'Shakespeare' identified as π:
the number and principle which squares the circle

N D van Egmond

Utrecht University

Abstract

On the front pages of the Shakespeare First Folio of collected works (1623), 'Shakespeare' is identified as the unnatural and transcendental number π (pi), which links the diameter of a circle to its periphery. In the enigmatic poem 'To the Reader', Ben Jonson's tells the reader that the 'figure' of 'Shakespeare' on the opposite page rather represents a number than a person and that this number is π. The many mutually confirming references to the number π, the square and the circle are made on three levels in the poem as well as in the associated Droeshout engraving on the opposite page. The front page of the First Folio positions the Rosicrucian 'squaring the circle' principle as the main theme of 'Shakespeare's' work. It directly refers to Da Vinci's Vitruvian man, which fits as well in the material / physical world (square) as in the spiritual (circle). 'Shakespeare' as the metaphoric (number) π, is the principle which unites and reconciles both. This principle calls for maintaining balance in the (circular) pattern of the human value orientation, thus maintaining human dignity and sustaining civilization.

Introduction

In a study into the more fundamental aspects of sustainability, 'sustainable development' was associated with value orientations (van Egmond and de Vries 2011). This brought about a circular pattern of mutual coherent, but opposing value orientations. Sustainability only can be achieved as long as a dynamic equilibrium can be maintained in between the fundamental opposites of mind and matter and of the I and the others (Van Egmond; *Sustainable Civilization*, 2014)[1]. In a subsequent search for a better understanding of these value orientations, and in particular its tendency to become one sided, van Casteren[2] suggested the allegoric literature of the northern European Renaissance to be relevant, as it dates back to the period just before the one sided descent into the euphoric period of materialization and industrialization. Her suggestion referred to the Transformation of Allegory in which Clifford[3] states that in allegory 'the energy expended in discovering meaning was justified, because it could lead to an awareness of values worthy of pursuit'.

Against this background, van Casteren studied the works of Shakespeare[4], in which she found many references to the circular pattern of value orientations. For example in the last scene of the Tempest, (almost) all characters enter the circle which the magician Prospero (prosper O) has drawn on the stage, representing the reconciliation of the fundamental opposites. In many of his works, Shakespeare refers to this circular pattern as 'O', for example in 'an O without a figure' (King Lear). The objective of the present paper is to explore further confirmations about the position of the circular value pattern in Shakespeare's worldview.

Squaring the Circle

In the Rosicrucian Enlightenment[5], Frances Yates describes how the northern European Renaissance emerged from its Hermetic and Neo-Platonic roots and in particular was characterized by a revival of the work of the fist century Roman architect Vitruvius (85 – 20 BC). Yates points to the influence of Vitruvius work on scholars as Leonardo da Vinci (1452-1519) and Palladio (1508-1580) and later on Shakespeare's contemporaries John Dee and Francis Bacon, who played a very significant role in the European Renaissance. In the Art of Memory[6] she more specifically shows the influence of Vitruvius

on the memory systems of Hermetic philosophers like Bruno and Fludd, which at first were directed to the ability to memorize in the ages before printing, but later gradually developed into 'masques' and plays. It demonstrates that architect and philosopher Vitruvius inspired both scholars, play writers and theatre building. Both scholar John Dee and play writer Ben Jonson had annotated copies of Vitruvius in their libraries. According to Jonson,[7] 'poems should be constructed like buildings, according to proportional principles which resemble those in Vitruvian architecture'.

Vitruvius describes how the figure of a man with extended arms and legs fits both into a square and into a circle, saying that Man is simultaneously part of both the physical and the spiritual world, as magnificently drawn by Leonardo da Vinci, later to be shown in Figure 3. It is the metaphor for unifying the physical and spiritual human aspects. In Renaissance, the Vitruvian image of Man within the square and the circle became the favourite expression of the relationship between the physical-material (earth) and the (spiritual) heaven, between microcosm and macrocosm. Maintaining equilibrium between the two would require the square and circle to have the same dimensions. In mathematical terms, this (unsolvable) problem of constructing a circle with the same periphery as the square is described as 'squaring the circle'.

In the words of Palladio, one of the scholars revaluing Vitruvius ideas, 'the most beautiful, and most regular forms, and from which the others receive their measures, are the round and the quadrangular'. Along the same lines, Fludd distinguished 'round art', which was about ideas, the spiritual and the imaginary, and 'square art', about corporeal, physical things. And specific to the work of Ben Jonson, Thomas Greene[8] concludes his 1970-essay by saying that 'the dual image of circle and centre is an organizing principle of all Ben Jonson's work. The circle (suggesting perfection, harmony, equilibrium in cosmos, society, household, soul) is doubled by the centre (suggesting governor, king, house, inner self). Both images are represented as achieved ideals in the masques; in most of Jonson's other works, the circle appears to be broken, and the centre, if there is one, is associated with solitary and upright independence'. Elsewhere in his essay, Greene writes:

> 'Most of the works in Jonson's large canon-including the tragedies and comedies, verse and prose can be categorized broadly in their relation to an implicit or explicit centre. That is to say, one can describe an image or character or situation as durable, as centre-oriented and centripetal (I shall use these terms as more or less synonymous) or one can describe them as moving free, as disoriented and centrifugal, in quest of transformation. To sketch these categories is to seem to suggest absolute poles, ethically positive and negative' (end quote).

This quote strongly resonates with the above described dynamics in societal value orientations, as deduced from nowadays social surveys. There even is a direct association between 'durable' (sustainable) and the orientation on the centre, with a positive ethical annotation. Greene associates the positive to 'masques' and comedies and the negative to 'anti-masques' and tragedies:

> 'The great storehouse of Jonson's centripetal images is the series of masques which assert, almost by definition, the existence of an order. The succession of anti-masque to masque, of crudity and disorder to beauty and order, demonstrates over and over the basic harmony of the cosmos and the realm'.

It represents an Aristotelian ethics, with the centre as the Aristotelian mean, corresponding to the navel as the centre of an inscribed square and circle in Vitruvian man.

Given the strong relation between philosophy and architecture in Vitruvian thought, this pattern became also dominant in theatre building. In Theatre of the World[9] and the Art of Memory, Frances Yates describes how the theatres of the time, like the Globe theatre on the south bank of the Thames, from which the Lord Chamberlain's Men', later renamed as 'the King's Men' operated, and the Fortune theatres at Cripplegate on the north bank were based on the Vitruvian philosophy and architecture. In discussing Fludd's memory theatre and the Globe theatre, she states that the fundamental geometry of square and circle was evidently the preoccupation of the designers of both theatres, which were built with much the same specifications, be it that the Fortune had a square, and the Globe had a circular ground plan. It has been suggested that the circumferences of square and circle were identical, but no confirmation could be found for this.

The Preface of the First Folio

'Squaring the Circle' is the central Vitruvian metaphor, running through northern European Renaissance, with parallel manifestations in philosophy, (renewed Aristotelian) ethics, poetry, plays and architecture, certainly also theatre architecture. In search for the significance of this metaphor as eventual underlying worldview of Shakespeare, many of these parallels lead to the Preface of the First Folio of 1623, in which Shakespeare's collected works were published for the first time, seven years after his death in 1616. This publication has been an enormous task and in case the editors would have had reasons to comment on the general notions, underlying the completed works, they are expected to do so in this Preface. The preface contains two poems of Ben Jonson, one on the front page of the Folio called 'To the Reader' and a second one called 'To the memory of my beloved, the Author mr. William Shakespeare; And what he hath left us'. Given its enigmatic character, attention is focussed on the poem 'To the Reader' and on the associated engraving by Droeshout on the opposing page; apparently showing 'Shakespeare' (Figure 1).
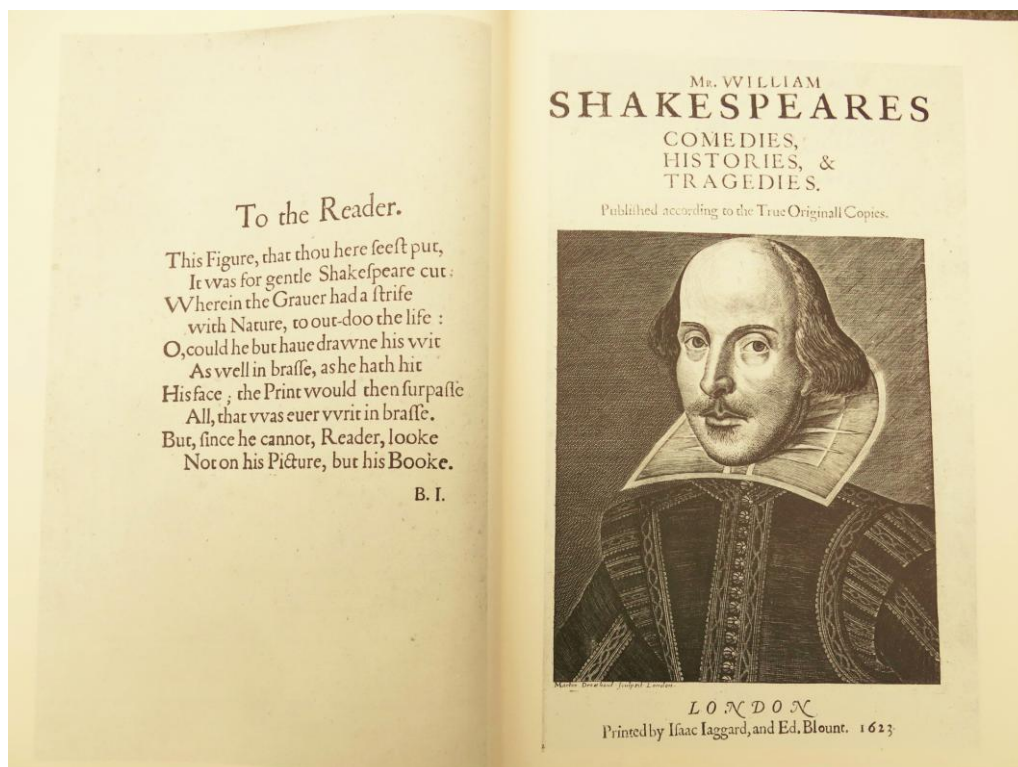

Figure 1 First pages of the First Folio (1623) with Ben Jonson's poem and Droeshout's engraving.

Through the ages there have been speculations that Shakespeare's work would contain 'hidden messages'[10]. This was motivated by the fact the First Folio was published only in 1623 under the reign of King James I, who rejected the above mentioned paradigms and teachings which had been supported by his predecessor Queen Elizabeth. Followers of such belief were persecuted. A second reason was the known preoccupation of Vitruvianism with numbers, partly related to cabalistic backgrounds. Many refer to the work of Francis Bacon, a contemporary scholar, writer, philosopher, musician, mystic, horticulturist and lawyer, who also published on cryptography and invented the binary cipher system. But also Jonson and many other contemporaries employed the meta-languages of architecture and mathematics, using numerical conceits as structural devices in works of literature. W.A. Johnson (1994) reports that Ben Jonson had excess to Neoplatonic number symbolists, like Ficino, Pico della Mirandola and Macrobius[11].

Against this background, the enigmatic poem 'To the Reader' is examined in search for the 'squaring the circle' theme. The analysis was made on four levels:
1. the enigmatic content of the poem;
2. the associated Droeshout engraving to which the poem refers;
3. the numerical structure of the poem – in particular, how it is shaped by the number of words and the anomalous use of capitals;
4. the hidden meaning of single words, through reverse (and in the first place sound) application of the cryptographic methods of the day.

To be accepted as meaningful, the analysis on these four different levels should result in a mutually confirming, consistent message. As will we see, this indeed turns out to be the case.

1 The enigma of the poem as such

To the Reader

This Figure that thou here seest put,
    It was for gentle Shakespeare cut;
Wherein the Graver had a strive
    with Nature, to out-doo the life;
O, could he but have drawn his wit
    As well in brasse, as he hath hit
His face; the Print would then surpass
    All, that was ever writ in brasse.
But, since he cannot, Reader, looke
    Not on his Picture, but his Booke.

The first line of the poem starts with 'This Figure' apparently referring to the picture (the engraving of 'Shakespeare' on the opposing page). Several authors have noticed that the word 'figure' has the plural meaning of both 'shape of a person', 'symbol representing a number' and 'drawing / picture, expressing something'. Given the use of the word 'figure' instead of 'picture', Dawkins[12], expects that 'the words of the verse therefore can be read as meaning that there is a figure or number to be found in the verse which was 'for gentle Shakespeare cut'. Dawkins states this 'figure' to be the number 'TWO', formed by the first capital letters of the first three non-indented lines. Although this 'TWO' is expected to play a role in the puzzle, it is unlikely that this is 'This Figure', as the figure (number) '2' does not meet the further specifications which are given by the poem:
- in the first place, this figure (number) 'was cut (for gentle Shakespeare)';
- second, 'the graver had a strive with nature'; apparently we are looking for a non-natural number (which cannot be 2, as 2 is a natural number);
- the graver also had a strive 'to out-doo the life' (number), which is understood to mean 'to surpass the original' or making it better than the original; apparently it is hard to reproduce the number to its full extent;
- printing the original number would require more (brass) then ever used for engravings; if the 'wit' of the figure (number) was drawn (engraved) in brasse, the print would surpass all that was ever writ in brasse;
- but 'since he (the engraver) cannot' draw the wit of the figure, the original number is apparently too large to draw.

So we are looking for a non-natural number which, if engraved, would require all the copper (brasse) in the world. For gentle Shakespeare this number was cut (truncated). Even without the above described inclination to the circle motif, there is an obvious answer to this enigma:

The number which meets the specifications given by the poem is the non-natural, transcendental number π, the ratio between the circumference πD of a circle and its diameter D. In terms of the radius R, the circumference is $2 \pi R$. We know that π has an infinite number of digits. To out-doo or

surpass the life (the real π), so much (so many digits) had to be written that this of course would surpass all that was written before and would require infinite amounts of copper. In the last two lines, the author of the poem tells us that this is impossible.

Given the apparent plural meaning of 'figure', 'this Figure that thou here seest put' is both the figure 'Shakespeare', on the opposing page, and the figure (number) π. Shakespeare and the number π are interchangeable. 'For gentle Shakespeare' the infinite number of digits of the number π (= 3.14159265358979.....etc.) is cut to two digits (3.14), given not only the impossibility of writing (or engraving) the real value of π, but also the impossibility of expressing or 'drawing' the 'wit' of Shakespeare. The reference to the number TWO in the first lines suggests that the number π is 'cut' to two digits (3.14).

It might be argued that there are more transcendental numbers which meet the requirements, such as the number e, the base of the natural logarithm. But there is an additional hint; the objective is 'to outdoo the life : O'. As mentioned in the introduction, there are strong indications that in Shakespeare's work, the O represents the circle, so it is the graver's intend 'to out-doo the life O', the real circle, which requires the real π.

But since he (the graver) cannot express the real π or the associated knowledge ('wit') of Shakespeare; the full 'wit' of π had to be cut to two digits, which means that his face had to remain hidden. Thus the 'Reader' is expected not to look *on* (!) the Picture but on 'his Booke', which is expected to represent the square. Johnson[13] refers to a poem of Jonson from 1621, where he praises King James as 'the book of all perfection':

> *Read him as you would doe the booke*
> *Of all perfection, and but looke*
> *What his proportions be;*
> *No measure that is then contrived*
> *Or any motion thence derived,*
> *But is pure harmonie.*

The parallel between the two poems suggest that also in 'To the Reader', Booke has the meaning of perfection. Lacking the ability to depict the spiritual 'wit' of Shakespeare, the reader might find that 'wit' in its allegorical form in the 'Booke'.

2 The Droeshout engraving

This finding raises the question whether the engraving on the opposing page not only shows a person (Shakespeare) but also relates to the number π indeed ?

In his influential study on the First Folio, Greg[14] comments that he engraving 'is not pleasing and has little technical merit'. On the other hand Greg describes with how much care and how much efforts the First Folio has been made. Why then accepting a low quality picture of the author on the front page ? Many other authors have studied and commented the Droeshout engraving and they also were far from complimentary. Well-known comments include descriptions such as 'monstrous' and 'ludicrous' and 'a hard wooden staring thing', while the large forehead gave rise to the presumption of representing a 'horrible hydrocephalous development'. Many authors have remarked on:
-   the long face and the extraordinarily large forehead;
-   the asymmetrical hair poufs; at eye level on the right-hand side of the face and way down under the earlobe on the other side;
-   the thick non-anatomical line from the left ear to the chin, eventually suggesting a mask mounted to the back of somebody's head;
-   the mouth, which floats weirdly to one side, and the asymmetrical lips, centred under the left nostril;

- the (collar and) head which are 'cut' from the body; the 'collar' seems to separate the two in an unnatural way;
- the garment which has two left arms, according to the judgement of tailors;
- the eyes which are drawn as two right eyes, according to medical specialists;
- the unnatural and asymmetrical side seam, on the person's right-hand side, veering toward the centre row of buttons.

The fact that this picture, which is 'of little technical merit', has been placed on the front page, notwithstanding all these 'not pleasing' features, suggests that these unusual features have been introduced on purpose. This assumption is supported by the two left arms, which in Rosicrucian and Masonic symbolism indicate hidden meaning.

To explore eventual references to (the number) π in the engraving, it has to be realized that in the original engraving (Figure 2; right), the 'Figure was cut'. Given the declared identity between the Figure Shakespeare and the number π, this is interpreted in the first place as the separation of collar and head from the body. So as a first step, this separation is undone by relocating collar and head in the proper position onto the body. The result is shown by Figure 2 left.
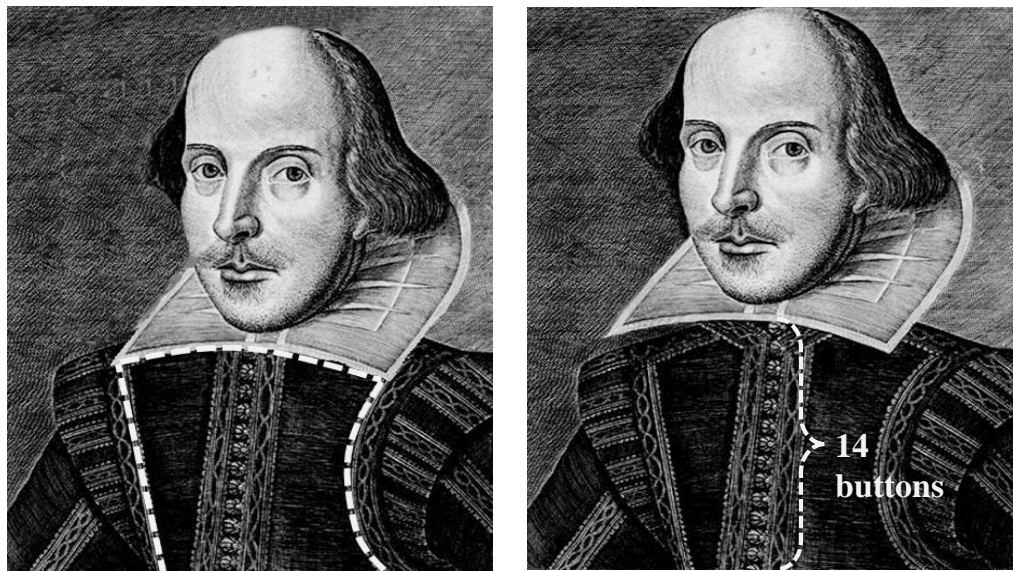

Figure 2. The Droeshout engraving:
the 'Figure' un-cut, with appearing π-symbol; dotted line (left)
the original 'Figure' cut, after which 14 buttons become visible (right).

Together with the front side of the collar, the seams of the garment now forms the (greek) π-symbol (dotted line). The earlier mentioned 'unnatural and asymmetrical side seam, on the person's right-hand side, veering toward the centre row of buttons' contributes to this effect.
As soon as the collar and head are 'cut', as is the case in Figure 2 right, the π-symbol is cut as well. But in this case the number of visible buttons on the garment increases to 14, which certainly hints at the decimal representation of π as 3,14. This suggests that the collar represents a separator (comma) or divide (slash) in a number. Interpreting the strange 'collar' as the separating comma, the 14 buttons indicate the digits beyond / below the comma.

This brings about the question whether the '3' (in 3,14) can be found in the upper half of the picture, above and before the separating collar /comma. Although less subtle and convincing than the poems enigma and its numerical structure which will be discussed later, the extraordinary large forehead

might be intended to denote the figure '3', at the right-hand side of the face, stressed by the hairline and also by the curious thick line from the ear to the chin.

It further is remarkable that the collar shows an inside pattern of the same shape as the collar itself. As the first lines, emanating from the head on both sides, are part of this inside shape, the remaining pattern shows one stripe at the left, and four stripes at the right hand side (of the picture). This then might be a further confirmation of the decimal 14 in 3,14.

Further, the area proportions of the poufs of hair on the left versus the right hand side also show a ratio of '1'to '4'. The haircut of the person ('Shakespeare') in the portrait also seems to confirm the 3,14 reference to the (truncated – cut) number π.

The other above mentioned extraordinary features in the Droeshout engraving eventually might be related to 'the Figure / number π as well. There are many reasonable options for this. But given the lower level of certainty in the absence of mutual confirmation of these findings, these results will not be reported here. In the light of the many other confirmations found, they are less relevant.

The appearing of the π symbol in the garment in case the cut is undone, is the only case in which reference is made to π as the Greek-symbol, rather than its numerical equivalent 3,14 or the reference to 'pi' in the cryptographic analysis, in which 'pi' stand for 'perimeter'. Although for this reason less relevant for the general conclusions, this raises the additional question whether the (Greek) π symbol was already known by those who gave Droeshout instructions for the engraving. This very well might be the case.

The Greek symbol π

According to current knowledge[15] the Greek symbol π was introduced at a later date than the First Folio publication in 1623. It is known that William Jones used the Greek symbol π in 1706, most likely as an abbreviation of the word 'periphery' (of a circle with unit diameter). However, there are also indications that the English mathematician William Oughtred used the symbol π already in 1647. It is known that the circles around (the mathematicians) Bacon and Dee were in contact, among others, with the mathematician François Viète, who before 1600 already introduced many abbreviation symbols in mathematics. The author of the poem may very well have been aware of the (Greek symbol) notation of π, as he must have been part of the most outstanding intellectual frontrunners of his time.

In any case it is very likely that the engraver Droeshout has been commissioned to draw a picture which represents both the figure Shakespeare and the figure (number) π. Inevitably this resulted in a picture with many artificial, extraordinary features. From this perspective Droeshout did a reasonable job.

3 The numerical structure of the poem

Johnson reports that 'Ben Jonson could have gained sufficient knowledge of basic number symbolism to have conceived the numerological conceits by which he structured his masques'. So it might well be that also in the overall numerical structure of the poem a structuring principle can be found with references to (the number) π .

Johnson describes how, more in general and in line with Palladian theory, Jonson positioned words like soul, mind, wit or muse in the centre of his poems[16]. Also in the present poem, the word 'wit' appears at its centre. Including the title 'To the Reader' there are 35 words before and 35 word after the word 'wit'. Also from the perspective of content, the word 'wit' is the core of the poem. Apparently, Jonson indeed is constructing this poem as a building, and this strongly hints at an underlying, structured pattern.

Given these expectations, the poem is further analysed to find eventual confirmation of the reference to the number π , and thus the circle, and to look for expected references to the 'square' as well.

The analysis starts from the many anomalies, deviations from the expected, in the overall structure of the poem in terms of lines and words. The anomalies of the poem are shown in Table 1:
-   the most obvious feature is its overall structure of 5 indented and 5 non-indented lines;

- a second feature is the writing of 8 words starting with a capital letter where one would not be expected: Reader, Figure, Graver, Nature, Print, Reader, Picture and Book. In contrast to this unusual use of capitals, and surprisingly, the fourth line starts with a lower case: 'with Nature'. Taking into account the very careful production process of the First Folio, including proof reading, it is virtually certain that these anomalies are deliberately introduced, not being the result of random writing errors.

line									number of words			anomalous words in upper case		
	To	the	Reader								3	1		
1	This	Figure,	that	thou	here	seest	put,		7	22	7	1	3	
2		It	was	for	gentle	Shakespeare	cut;			6	6			
3	Wherein	the	Graver	had	a	strife			6		6	1		
4		with	Nature,	to	out-doo	the	life:			6	6	1	1	
5	O,	could	he	but	have	drawne	his	wit	8	22	8			
6		As	well	in	brasse,	as	he	hath	hit	8	8	7		
7	His	face ;	the	Print	would	then	surpasse		7	7	7	1		
8		All,	that	was	ever	writ	in	brasse.		7	7	7		
9	But	since	he	cannot,	Reader,	looke			6	6	6	1	4	
10		Not	on	his	Picture,	but	his	Booke		7	7	2		
									34 x 34		71			

Table 1   Numerical analysis on word-level of the poem 'To the Reader'.

The square .....

The most outspoken feature results from the 2 x 5 indented and non-indented lines. Both groups of five lines each contain 34 words, as shown in Table 1. These 2 x 34 words for the two groups of 5 lines suggest a 34 x 34 square with its equal sides and a perimeter of 4 x 34. So, the square is formed by the 5 indented and 5 non-indented lines.
Johnson extensively reports the number 34 to be a special number in the works of Ben Jonson. The number appears many times in his masques and plays, although it remains rather unclear why this number was special to him.

However, there is an explanation which links the number 34 to the 'squaring the circle' theme:
As indicated above, the unification of the material-physical and the spiritual has been interpreted throughout history as the unification of the square and the circle. This is achieved by equating the perimeter of the square to the circumference of the circle, requiring 4 x d (side of the square) to equal $2 \pi R$ (with R the radius of the circle). This question resonates an old mathematical problem addressed by ancient geometers, meanwhile proving unsolvable because of the transcendental nature of the number π, which cannot geometrically be constructed, as well as its irrational nature, because it cannot be expressed as the ratio between two integers.

....and the circle

The 'squaring the circle' principle requires the perimeter of the square to be equal to the circumference of the circle. From simple calculus, it follows that the circle with a circumference equal to the perimeter of a 34 x 34 square (4 x 34) has a radius of (almost) 22. In other words, the circle with a radius of 22 has a circumference of $2 \pi 22 = 4 \times 34$, the perimeter of the square, as indicated in Figure 3.
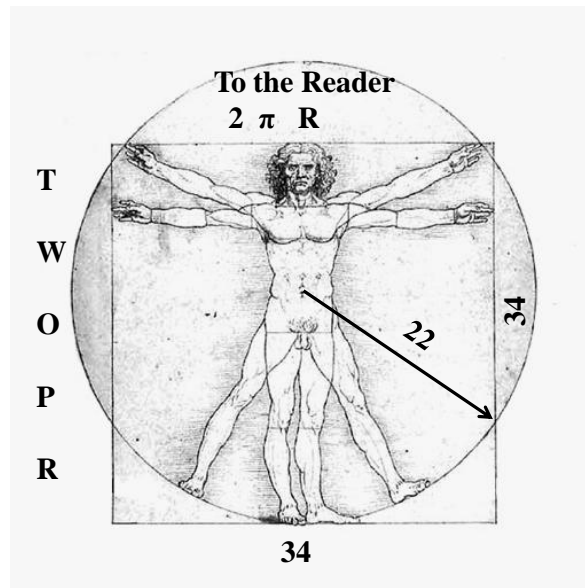
Figure 3 Derived 'squaring the circle' features superimposed on Da Vinci's Vitruvian man

But the number 22 immediately evokes the association with 22/7, the well-known approximation of the number π by Archimedes. Up to the present day the ratio 22/7 is used as an acceptable approximation of π. From the annotations in the books in his library, it is concluded that Jonson was familiar with the works of Archimedes. It is likely that the special meaning of the number 34 to Jonson, relates to the 'squaring the circle' radius 22, which in turn is associated to π via Archimedes' approximation of 22/7. Following the same reasoning the question remains whether within the same 'square', a reference to '7' can be found.

This indeed is the case. Within the 'square' of the 2 x 5 lines, 7 words start with a capital letter without any grammatical reason to do so (thus called anomaly), as indicated above and shown in Table 1. Thus, the poem represents both the 2 x 34 word square and the corresponding (squaring of the) circle with a radius of 22, in combination with the 7 deliberately capitalized words referring to the number $\pi = 22/7$, and thus the circle.

The likelihood that these findings are due to chance is already very small, and there intentional use is further confirmed by additional significant features in the overall structure of the poem.

Additional remarkable features

As shown in Table 1, the overall number of words is 71; the 10 lines consist of 68 words and the title of 3 words. The above mentioned anomalous writing of 'with Nature' (without the expected capital letter) at the beginning of the fourth line is interpreted as a separation mark, dividing the first six lines into two groups.

Now the title and first three lines contain 22 words and so does the second block of three lines, as shown in Table 1. The seventh and eighth line each contain 7 words. The author of the poem appears to deliberately hint at the fraction 22/7.

The two last lines contain 6 and 7 words, respectively, where 2 x 7 words were expected as further confirmation of the 22/7 fraction in reference to π. Although without further meaning in relation to the analysis here (conducted as systematically as possible), it is remarkable that this missing word occurs in the 9th line starting with 'But'. Together with 'O' as the first word of the 5th sentence, it brings about the association with the exclamation of Sebastian in the Tempest 'O, but one word', suggesting a special meaning of the 6 instead of 7 words in the 9th line. Knowing that the O in Shakespeare's work, in many cases, refers to the circle motif (see van Casteren 2014), this could be also interpreted as there being 'but one word' missing to complete the O, the circle. Including the missing word, the numerical structure thus shows 2 blocks of 22 words and 4 blocks of 7 words (minus 1).

Starting from the same division into the groups of 22 and 7 words, thus including the title, the 8 anomalously capitalized words in the poem then can be divided into 3, 1 and 4 words, as shown in the last column of Table 1. Herein the separation in the first group of 4 words is indicated by the anomalous writing of 'with Nature' with a not expected lower case w'. This then expresses the digital representation of π as 3.14, complementary to Archimedes' approximation by the fraction 22/7.

It is concluded that on the level of the overall (word) structure of the poem there are many references to the numbers 22 and 7, immediately suggesting a link with Archimedes 22/7 approximation of π. Even if these 'additional remarkable features' are seen as 'not convincing', the numerical structure states beyond doubt that the square and the circle are the structuring principles of Ben Jonson's poem; it indeed appears to be constructed like a building.

Preliminary conclusion

It is extremely likely that Ben Jonson's introductory poem 'To the Reader' on the front page of the 1623 First Folio of Shakespeare's works, refers to the unnatural and transcendental number π (3.14 or 22/7), the ratio between the diameter and the circumference of the circle. The figure of Shakespeare is equated to this figure (number) π . The poem is constructed as the synthesis of a square and a circle with the same perimeter / circumference. Jonson herewith indicates the Rosicrucian 'squaring the circle' theme, to be the central theme of Shakespeare's works.

These mutually confirming findings are considered to be very robust. Nevertheless the poem, and the associated engraving contain more confirming information. Although this type of information might be considered as less convincing from nowadays point of view, it in any case further strengthens the high level of certainty which is already reached so far. It adds up to the plausibility of the hypothesis.

4 Cryptography

Nowadays scientists generally have an aversion against 'hidden meanings' and 'cryptography'. This can be understood from the poor scientific quality of cryptographic analysis over the last centuries. Studying the existing research on cryptographic systems used in Shakespeare studies, William and Elizabeth Friedman[17] concluded that such analyses only make sense if the deduced rules are applied rigorously and with 100 % consistency throughout the texts studied. A certain rule, once applied, should be used either everywhere throughout the text or nowhere. A system of 'pick and choose' may yield unreliable results. As an additional requirement, the results from such a rigid analysis should be meaningful and convey a consistent message.

Under these strict scientific conditions, cryptography could be relevant given the unambiguous fact that the encoding of messages was the practice of the day. Universal scientists like Francis Bacon and John Dee were counsellors to Queen Elizabeth and while travelling over Europe, they sent encoded messages to the queen about the foreign political and military situation ('for your eyes only'). After the death of Queen Elizabeth in 1603, the regime under King James was gradually shifting away from the earlier Rosicrucian paradigms and the now heretic teachings were 'encoded' into plays and poems. Centuries earlier the builders of the cathedrals had done the same to escape the stake.

In 'the Advancement of Learning' (1605) and later in the 'Augmentis Scientiarum' (1624) Francis Bacon describes the cryptographic systems that were in use at that time. The three most important ones being simple cipher, reverse cipher and Kaye cipher. However, so far, computer-aided analysis of the text has not revealed any use of the Kaye cipher system, which, therefore, will not be discussed here. In simple cipher, the letters of the alphabet are numbered from a=1 to z=24, as in those times, the (phonetically different) letters i and j were written both as i, while u was written as v. This means that z ends up with the number 24 instead of 26. It should be noted that Bacon refers several times to this 24 letter alphabet.

These systems convert the sequence of letters into a sequence of numbers. By imposing a certain shift onto these sequences, other number sequences are obtained. In this way, hidden information can be added to an original text. This is called Caesar cipher after Roman emperor Julius Caesar, who invented or already used this system.

Again, the Friedmans' warning is repeated that such an analysis only makes sense when the rules are applied with 100% consistency; that is to say, everywhere or nowhere. A second requirement is that the results obtained through such a rigid analysis produce a meaningful outcome only.

To the Reader

Given the fact, later to be discussed, that the first three non-indented lines start with the letters T W O, it is remarkable that the title 'To the Reader' starts with the phonetically identical 'to' as well, suggesting a special meaning. Interpreting this as an instruction, simple Caesar cipher is applied in which 'to' is interpreted as a required shift of two numbers/letters in the following word 'the'. In 'the', letter t has the simple cipher value of 19, h=8 and e=5 (taking into account that i=j and u=v). The prescribed shift + 2 then results in the fraction 22/7:

To		t	h	e		Reader
		19	8	5		
+2		21	10	7		
		2 2		7		
2		π				R

In this interpretation the separator between nominator 22 and denominator 7 is the '0' in between: 22 over 7. This means that 'the' stands for the number π. In 'Reader', the anomalous capital R, stands for R; meaning that the title 'To the Reader' thus translates into 2 π R. This fully confirms the whole poem to be about the (metaphor of) the circle. It now also becomes clear why the first line starts with 'This Figure' where 'The Figure' would have been expected. 'This' suggests that the figure has already been mentioned earlier in the text. As the (hidden) title appears to be 2 π R this is indeed the case; this figure (the number π) is already mentioned in the title.

This Figure that thou here seest put, It was for gentle Shakespeare cut;

Consistent and 100% consequent application of the simple cipher shift rule, as used in understanding the title, requires that the word 'for' has be interpreted as 'four'. This meansa shift of +4 letters in the following word 'gentle'. This gives the following result:

for		g	e	n	t	l	e
		7	5	13	19	11	5
+ 4		11	9	17	23	15	9
		l	i	r	y	p	i

The last four letters now show the expression *liry pi*, making an explicit reference to 'pi'. Interpreting 'liry' fonetically as 'leery', which has to be understood as 'knowing', the text suggests 'for knowing pi as Shakespeare'.

Wherein the Graver had a strive
with Nature, to out-doo the life;

Consistent application of the shift rule requires '*to*' to be interpreted as 'two', implying a shift of 2 letter positions, which gives the following result:

to		o	u	t	.	d	o	o
		14	20	19		4	14	14
+ 2		16	22	21		6	16	16
		q	x	w		f	q	q

The (strange) 7-digit word 'out-doo' now reads as 'qxw-fqq' which is about q and q-square. This 'out-doo' thus suggests a link to the square. The qq square can only be obtained by deliberately using the rather strange word 'outdoo', with two o's.

> **O**, could he but have drawn his wit
> As well in brasse, as he hath hit
> His face; the **P**rint would then surpass
> All, that was ever writ in brasse
> But, since he cannot, **R**eader, looke
> Not on his Picture, but his Booke.

Finally, application of the cipher-shift rule as consequently as possible should require a +2-shift for the word or letter following the vertical word 'TWO' formed by the three first capital letters of the non-indented lines 1, 3and 5. The first capital letters of the remaining two non-indented lines 7 and 9 are H and B. In the same lines the two anomalies with notable capitalizations are P (Print) and R (Reader) appear. Consequent application of the instruction TWO would mean that the +2 shift in capitals has to be understood as shifting to the second next capitals thus P and R, which then results in TWO P R = 2 π R.

The result is the message '2 π R' in both the horizontal (the title 'To the Reader' = 2 π R) and in the vertical direction (TWO PR). This exactly confirms the ('architectonic') construction of the square, with equal sides 34 x 34 words, or both equal to 2 π R, as depicted in Figure 3.

This mutual confirmations supports the (Baconian) cryptographic interpretation applied here, based on shifting within the simple cipher system (a=1, z=24) according to 'instructions' given in the text. The results of consequent application of this rule elsewhere in the text do result in further hints to 'pi' and the (qq) square, but are not as convincing as the findings on the numerical structure of the poem at a higher level.

Conclusion

Based on the following, summarized observations and considerations, it is concluded with a high level of confidence that on the front page of the 1623 First Folio of Shakespeare's works, 'Shakespeare' is declared to be identical with the unnatural, transcendental number π, the ratio between the circumference of a circle and its diameter:

- Ben Jonson, the author of the poem 'To the Reader', and many other contemporaries employed the meta-languages of architecture and mathematics, using numerical conceits as structural devices in works of literature. The poem indeed is constructed like a building. This was literally inspired by Vitruvianism of which the 'squaring of the circle' was the philosophical core;

- the unambiguous answer to the enigma posed in the poem 'To the Reader' is the number π. Not only the figure 'Shakespeare', but also the figure (number) π is 'this Figure that thou here seest put';

- the Droeshout engraving indeed shows both the figure 'Shakespeare' and the figure π (= 3,14). Both the figure 'Shakespeare' and the figure π are 'cut'. If the cut is undone, both figures, Shakespeare and π, regain their original shape.

- the numerical structure of the poem reveals a square (of 34 x 34 words). The corresponding circle with the same circumference has a radius of 22. Given the 7 anomalous capital letters within the square, the numerical structure points at Archimedes approximation of π as 22/7. The structure many times more refers to the number π, both as 3,14 and 22/7;

- corresponding to the practice of the day and with a strict and 100 % consequent application of cryptographic rules which were described by Francis Bacon and other contemporaries of Ben Jonson (without 'pick and choose'), the poem also on the level of single words reveals references to the number π and to the square. The cryptographic analysis is just an additional confirmation of the already robust conclusions which were based on the poem's enigma as such and on its numerical structure;

- the title 'To the Reader' translates into $2 \pi R$, which, as the horizontal side of the identified square, corresponds to the TWO PR of the (equal) vertical side;

This message is told with surprising redundancy on all the four levels which were analysed. It consequently allows conclusions with a high level of certainty, even when a part of the above deductions and interpretations is judged as too speculative. Already the first level, with the plain answer to the poem's enigma, and the second level of the Droeshout engraving, support the overall conclusion from the view point of simple mathematics. This answer then is further confirmed by the findings on the other two levels.

It is concluded that in the Preface of the First Folio of 1623, 'Shakespeare' is identified as (the number) π and the Rosicrucian 'squaring the circle' principle is found to be the central theme of the work, published under the name of 'Shakespeare'. The 'squaring the circle' theme and the many references to the circle as a metaphor for the immaterial-spiritual domain and the square for the physical-material domain, is central to this philosophy, in which numbers and ciphers were equated with the divine. It is the unnatural and transcendent number π (in the poem stated to be identical to 'Shakespeare') which links the material world of the square to the spiritual world of the circle. 'Shakespeare' appears to be rather a principle, than a person.

Discussion

In contrast to these virtually certain findings, two more questions remain open for discussion:
- was the pseudonym 'Shakespeare deliberately chosen to incorporate these thoughts';
- what is the meaning of these findings.

Hypothesis; Shakes-pe-are = 2 π R

The original name Shaxper of the existing Stratford actor later has been changed into 'Shakespeare'. In combination with the findings reported here, this suggests the hypothesis that the name was changed to express the relation with π or the metaphoric circle $2 \pi R$, as discussed here. In contrast to Shaksper, Shakes- pe- are is a suited 2-π-R pseudonym, taking into account that π is pronounced as 'pee' in continental languages. In many studies the real author of 'Shakespeare' is said to have been abroad many times.
This would require that the first part 'shakes' can be interpreted as '2'. But for the time being this remains rather uncertain. Some plausibility may be derived from the association to the word 'shack' which stand for a couple (living informally together). According to the Online Etymology Dictionary,[18] it is or may be a dialectical variant of 'shake'.
A few pages further in the First Folio, after the poem 'To the Reader', there is another poem of Ben Jonson. This poem 'To the memory of my beloved, the author, mr. William Shakespeare' starts with the line 'To draw no envy (Shakespeare) on thy name'. It is remarkable that Jonson starts this long poem with this reference to the name 'Shakespeare', as some sort of hint that 'To the Reader' was all about this name.

Against this background, the name 'William Shakespeare' can be understood as Will-I-am 2-π-R ? This is the philosophical question 'will I am the whole (circle) rather than the one-sided (imperfect) part ? Will I be a complete human being, to its full nature ?

Without given the underlying, detailed numerical analysis, it finally should be remarked that the name Shakespeare, although at a far lower level of confidence, also might refer to the square. This can be illustrated by breakdown of S-hakespe-are into S-qu-are, for which numerical arguments can be given.

Meaning and implication

As indicated earlier, times were changing after the succession of Queen Elizabeth by King James in 1603. As Deacon reports in his book on John Dee[19], 'the new century saw the beginning of a reaction away from the enlightened, inquiring liberalism of the neo-Platonists and Renaissance Magia and the mounting of a nation-wide drive against all suspected of witchcraft and magical practices'. Spiritual knowledge could not be brought into the open any more. The Rosicrucian 'chemical wedding', creating consciousness and self-knowledge by the reconciliation of opposites (the square and the circle), had to remain hidden, only to be revealed indirectly, via metaphors and allegories.

In the introduction, Greene was quoted, stating that the process of reconciliation of the polar opposite values is found throughout the works of Ben Jonson. Greene associated the positive, centripetal movements to 'masques' and comedies and the negative, centrifugal movements to 'anti-masques' and tragedies. The findings of the present paper, in particular the fact that (at least) Jonson declared Shakespeare to be identical to the number π and the circle, support Dawkins[20] observation that also in the Shakespeare plays, 'the various characters take one side or the other and either are being brought into a harmony (in the comedies) or are disintegrating in disharmony (in the tragedies)'. This is further confirmed by Van Casteren[21], who found many indications for the circle of value orientations and its centre, with centripetal and centrifugal forces around, as recurring metaphors in Shakespeare's allegories. It represents an Aristotelian ethics, with the centre as the Aristotelian mean, corresponding to the navel as the centre of an inscribed square and circle in Vitruvian man (Figure 3). The good thus is associated with the equilibrium in the centre and 'evil' is nothing but the many forms of one-sidedness that dominate outside the circle. Centrifugal forces tend towards tragedy and catastrophe in the periphery and centripetal forces towards harmony in the centre. This delicate and dynamic balance between these centrifugal and centripetal forces appears as the central metaphor in Shakespeare's allegoric plays. This balance, between the values, worthy of pursuit, is very relevant to the fundamental question of all times, in particular those of the present day: how to sustain civilization (van Egmond 2014).

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