as possible increases its symbolic power. One would therefore expect that more complex signs would encode additional observables. If this can be convincingly shown, it would further strengthen the case. Corroborating evidence can also come from the particular position of the stone, the orientation of the design, or from adjacent motifs, which could be related.

Characteristics of cyclical representations

The continuous, but regularly changing apparent rotation of the sun, the moon, and the stars must have intrigued humans already in prehistoric times. They would naturally have wished to transmit to the next generation the knowledge gained through observations. Better than many words, tracing a circle is clearly the most trivial representation of a cycle. The drawing has a starting point and a direction of rotation. This information is lost once the circle is completed, unless one ends the loop slightly off the starting point. Doing this enables to continue tracing a second cycle, a third one, and so on. The resulting motif is a spiral, which is characterised by a clockwise or counterclockwise rotation and a number of loops.

The reasoning that spirals are most likely representing cycles seems so logical, that it is difficult to understand why this was not recognised earlier (see section Discussion below). It is probably related to the fact that our modern mind is used to represent a cyclical process by a sinusoidal line. The latter is however much more abstract, because it implies the convention to represent time on a horizontal axis, while the vertical movement of a point on a rotating wheel is projected on the orthogonal axis.

![Figure 1. Schematic representation of the daily paths of the sun and the moon at solstices and equinoxes for a typical latitude of ~45° N and ignoring the small disturbance due to the ~5° inclination of the moon orbital plane with respect to the ecliptic. The full moon (white circle) and the sun (rayed yellow circle) follow opposite extreme paths on the winter and the summer solstices. The wide, ‘dominant’ path from north-east (NE) to north-west (NW) is followed by the first quarter moon on the spring equinox and by the third quarter moon on the autumn equinox.](image)

Observable properties of astronomical cycles

Days, months and years are observable astronomical cycles. The day is due to the spin of the Earth around its north-south axis and results in an apparent movement of the sun and the stars. The month relates to the revolution of the moon around the Earth. The sidereal month (~27.32 days) is the time the moon takes to complete a full revolution through the constellations, while the synodic month (~29.53 days) is the more familiar interval between two consecutive full moons. Both phenomena can be followed easily with the naked eye, it just requires regular observations. The (tropical) year (~365.24 days) relates to the orbit of the Earth around the sun in the ecliptic plane. Its visual manifestation is the apparent movement of the sun through the constellations of the zodiac. The tilt of ~23.5 degrees between the spin axis of the Earth and its rotation axis around the sun causes the seasons and associated celestial manifestations described below.

In an ideal world, the month would have an integer number of days and the year an integer number of months. As this is not the case – a year counts ~12.37 synodic months – finding a coherent relation between the three time units is a puzzle since millennia. A very simple calendar is the ancient Egyptian civil calendar dividing the year into 12 months of 30 days plus five additional days (Richards, 1998: 153). Working only with integers, a closer match is however reached with 13 months of 28 days totalling 364 days, which needs just one additional day to complete the year. There are several arguments in favour of such a calendar. Indeed, 28 days in a month is in between the sidereal and synodic cycle, corresponds to the number of
daily double-cycles of tides (~24 hours and 50 minutes) in a synodic month and matches on average the menstruation cycle. The number 28 is furthermore divisible by four to mark quarter moons, our modern weeks. Although there is no such calendar currently in use, several primitive calendars have 13 months, like those of some of the Native American tribes, e.g. Lakota and Cherokee, possibly the Rapa Nui calendar of the Easter Island, as well as the Celtic Tree Calendar. Such a 13-month calendar was actually proposed in 1849 by August Comte and called the ‘positivist calendar’ (Richards, 1998: 113). The idea was taken over in the early 20th century to replace the complicated Gregorian calendar with the International Fixed Calendar, which has the advantage to be perennial with exactly 13 months of 4 weeks plus an extra day (or two on leap years) incorporated in a long week-end such that each month starts on Monday. On the other hand, the now commonly used 12-month calendar has the great advantage to be divisible in two semesters and in four seasons with equal numbers of months.

During the night, the changing size of the daily movement of the sun from one solstice to the other naturally results in a spiral pattern (Brennan, 1983: 188). The notion that the same sun returns over the night is not as obvious as it would seem. For instance, ancient Egyptian mythology refers to the birth of a new sun every day. We note, however, that this understanding is much easier for inhabitants of high-latitude regions, because many constellations can then be seen to make almost a full revolution around the pole during the long winter nights and also the sun, in the summer, nearly revolves fully from north-east to north-west.

**Figure 2.** The curves of this gnomon pattern represent the daily path of the shadow of the tip of a vertical gnomon (black dot), cast by the sun on a horizontal ground (the figure plane). They are calculated for a typical latitude of 45° N on the 28th of each month using exact formulas (Demers & DuPuy, 1980). The colour coding is green, yellow, red, and blue for spring, summer, autumn, and winter, respectively. The upper-right figure represents a stylised idealisation of the observed pattern – including the necessary return of the sun from west to east over the night (dotted line) – as two sets of concentric circles.

Besides the calendrical challenge to relate daily, monthly, and yearly cycles, there is a series of interesting seasonal manifestations to be observed by people living at relatively high geographic latitude. The most affecting consequence is that the night is much longer in the winter than in the summer and this is directly related to the daily path of the sun in the sky. In winter, it traces only a small arc on the southern horizon, while in summer it draws a long, high arc from north-east to north-west (see Figure 1). Starting from the winter solstice, the solar arc widens on the horizon over days and months until the summer solstice and then shrinks again in the second part of the year. By understanding that the sun has to return from west to east below the horizon during the night, the changing size of the daily movement of the sun from one solstice to the other naturally results in a spiral pattern (Brennan, 1983: 188). The notion that the same sun returns over the night is not as obvious as it would seem. For instance, ancient Egyptian mythology refers to the birth of a new sun every day. We note, however, that this understanding is much easier for inhabitants of high-latitude regions, because many constellations can then be seen to make almost a full revolution around the pole during the long winter nights and also the sun, in the summer, nearly revolves fully from north-east to north-west.

**Figure 3.** Three examples of stones engraved with one or several pairs of rings, cup-and-rings and/or spirals, which are likely inspired by the gnomon pattern. The drawings are all from Brennan (1983): a. chamber stone 1 in Cairn H at Loughcrew, Ireland with a pair of adjacent spirals with central rings and, interestingly, only one cup mark; b. fully engraved stone at West Ray, Orkney, Britain with a pair of concentric semicircles and three other pairs of connected spirals; c. another variation on the theme are the two pairs of spirals – one with an interesting central connection – on a stone from Barclediad y Gawres, Anglesey, Britain.

While the two solstices are clearly distinct when living at high latitude – one is light and warm and the other is dark and cold – the two equinoxes are usually thought to be indistinct. Actually, there is a subtle difference that is easy to observe, but that does not affect people. The wide, ‘dominant’ arc of the summer sun is followed by the waxing, D-shaped half moon (i.e. the first quarter moon) at the spring equinox, whereas at the autumn equinox it is traced by the waning, C-shaped half moon (i.e. the third quarter moon). This intriguing difference is schematically illustrated in Figure 1. The ~5° inclination of the moon orbital plane will induce somewhat higher or lower paths of the moon compared to those of the sun, but the effect is small (at most at a 5°/23.5° = 21% level) and it averages out over decades. The result is that one can divide the year
according to the shape of the dominant half moon. The waxing half-moon is dominant from the winter to the summer solstice – the winter-spring semester – whereas the waning half-moon is dominant in the summer-autumn semester.

A final interesting seasonal manifestation is the pattern of curves traced by the shadow cast by the tip of a gnomon. The stick at the centre of a sundial is a gnomon, which in its simplest form is a wooden post hammered into the ground. Figure 2 shows a series of curves traced by the shadow of a gnomon’s tip every month over a year. This curve is bending around the gnomon at the summer solstice, flattens out towards the autumn equinox and bends again in the opposite direction during the autumn season around an imaginary point located further north. The pattern then inverses again from the winter to the summer solstice passing by the straight west-east line at the spring equinox. A natural styled representation of this yearly pattern would be in the form of two juxtaposed groups of concentric circles, which have striking similarity with the numerous cup-and-ring motifs found both in Ireland and Great Britain and their frequent association with spirals (van Hoek, 1993; Waddington, 1998). Figure 3 reproduces the motif of three stones (Brennan, 1983) found in different locations outside of the Boyne Valley and displaying diverse motifs likely inspired by the gnomon pattern.

We presented here an exhaustive list of astronomical manifestations associated to the passage of a year, which could have been easily observed by Neolithic people. We can summarise them as:

1. the ratio of 12 or 13 lunar cycles (months) per solar cycle (year);
2. the increase, respectively decrease, of daylight in the winter-spring and the summer-autumn semesters;
3. the associated widening, respectively shrinking, of the arc daily traced in the sky by the sun;
4. the wide, ‘dominant’ path in the sky of the first quarter moon in the winter-spring semester and of the third quarter moon in the summer-autumn;
5. the gnomon pattern with an equinoctial flip from a light spring-summer semester to a dark autumn-winter.

In addition, a calendrical representation would also aim at representing the endless succession of years by having the start and the end point of a curved pattern such as a spiral at the same location, so that one can follow the engraved line without lifting the finger from one year to the next.

Dataset

We have identified the spiral motif as the most natural representation of cycles. We therefore concentrate our study on the most carefully engraved or prominently placed examples to test the hypothesis that they could represent astronomical cycles. We restrict ourselves to the tumulus of Newgrange and to the main mound of Knowth, because of the quantity, quality and variety of their motifs and because they have engraved sundials and aligned passageways already linking them to daily and yearly cycles (see Introduction).

Results

We present here a calendrical interpretation of five specific spiral motifs – from the simplest to the most elaborated one – and show that they appear to incorporate an increasing number of the astronomical manifestations described above.

Figure 4. The great spiral on stone C3 in the west recess of Newgrange (O’Kelly, 1982). The engraved motif is composed of a spiral with 13 loops widening counter-clockwise surrounded by two long arcs (shown in blue) and two short arcs (in red). In a calendrical interpretation, the spiral represents 13 moon cycles in a year and the arcs the moon phase quarters with two short arcs for the waxing and waning crescent moon and two long arcs for the waxing and waning gibbous moon.

We start with the great spiral on the chamber stone C3 inside the west recess of Newgrange (Figure 4). The spiral widens counter-clockwise, which is the direction of the monthly movement of the moon against background stars. It traces 13 loops, which could therefore represent 13 moon revolutions around the earth in a year. As explained above, there are many arguments in support of a simple calendar made of 13 x 28 days, falling just one day short of a year of 365 days. The four arcs around the spiral reinforce the calendrical interpretation as they could represent the four quarters of the moon phases exactly as our seven-day weeks, since 4 x 7 days completes a month of 28 days. The two short arcs could thus be stylistic representations of the moon crescents of the first and last quarters and the two long arcs of the gibbous waxing and waning moon of the second and third quarters.

Corroborating evidence is found in two other spirals with a count of 13 cycles (Figure 5), but including three additional calendrical features: 1) the endless succession of years, 2) the increasing daylight duration from the winter to the summer solstice, and 3) the associated widening of the sun’s daily path in the sky (see section Methods).
These features are apparently all incorporated in the spiral engraved, interestingly, just next to the fan-shaped sundial or, alternatively, the 16-“month” solar calendar on kerbstone K15 in Knowth. The motif starts from the centre like the 13-loop spiral, but subtlty returns on the same path after seven widening loops to spiral back into the centre over six loops. Assuming each turn to represent a month with the winter solstice at the centre, the seven widening and six shrinking loops could represent the variations over months of the arc traced by the sun in the sky (see Figure 1). The associated longer daylight in the summer would then also be represented by the longer duration needed to engrave – or follow with the finger – the outer loops. With the year both starting and ending at the central point, it is possible to follow the path over many years without leaving the groove.

Figure 5. Two other spirals with a count of 13 loops. a. The motif on kerbstone K15 at Knowth (Brennan, 1983) spirals out for seven loops before turning around to spiral in on the same line for six additional loops. b. The S-shaped spiral on kerbstone K67 at Newgrange (O’Kelly, 1982) can be seen as an unfolded version of the same pattern. In a calendrical interpretation, a month is represented by a loop and the winter solstice would be at the centres of the spirals (blue spots) and the summer solstice at the rewinding points (yellow marks).

All these three calendrical features are equally present in an S-shaped spiral in Newgrange on kerbstone K67, which is apparently an unfolded version of the previous motif. The 13 loops are now disposed in order to divide the year into winter-spring and summer-autumn semesters with a transition at the summer solstice. This fundamental moment in time could have been marked by placing in front of the kerbstone a standing stone or a wooden post, which would shed its shadow on the dividing, vertical line at the sunrise of the summer solstice according to the precise north-east position of this richly decorated stone (Brennan 1983:192). This would be analogue to the standing stone in front of the west passage of Knowth, which is casting its shadow around equinoctial sunset on the vertical line of the entrance kerbstone (Brennan 1983: 104).

Figure 6. The double spiral motif on the chamber stone C2 inside Newgrange (O’Kelly, 1982). The engraved motif leaves in relief a wound ‘double-spiral’, which is coloured in blue, green, yellow and red to mark the supposed winter, spring, summer and autumn seasons, respectively. The corresponding numbering of the months from the summer solstice (yellow arrow) to the winter solstice in the centre and back to the summer solstice (green arrow) is indicated with numbers (January=1). The month is supposed to be counted each time the spiral arc matches the orientation of the crescent shape of the ‘dominant’ half-moon as seen rising on the east horizon and represented schematically in the upper-right corner of the image.

A more elaborated spiral pattern is located in the chamber of Newgrange on stone C2 just to the left of the simple 13-loop spiral. As shown in Figure 6, the engraving of two intertwined spirals leaves in relief a continuous path that is like a rope wound from its middle, producing a ‘double-spiral’ with each extremity tracing a distinct path towards the centre. The symbolic importance of this motif is reflected by the presence of five such spirals on the entrance kerbstone K1. The motif is similar to the returning spiral on the K15 stone in Knowth (Figure 5), except that the inward and outward spiralling paths are now distinct. The previous calendrical features are present with the winter solstice being again supposed to be at the centre of the spiral and the summer solstice at its border. The motif enables an endless succession of years with the entry and exit points next to each other, but, by doing so, the number of loops is no more integer. A different way of counting months is needed to have them totalising an integer number. An interesting possibility when following the spiral path with the finger is to count a month each time the orientation of the traced arc matches the crescent of the ‘dominant’ half-moon, which is the waxing, D-shaped moon in the winter-spring semester and the waning, C-shaped moon in the summer-autumn (see Methods).
this with the slightly inclined orientation – at such a northern latitude – of this ‘dominant’ moon shape as seen rising on the east horizon results in a count of 12 months in a year. Compared to the previous spirals suggesting 13 months, twelve has the advantage to be even and divisible into four seasons of three months. We note however that this new design still ignores the equinoxes. The five filled lozenges of the chessboard pattern at the top of the spiral could possibly represent the missing days to complete a year of 12 x 30 days, while with the addition of the six empty lozenges, they could represent the 11 days missing for 12 synodic months of more accurately 29.5 days, which totalise only 254 days.

**Figure 7.** The delicate S-shaped double spiral on kerbstone K13 at Knowth. The central motif uses the same colours as in Figure 6 to indicate the proposed seasons and is based on the exact shape of the engraved pattern as derived via 3-dimensional capture and shown in the upper-left corner (Corns et al., 2015, www.3dicons.ie). Here again, the suggested count of months corresponds to the orientation of the rising half moon visible on the east horizon and starts with the winter solstice (January=1). The lower-right image shows that the same motif forms a part of the beautiful triple-spiral in the central recess of Newgrange (O’Kelly, 1982).

An even more elaborated spiral pattern is located on kerbstone K13 at Knowth (Figure 7). The central autumn-winter part of the previous ‘double-spiral’ is kept, but the outer spring-summer part is wrapped around another centre. A total of 12 months is obtained when counting them, as before, each time the bend of the spiral corresponds to the orientation of the ‘dominant’ half-moon as seen when it is rising on the east horizon. The unique feature of this delicately chiselled motif would thus be to separate the year into a light spring-summer semester and a dark autumn-winter with a transition at the equinoxes. The two distinct centres at the solstices and the change of bend through a straight line at the equinoxes is perfectly matching the observations of the shadow of a gnomon over the year (see Figure 2). It suggests that this observation has led to a rethinking of the calendrical representation, which has to incorporate the important transition occurring at the equinoxes. That this motif is engraved at Knowth is in accordance with the roughly equinoctial alignment of the passageways of this mound.

**Discussion**

**Are the motifs only decorative?** The megalithic art in Ireland is apparently non-figurative (O’Sullivan, 1986). With possibly some rare exceptions (Doyle, 2016), there are no representations of humans, animals or plants. The art being abstract, one could pretend that it is purely decorative. We object this view because an ornamental motif is a repetitive pattern like on carpets, tapestries, or mosaics. While there is a recurrence of typical symbols, such as triangles, lozenges, arcs, concentric circles, chevrons and wavy lines, there is no single pair of decorated stone that has the same disposition of these motifs. They rather look like the pages of a drawing book: each one is a distinct composition. Furthermore, the location of the two richly decorated kerbstones K52 and K67 opposite and very far from the entrance stone K1 at Newgrange is incompatible with them being ornamental. Actually, their location is aligned with the direction of sunrise and sunset at the summer solstice (Brennan 1983: 192), strengthening the case that their design should be related to celestial observations. The five spirals described here are all unique symbols of increasing complexity, making them unlikely to be purely decorative. In this respect, it is worth citing Brennan (1983: 128) “The enormous investment in time and energy suggests the engravings were too important for the community to have been mere artists’ doodles.”

**How were these spirals interpreted so far?** Earlier attempts to relate the engraved symbols with astronomical cycles did not identify spirals as the most likely shape to represent them. Brennan (1983: 188) correctly noted that the sun traces a clockwise spiral with daily loops increasing in size from the winter to the summer solstice on the southern horizon and concluded that clockwise spirals are representations of the sun. He also noted a link between the gnomon pattern (see Figure 2) and an S-shaped spiral, but this relation was deduced from the work of an American artist, Charles Ross, who used a magnifying glass to focus the sun rays every day over a year to burn curves on wooden planks subsequently assembled to form a double spiral (Brennan, 1983: 190). He did not push the argument further to recognise that S-shaped spirals could be calendrical representations. Thomas (1988) identifies an S-shape spiral as a symbol of the equinox linking the winter sun (a clockwise spiral) to the summer sun (an anti-clockwise spiral), but without justifying this interpretation. He does not mention the link with the gnomon pattern when discussing the double S-shaped spiral of Knowth on kerbstone K13, but has apparently the right intuition when stating: “It is possible the left and right spirals may represent the summer and winter solstice, the centre pair of joined spirals the equinox events.” (Thomas 1988: 41).

**How representative are the five cases?** We considered all elaborated spiral motifs to be found either inside or outside the mounds of Newgrange and Knowth and present five spirals among them. There are many more engraved spirals in Knowth, but usually there have a much simpler design
and therefore are not suited for the kind of detailed individual analysis presented here. A statistical study on the number of clockwise or anti-clockwise rotations could possibly identify some preferred pattern, put the conclusions that can be drawn from this are likely rather limited. There are also some other complex spiral motifs that are not discussed. Most notably the famous triple-lobe spiral delicately engraved in the central recess of the chamber of Newgrange on stone C10 (e.g. O’Kelly, 1982; Stout & Stout, 2008: 40). Very interestingly, however, two of the lobes have precisely the same pattern as the S-shaped double-spiral of Knowth (Figure 7). The only difference is that the motif is picked in relief like the ‘double-spiral’ on stone C2 (Figure 6) and is connected to a third spiral on the left. The implications of this finding and the discussion of this beautiful sign, which could have had a symbolic power (Stout & Stout, 2008), is beyond the scope of this article. Other omissions are the five ‘double-spirals’ magnificently engraved on the entrance stone K1 of Newgrange. We note, however, that the group of three spirals on its left side appears to be a stylistic version of the three-lobe spiral hidden to the view on stone C10, possibly with the intention to refer to it without exposing its exact pattern to the view of everybody. The similarity of the two designs actually lead to a confusion (Brennan 1983: 194). The two other double-spirals on kerbstone K1 and the pair on kerbstone K52 located on the other side of the mound could then also just be suggestive representations of the more genuine patterns discussed here. Their appearance in adjacent pairs is notably reminiscent of the gnomon pattern like on other stones displayed in Figure 3. We consider therefore that these spirals do not constitute valid counter-examples to the presented evidence. We note, finally, that the spirals on the ‘calendar stone’ K52 at Knowth and on the adjacent stone K51 are actually also ‘double-spirals’ and according to the count of months proposed in Figures 6 and 7 would represent a six-month semester.

Conclusion

We followed a rigorous methodology and found a beam of indices that some of the most carefully designed spirals could be calendrical representations. Each of the five different spiral patterns satisfy many of the expected characteristics. The sum of the evidences gives us confidence in the interpretation, which is sometimes corroborated by the location of the stone or by related adjacent motifs. The coherent picture that emerges suggests that an intellectual elite of the Neolithic community of the Boyne Valley developed skills to observe astronomical cycles and to represent them in spiral motifs. The intention was likely to encapsulate the knowledge of the cosmos in powerful symbols. The increased complexity of the design seems to follow the wish to include more observables and thus to have a more complete description of the celestial manifestations. This full process – from careful observations to imagining specific designs and engraving them for preservation – can be qualified as a real scientific methodology.

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