Between geometric schemes and mnemonic images: The three paradigmatic figures of Giordano Bruno's *Articuli adversus mathematicos*

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Abstract
Giordano Bruno's *Articuli adversus mathematicos* (Prague 1588) is an emblematic text for more than one reason: it contains a harsh critique of the astronomical measurement techniques in use at the time, but also a radical attack on the theoretical foundations of geometry itself, proposing a discrete notion of basic geometric objects such as the point, the line, the plane, and solid figures. Moreover, Bruno enriches the text with some important references to the art of memory, not only to make his argument easier to understand, but also to offer concrete mnemotechnical tools to help the reader perceive and remember the geometric constructions he proposes. In this sense, the three archetypal images are a unique attempt to construct graphic schematisations to illustrate and memorise (by means of a technical tool called *sigillus*) the main propositions of Euclidis *Elements*, as well as the particular theoretical approach that Bruno gives to his geometry.

Keywords
geometry, *sigillus,* atom, monad, Prague

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During the Venetian phase of the trial, Giordano Bruno reported that he arrived in Prague in the spring of 1588 and stayed there for about six months.[1] From the point of view of his intellectual production, this was a very fruitful period. He printed texts such as those on Llull's art, the Frankfurt poems and the last of the mnemonic works, as well as the so-called magical works and two texts on dialectical and metaphysical subjects, which were published posthumously.[2]

In Prague, Bruno stayed with the Spanish ambassador Guillén de Haro, Marquis of San Clemente.[3] Bruno is in search of a contact with the emperor, and the goodwill of the Spanish ambassador may be his best opportunity in every respect. Rudolf II of Habsburg was a Spanish Catholic by birth – his mother, Maria of Spain, was the eldest daughter of Charles V – and as such had distinguished himself by his open support of the Jesuit Counter-Reformation initiative in the territories of the Empire, he had therefore antagonised many German princes and nobles, while the Spanish court and the Catholic world in general were less hostile to him.[4] The affinities between the emperor and the representative of the Spanish Crown were not only political: Sanclemente, like Rudolf II, was an ardent admirer of the occult sciences and was interested in alchemy and magic; he was also a great admirer of Llull's method, of which he considered himself a descendant, boasting of his ancient Balearic origins. This political closeness, reinforced by common intellectual interests, was undoubtedly the main factor in Bruno's decision to take up residence with the Spanish ambassador. Thus, in order to win the favour of his powerful host, he published a work on Llull's art, taking up the Wittenberg edition of *De lampade combinatoria* and combining it with *De specierum scrutinio* (a rewrite of *De compendiosa architectura*, Paris 1582), creating a new text that accentuated the combinatory mechanisms of the first two for an even more effective and explosive rhetorical *inventio*.[5] This synthesis of Brunian Lullism is, moreover, consistent with the project of unveiling his own mnemonic-combinatorial dialectics, which he began in Wittenberg with the commentary lectures on Aristotle's *Organon* and which culminated in the elaboration and partial publication of the so-called '*Lampades*' cycle.[6] The obvious theoretical proximity between this Prague text and

1 Cf. Spampanato, *Vita di Giordano Bruno con documenti editi e inediti*, 703; Mercati, *Il sommario del processo di Giordano Bruno*, 105.

2 Cf. Matteoli, *Giordano Bruno a Praga tra lullismo, matematica e filosofia*, 301-324.

3 Cf. Bruno, *Opere lulliane*, 571-573; Brotto, *Haro Guillén*.

4 Cf. Evans, *Rudolf II and His World*; Marshall, *The Theatre of the World: Alchemy, Astrology and Magic in Renaissance Prague*.

5 On the shift in the interpretative register, with regard to Llull's works, between *De compendiosa architectura*, *De lampade combinatoria* and *De specierum scrutinio*, cf. Cambi, *La* machina *del discorso. Lullismo e retorica negli scritti latini di Giordano Bruno*.

6 Cf. Ricci, *Giordano Bruno nell'Europa del Cinquecento*, 398-403; Ciliberto, *Il sapiente furore*, 474-479; Lepri, *Giordano Bruno teacher at Wittenberg and the Rar. 51*.

the previous ones thus shows Bruno's initial desire to continue exposing his philosophy by addressing a readership sensitive to instances of methodological reform, overlapping original philosophical themes with less heterodox dialectical, mnemotechnical and Lulian interests. One of the most curious features of the first Prague publication, apart from its singular revival of Lullism, is the announcement of a subsequent and imminent publishing project, "sub titulo Lampadis Cabalisticae", which can be interpreted as an intention to publish the first version of the *Lampas triginta statuarum*, composed the previous year in Wittenberg. Bruno thus and yet again manifested his ambition to reshape his own philosophy through the evocative representation of a series of thirty visual archetypes, albeit no longer within the mnemotechnical and Lullian framework of *De lampade combinatoria* and *De progressu et lampade venatoria logicorum*.[7] However, this initiative was not immediately successful and instead of the announced work, Bruno printed a geometry text with an explicitly provocative title – *Articuli centum et sexaginta adversus huius tempestatis mathematicos atque philosophos* – which contains an innovative reinterpretation of Euclidean geometry centred on the concept of the geometric minimum, but also some very important theoretical references to his own philosophy and, as we shall see, to the art of memory.

1. Between geometry and the art of memory

The *Articuli adversus mathematicos* is a text devoted mainly, if not exclusively, to Bruno's geometrical reflections, although it directs its readers towards a 'different' geometry based on a notion of the minimal point. The reason for this radical and controversial choice is rooted in a discussion which took place a few years before, in Paris in 1586, between Giordano Bruno and the mathematician Fabrizio Mordente.[8] The Campanian geometrician had invented a proportional compass which made it possible to enlarge very small fractions of circumferences and chords so that they could be measured with respect to each other. In practical terms, this made it possible to carry out astronomical measurements more accurately than with the calculations which involved the approximation of π and the recourse to the sine and cosine tables then in use. In adopting and making his own this technical solution, Bruno, initially at the request of Mordente himself, attempted to establish its validity not only 'mechanically', i.e. by virtue of the technical and practical effectiveness of the instrument, but also theoretically. Bruno's approach, however, was not appreciated by Mordente, who polemically withdrew from the joint project, but allowed Bruno to carry out a mathematical 'revolution' that had radical theoretical consequences,

[7] About *Lampas triginta statuarum* and the two other Lullian texts, cf. Cambi, *La* machina *del discorso*, 159-172.

[8] To reconstruct how this debate unfolded and evolved, cf. Aquilecchia, *Nota introduttiva* to Bruno, *Due dialoghi sconosciuti e due dialoghi noti*, vii-xxiii; Camerota, *Il compasso di Fabrizio Mordente*, 83-105.

especially at the philosophical level. In fact, in Bruno's hypothesis, the discovery and valorisation of minimal fractions – which, in fact, make the curved and the straight almost coincide – testify to the existence of a material background (both physical and geometrical) corpuscular in nature, which is the ultimate and substantial expression of reality and it is made up of atoms and the void.[9]

As can be imagined, such a perspective has a theoretical implication that is more significant on a philosophical level than on a mathematical one. Nevertheless, it is in line with Nolano's philosophical project, which already, in the years of the so called *Cosmological Dialogues* published in England, claimed the primacy of philosophy over mathematics and mathematicians.[10] In the case of the *Articuli adversus mathematicos*, therefore, Bruno's aim is twofold: firstly, to present his atomistic view of geometry as the technical outcome of his 'physics'; secondly, to show, in the concrete practice of geometric constructions – largely taken from the main practical geometry manuals in use at the time and from the various commentaries on Euclid's *Elements* – that geometry, even if at its base there are minimal points, does not change but rather becomes more functional to the needs of astronomical measurements. In order to act as a 'hinge' between these two requirements, and in a way that is quite unprecedented for a geometry text, the art of memory is brought into play through three interventions that are unusual in both the mathematical and mnemotechnical contexts.

The most significant contribution to this is to commit the understanding and memorisation of the proposed geometric constructions, as well as the corpuscular theory behind them, to three archetypal images: these will be examined in detail in the second part of this essay. Furthermore, Bruno suggests two other very important mnemonic devices. The first of these is found at the beginning of the iconographic corpus that accompanies the text, entitled *Figurae subalternae*, precisely to distinguish it from the three main figures that are functional to the entire work. This section is made up of thirty-one images, the first of which has a completely different graphic connotation from the others: it shows a man standing by a well (marked with the letter U) with his back turned and his arms extended. Around this man, in the four corners of the image, the other four vowels are displayed in order to mark: the sphere of the world (A); a kind of map of the earth (E); a square with another square inside it (O) and, lastly, a circumferential quadrant in which some rectangular boxes are outlined. Finally, the picture is surrounded on all four sides by the motto: "asta que venga meior" (Fig. 1).

9 Cf. Matteoli, *Lo sviluppo dell'atomismo geometrico di Giordano Bruno*.

10 Cf., for example, Bruno's judgement on Copernicus in A. Ingegno, *Cosmologia e filosofia nel pensiero di Giordano Bruno*, 26-70; Maspero, *Scienza e copernicanesimo in Bruno: principali orientamenti della critica dal 1950 ad oggi,* 141-162; Granada, *L'interpretazione bruniana di Copernico e la "narratio prima" di Rheticus*, 343-365; De Bernart, *Bruno e i "fondamenti" filosofici della teoria copernicana*, 47-74; Gatti, *Copernico*, 511-520; Bassi, *Il Copernico di Bruno*, 123-137.

Fig. 1. *Articuli adversus mathematicos*, 88.

The nature of the figures, the order in which they are arranged (in relation to the series of five vowels) and what they refer have a significant mnemotechnical value for Bruno: this depiction represents the five levels of distribution of mnemonic material, i.e. the five types of places used to memorise images. In the *De umbris idearum*, the mnemonic place (*locum*) is called 'substratum' (*subiectum*) and is defined as an "artificial extension, that is, a sinus prepared in the fantastic faculty, occupied by the figures of the receptacles [...], distinguished according to different parts, capable of receiving all the realities seen and heard according to their order and of retaining them according to the will of the soul".[11] According to the 'tradition' of the *ars memoriae*, the place consists of the inner visualisation of a delimited space ("extension" and "sinus") that serves to receive the mnemonic images (the "figures of the receptacles"); it can be of variable width, divided into parts and, above all, inserted into other places. This is how Jacques Colin, author of *De memoria artificiosa compendiosum opusculum* (Paris 1515), defines its characteristics:

> Places are therefore of three types: the first are maxima, the second are majors and the last, which will be considered very suitable as words, we will call small. The maxims contain the majors and the minors are contained by the majors. The maxima are all those complete buildings, such as temples, houses or monasteries; the majors are the individual square dwellings; the minors, on the other hand, are the walls, corners and openings of the majors.[12]

[11] Bruno, *De umbris idearum*, 148-149: "subiectum est technica extensio, sive sinus in phantastica facultate ordinatus, ex speciebus receptaculorum consitus, quae ex animae fenestris influxere, diversis distinctum partibus, visa omnia atque audita suo recipiens ordine et ad animae libitum retinens".

[12] Colin, *De memoria artificiosa*, ff. aiii*v*-av*r*: "Locos igitur sunt triplices. Alios maximos: Alios maiores: ceteros vero quoad aptiora invenientur vocabula: parvos appellabimus. Maximi maiores continent: parvi a maioribus continentur. Maximi absoluta quaecumque aedificia. ut templa/domus/coenobia. Maiores dicuntur singulae habitationes quadratae. Parvi vero maiorum parietes et anguli cum ianua".

Smaller places, moreover, according to Peter of Ravenna's *Phoenix* (Venice 1491), should not be too "high, for I wished that men placed as images could touch the places, which I have always found useful".[13] Indeed, as Romberch writes in *Congestorium artificiosae memoriae* (Venice 1520):

> If you place a man of suitable stature on the floor with his arms outstretched, you will measure the entire length upwards and the width from right to left. Nor should the place be made higher than the hand of the person standing on the ground can reach; nor should the stature be greater of an ordinary man.[14]

Finally, in *Ars memoriae* of *De umbris idearum*, this very important distinction is made with even greater precision:

> The first of these substrata is maximally common, and may extend as far as the bosom of the phantasy, which may widen the circle of the horizon according to its own pleasure, but cannot limit it to itself. The second is the common substratum, which consists of the set of identified regions within the cosmos. The third is less common, or, if you like, equivalent to a city. The fourth is the proper substratum, and you can call it equivalent to a house. The fifth is the more proper substratum, which is a portion of space that can be divided into four or five sectors. The last is the most proper substratum and coincides with the substratum called 'atom' [...].[15]

The passage describes the hierarchical scale of mnemonic places, from the largest in absolute terms (the imagination itself) to the smallest (the individual place, and for this reason called 'atomic', i.e. which cannot be subdivided into further places), passing from the celestial vault – it was already customary among the ancients using constellation fig-

[13] Tomai, *Phoenix*, f. [biii]*r*: "loca non sint alta quia volui quod homines pro imaginibus positi loca tangere possint quod utile semper iudicavit".

[14] Romberch, *Congestorium artificiosae memoriae*, f. [Cvi]*r*: "ut si competentis staturae virum expansis lacertis superficiei applicueris recte longitudinem scilicet sursum et latitudinem dextrorsum atque sinistrorsum metieris. Non enim altior erit locus quam in pavimento sistens manu contingere valeat; neque amplior erit statura mediocris viri".

[15] Bruno, *De umbris idearum*, 150-153: "Horum aliud est communissimum, quia tantum valet extendi, quantum phantasiae potest comprehendere sinus, qui positae orbis quantitati quantumlibet addere potest, licet non quantumlibet substrahere. Aliud est commune quod cosmicarum perspectarum partium cumulo constat. Aliud est minus commune, utpote si libet politicum. Aliud est proprium, nempe si placeat oeconomicum. Aliud est magis proprium, tetrathomum videlicet vel pentethomum. Aliud est propriissimum, quod est athomum, athomum inquam non simpliciter, sed inisto genere".

ures as a mnemonic system[16] –, through spaces configured as cities, houses and, finally, rooms (composed of four or five individual places). The scansion of the types of places suggests precisely the mutual inclusion of mnemonic places: several individual places fill a room, several rooms form a house, many houses form a city, and cities and regions are arranged under the vault of heaven, etc. In *Cantus Circaeus*, Bruno also provides a similar scansion, albeit with some differences. The equivalence between the maximally common substratum and the fantastic faculty is avoided, while he introduces the substratum equal to the "space described by geography" and that which "coincides with the boundaries of a given continent". Furthermore, the "most proper substratum" is "one of the many and varied parts and sections of the house", that is, it reunites in a single typology the space and the corners that can be identified within it; finally, it is specified that those places that, in terms of size, comprise the city, the building and the parts of the building (from the "proper" to the "most proper" substratum) are more useful (or easier) for the mnemonic operation.[17] Beyond the specific details, thus Bruno points out that the system of mutual organisation and inclusion of places is centred on the individual place, which is to be considered as the module at the base of internal architectures: it must be "equal in height and width to that of a man with his arms raised and outstretched".[18]

In this image from *Articuli adversus mathematicos*, we can therefore find the main distinctions of place established in these passages: in fact, in the corner marked by the letter A, there is the representation of the celestial sphere which, in the case of *Cantus Circaeus*, corresponds to the substratum of the "very common" genus (defined instead as "common" in *De umbris*), that is, that which is immediately less extensive than the fantasy and which, in any case, takes as its reference the cosmic space as perceived from an 'anthropo-geocentric' point of view. At the second corner (letter E), comes that of geographical extension (a region of the Earth or a continent), while at the third (I) we find the depiction of a circular set of boxes: this type of structure, in Bruno's mnemonics, is often called an "atrium", a term used to indicate either a very large room capable of containing 24 or 30

16 For this aspect, and more broadly for a history of the art of memory, cf. Yates, *The art of memory*, 39-42; Bolzoni, *The Gallery of Memory*, 212-213; Waddington, *Pardise Lost: Memories are Made of This*, 220.

17 Bruno, *Cantus Circaeus*, 672-673: "Subiectum vero [...] vel potest esse communissimum, extentum iuxta latitudinem ambitus universi, vel communius iuxta latitudinem Geographiae, vel commune iuxta latitudinem alicuius continentis, vel proprium iuxta latitudinem politicam, vel proprius iuxta latitudinem domesticam, seu oeconomicam, vel propriissimum iuxta multitudinem atque numerum partium domus, et particularum eiusdem".

18 *Ibid.*, 674-675: "Quoad quantitatem eorum continuam, subiecta propria debent esse non admodum magna, ne quasi visum obtundant et disperdant, nec admodum parva, ne quasi visum fugiant: sed mediocria ad hominis magnitudinem talem, quae sit iuxta altitudinem elevatorum et latitudinem extentorum brachiorum".

individual places,[19] or a system formed by several rooms placed one after the other (thus more like a building).[20] In the fourth corner there is the figure marked with the letter O, which represents a square in which another square is inscribed: this is the representation of a single space in which there are four, five (the corners plus the centre), nine (if we add the halves of the sides) or even thirteen (one at each vertex of the four inner triangles plus the centre) individual places. Finally, in the middle of the picture, and most prominently, there is the individual place, the basis of the mnemotechnical structuring, represented as a man (at a well that specifically characterises the space[21]) with his arms outstretched across the entire width of the figure: this corresponds precisely to the definition of the individual substratum given in the *Cantus Circaeus* and that of traditional mnemonics.

Bruno's invitation to refer to the art of memory, at the beginning of the section devoted to images designed to aid understanding of the geometric constructions of *Articuli adversus mathematicos*, is all the more disorienting when one understands the specific meaning of this image, namely to describe to the reader the types of places and the structuring implicit into them. No doubt Bruno takes it almost for granted that the reader knows what he is talking about when the only didactic reference he adds is a phrase with a sibylline meaning: "asta que meior venga". This expression can be understood, as Mino Gabriele suggests,[22] as a Hispanism ("hasta que venga mejor"), inviting us to 'heuristically' accept this methodological perspective – perhaps also including the concept and the use of *minimum* – until a better one comes along. In another way it can be read as written in Italian vernacular, in the sense that there is no "asta", i.e. unit of measurement, better than this (and again perhaps with a double reference to mnemonics and the *minimum*). In any case, the only way to mnemonically link these pages to the rest of the text is by direct reference to the three archetypal figures: having used them to memorise and understand the basic concepts and constructions of Bruno's geometry, it is now possible to access these other figures and, through them, to continue to understand and memorise Bruno's new geometry through his mnemonic devices.

A second valuable piece of mnemonics occurs in one of the most original sections of the text, namely when Bruno proposes his own technique for identifying the "common measure" to be used for arcs of circumference to commensurate with chords. Following Mordente's technique, Bruno's hypothesis consists in finding very small fractions on the circumference in a number equal to those taken on the radius (which constitutes the 'inner' unit of measure of the circle) and on the chord taken as the main reference, i.e. that

[19] For a technical definition of 'atrium, cf. Bruno, *De imaginum, signorum et idearum compositione*, 552 et seq.

[20] Cf. Bruno, *Explicatio triginta sigillorum*, 140 et seq.

[21] Bruno, *Cantus Circaeus*, 676-678: "In quibus tamen si placeat aliquid collocare: instituere potes aliquod receptaculum cuiusmodi est altare, mensa, solium, ceteraque huiusmodi".

[22] Cf. Bruno, *Corpus iconographicum*, 398.

of the sextant arc of the circumference, which coincides with the radius itself taken six times on it. In this way, the smaller these curved fractions are, the closer they are to the straight ones, reducing the margin of error in their commensuration. According to this Brunian *praxis*, therefore, it is finally possible to "reject that measurement of the circle which has been handed down from the time of Ptolemy to the present day" and to "throw away the tables of sines and chords",[23] "that confused, indistinct and uncertain jumble of arithmetic and tables", since to "carry out all astronomical, geographical and mathematical operations", it is sufficient to "divide the circle geometrically according to a regulated and continuous proportion", that is to say:

> I intend to divide it into twelve regions, or houses, each of which is divided into twelve atriums, which in turn are divided into twelve orders, each of which is divided into twelve rooms, and so on, into twelve sides, twelve spaces, twelve dwellings, twelve inhabitants, twelve faces, twelve members of the body, and twelve articulations of the members. Let us therefore always take parts which are similar in name and nature, and of the same order and analogy, and follow the order of nature which proceeds by division.[24]

The proposed solution divides the circle into parts and subparts of the number twelve, taking as starting point the sextant arc and the chord formed by the radius, itself divided into two, and then, from division to division, up to the paroxysmal number of 12^{11} (743,008,370,688) fractions on the circumference (and on the radius/chord), truly minute and infinitesimal portions of it. However, in order to help the reader understand this progressive and recursive algorithm, Bruno does not resort to mathematical language. Instead, he presents it by means of an 'exercise' in mnemotechnical visualisation, that is to say, by resorting once again to the lexicon of the *ars memoriae* and, more specifically, by suggesting the very distribution of places that has been shown to underlie the image that opens the section on *Figurae subalternae*. Nevertheless, at this stage the structuring of the mnemonic places is even more layered than in the five types previously seen, reaching the even more 'minimal' details of the images defined as 'atomic', such as the features of the face, the limbs and postures they may assume, or the objects they may wear, hold or use. A dense scanning of places, designed precisely to make the

[23] Bruno, *Articuli adversus mathematicos*, 69: "Ut mensuram circuli a temporibus Ptolomaei ad haec usque tempora servatam damnas? Ut sinuum et chordarum tabulas abiicis?"

[24] *Ibid.*, 70: "Ut ad omne astronomicum et geographicum et mathematicum opus circulum regulata et perpetua ratione geometrice dividis, non inquam confusa, indiscreta et indefinita arithmetica et tabularia turba, sed geometrica et continua partium subalternatione? Circulum in 12 intelligo divisum regiones seu domos, harum singulas in atria 12, haec singula in 12 ordines, horum singulos in 12 cubilia, et ita deinceps ad latera 12, spatia 12, sedes 12, sessores 12, facies 12, membra 12, articulos 12".

reader imagine, with the inner eye of fantasy, a deep and articulated fractioning of the circumference, which neither sensitive perception nor reason can grasp in its true extent. An overt and instrumental mnemotechnical solution that, among many possible suggestions, refers very significantly to the first of the thirty "seals" of *Explicatio triginta sigillorum* (London 1583), entitled "the Field", precisely because it defines the characteristics of the mnemonic place, as the "substratum" of the creative and "cultivating" action of the imagination:

> The field is the first seal. It is well to form it from those inner representations whose images are contained in the very wide sinus of the fantastic faculty, precisely for the purpose of bringing to the desired harvest the seeds of all meanings and fantastic images. This, moreover, we want – in order that it may be maximally effective for us – to be divided into parts that are visible, of medium size, neither too much nor too little clear, diverse and differentiated, arranged in order, separated and paced by appropriate intervals, of sufficient width and height to accommodate a man with his arms open and stretched out, provided with additional and movable elements proportional to the number of striking images, and, finally, to be visited and examined many times. Then, if you can divide it skilfully into parts and sub-parts, it will be of immediate and extraordinary advantage to you. Thus the Talmudist, having divided Jerusalem into four sides, east, north, south and west, first of all, in order to multiply the number twelve, distributes in each of them three gates, distinguished according to the names of the twelve patriarchs, and then immediately, in a very precise order, enters twelve quarters, each of which contains twelve dwellings, each of which consists of four floors, all of which are divided into twelve rooms, which in turn are divided into four according to the corners or half of the walls.[25]

[25] Bruno, *Explicatio triginta sigillorum*, 79-80: "Campus est primus sigillus. Hic ex illis speciebus confletur oportet, quarum simulacra in phantasticae facultatis amplissimo sinu ideo continentur, ut iacta intentionum et phantasiabilium universorum semina in exoptatam messem promoveant. Hunc etiam, quo nobis maxime subsit officiosus, in eas distributum esse voluimus partes, quae sensibiles, mediocris dimensionis, non excellentis nec diminutae perspicuitatis, diversae, differentes, ordinatae, congruentibus sepositae seiunctaeque intervallis, ad humanorum brachiorum elevatorum altitudinem et extentorum amplitudinem, adiectivatae animataeve, exquisitarum formarum numero adcommodatae, iterum iterumque lustratae existant. Non vulgari tibi praesto erit emolumento, si affabre ipsum divisionum portionibus distributum concipias. Sic Thalmutista Solymam in quattuor latera orientis, aquilonis, austri et occidentis divisam, primo eiusdem laterum singula ad duodenarium multiplicanda numerum, in tres patriarcharum nominibus insignitas portas subdividit, moxque in atria duodecim, quorum singula domorum duodenarium complectuntur, quarum singulae quattuor constant ordinibus, quorum quique duodecim ad summum referunt cubilia, quae tandem vel quattuor angulos, vel etiam in quattuor mediantibus lateribus intersituata recipiant, certo ingressum facit ordine".

This important paragraph brings together all the traditional rules of mnemonics on place: the reference to the "sinus of the fantastic faculty" as the place par excellence of mnemonic activity; the criteria of size, distance, luminosity taken from classical texts,[26] together with the rule that defines the canon for the particular place ("sufficient [...] to accommodate man with his arms open and stretched out"); finally, the advice/rule to subdivide and structure places on the basis of their breadth, in order to guarantee their mutual inclusion. Considering all that, the affinity between these pages and those of *Articuli adversus mathematicos* is not insignificant: in both texts, the criterion for the division of places is based on the recursive division of the number twelve, taking, in the case of *Explicatio*, the Heavenly Jerusalem described in the Book of Revelation as a symbol and inspiration. Certainly, it is not easy for the reader of Bruno, and even more for a contemporary reader, to imagine such a laborious symbolic and visual connection between the Apocalyptic Jerusalem and a circle with so many tiny fractions of arcs and chords to be commensurated, indeed Bruno's suggestion is precisely that: since the irrational measurements and exhausting calculations of the astronomers have lost the true foundation of measure, perhaps the philosopher's audacious vision of nature – a nature that is an infinitely living and changing organism – can help us to understand the right approach to giving each point of view and each object the right position and the most correct (ontological and not only cosmological) distance.

2. The three archetypal figures and their mnemotechnical use

The three figures, defined by Bruno as *principes*, are placed, from the very opening of the section in which they are presented,[27] in a close relationship with the construction principles of geometry. Since every measurement practice can be traced back to two basic instruments – the square and the compass –, so these figures must to refer back to the primordial forms of all geometric constructions, which are the straight and the curved line. The straight line and the curve, as we have seen, are also the 'problematic' object of any astronomical measurement practices, since it is their commensuration (by the arc, the chord and the radius) that determines the distance of the celestial bodies from the observer. Moreover, these two 'primordial' types of line correspond to the two primary figures of geometry, the triangle – from whose construction the propositions of Euclid's *Elements* start – and the circle: in Bruno's 'atomistic' perspective, they are expressed by the circle-minimum (or point), which for Bruno is the material constituent of the line; additionally, by a form with three tangent minima (among which there is a curvilinear triangular space called the 'term-minimum'); finally, by a circular/hexagonal structure consisting of six minima tangent to a central one, a figure that is the starting point for

[26] Cf. Yates, 1-26.
[27] Cf. Bruno, *Articuli adversus mathematicos*, 19-21.

considering measurement, since in it the minimum radius, the minimum chord and the minimum arc are all formed by two point-minima and thus are equal.[28] These three basic and fundamental forms are therefore embodied and represented in the three archetypal figures (especially and most clearly in the second). It is from them that all geometric figures can be developed, since, in Bruno's view, they are to be considered "as if they were" composed of many minimal particles. This is a crucial aspect of Bruno's geometry, because it marks his theoretical attempt to hold together his atomistic view of nature and a mathematics that, as knowledge and *scientia*, must be philosophically consistent – hence also 'corpuscular' – while still working according to the rules and laws of Euclidean geometry. This is realised, not without strong and significant tensions, through an idea of geometric figures that are precisely constituted by an indefinite and indefinable number of indiscernible points: they are revealed in the very small and numerous fractions of measurements and, in Bruno's opinion, provide a legitimate explanation for the irrationality of certain measurements; finally, through the minimal points, the continuity of lines, surfaces and solids is made real, albeit discretely. Indeed, if we imagine the line to be composed of an infinite series of minimal points, phenomena such as tangency, intersection or the relationship between the diagonal and the side of a square, the height and base of an equilateral triangle and the circumference and diameter of a circle take on a completely different theoretical value. In fact, the point of contact (and/or section) between two minima is defined by Bruno as the 'term' and, in general, it is the geometric 'space' (*vacuum*) between all minima, whether they are minimally packed (and thus three points-minimum tangent to each other), or otherwise arranged. This gives rise to those 'inconsistencies' which, in Euclidean geometry, lead to the impossibility of relating different objects. If we imagine a 'minimal' square composed of four minimal points tangent to each other, we have a 'square' shape whose sides are the two minimal points tangent to each other, but whose diagonal is the two minimal points not touching each other and separated by the space between them; this, therefore, produces a length that is not 'congruent' with that of the side. By increasing this compositional practice to the utmost and understanding it as the geometric 'substratum' of every figure, one can understand the structural and 'philosophical' reason for every geometric form, and therefore it is both pragmatically and theoretically permissible to abandon measurement practices based on the approximation of π in order to adopt the method of ever smaller fractions (tending towards minimal, constitutive and unitary fractions), as Mordente had done with his proportional compasses, unaware of these philosophical and theoretical implications. In brief, to use Bruno's words, if one only understands "that all plane figures are made up of straight triangles", even though one has "clearly perceived the continuity of the plane", but does not have a full understanding of the minimum, or that these figures "are made

[28] Cf. *ibid.*, 21-27.

up of minima", then he cannot really understand "that the straight triangle is made up of the curved triangle [i.e. the 'term'] and the circle [i.e. the point-minimum]".[29] Consequently, when one measures "by dividing to the minimum", he discovers that the *continuum* of geometric figures is "instead divided into heterogeneous parts", which "is at the foundation of reasoning and intending",[30] because the minimum (physical and geometric) "is the primary matter and substance of things, since it really implies the maximum to such an extent that every quantity, whether physical or geometric, is in it, with it, from it, through it, at it, and in relation to it".[31] The latter formulation explicitly takes up the terms that traditionally define the material substratum, because Bruno philosophically considers, "rightly" and "with certainty", that "all quantities and dimensions are understood to be implicated in potency or action in matter, insofar as it is pregnant and insofar as it generates, inasmuch as outside of potency and the act of the unity there is no number".[32] It is therefore, and ultimately, to this principle of unity and oneness that underlies all things (metaphysically as the monad, physically as the atom, and mathematically as the unit and the point) that geometric considerations must be traced, in an unprecedented convergence of atomism ("Democritus and the Epicureans correctly state that the sensible minimum is composed of several physical minimums"[33]) and monism:

> Therefore, not false were the statements of Xenophanes and Parmenides, but too sublime to be perceived by the coarse senses of the Peripatetics: the essence is one, immovable, because in its essence it is principle and principled; just as at the level of substance there is no number but unity; what is not one is nothing; therefore the one is essence, the one is true, and multiplicity remains instead as accident, as vanity, as non-entity. So you will understand when you hear the voice of the monad affirm: I AM WHAT IS. [...] Just as, therefore, apart from the monad there is nothing, and apart from atoms and points there is no quantity, so

[29] *Ibid.*, 23: "Ubi ex triangulis rectilineis omnes planas figuras constitutas intelligas, continuum certe, sed non minimum vel ex minimis percepisti; rectilineum quippe triangulum triangulo curvilineo et circulo compositum indicamus".

[30] *Ibid.*, 23-24: "Tale igitur continuum non mensurando intelligis, et ego tecum esse dico, quale si metiri velis usque ad minimum resolvendo, vel etherogeneis discretum partibus invenies. Ad talia etenim minima natura omnis (quae rationis et intentionis est fundamentum) resolvendo progreditur".

[31] *Ibid.*, 24: "Minimum ergo est prima rerum materia et substantia, quod sane ita implicat maximum, ut ab, in, cum, ex ipso, item per, in, ad ipsum sit omnis tum physica tum geometrica magnitudo".

[32] *Ibid.*: "Bene igitur atque tuto in materia quantitates omnes atque dimensiones implicatae intelliguntur virtualiter aut actualiter, ut est parturiens et ut est pariens, quemadmodum extra virtutem et actum unitatis nullus est numerus".

[33] *Ibid.*: "Minimum sensibile ex pluribus admodum physicis minimis esse compositum bene dicit Democritus et Epicurei".

> apart from the part that is the minimum and its definition there is no measure, no geometer and, consequently, no philosophy.[34]

Having adopted this position, which is radical mainly on a philosophical level, it follows that "for those who admit the existence of the minimum, all things are commensurable, and the concept of continuous necessarily derives from that of discrete; therefore, as has been argued, both number and unit constitute the common notion of all numbers".[35]

Returning to the three archetypal figures, it is therefore important to read them both as 'symbols' representing and showing all this fundamental theoretical background, and as tangible signs explaining and helping to recall not only this primordial perspective, but also the practical and geometric applications deriving from its concrete application to geometry and astronomical measurement. Thus, and in summary, these "three figures that generate all the others" are intended to "reveal in them all the concepts of this art".[36] In order to further emphasise this double value of the archetypal figures – methodological and mnemonic – Bruno uses a metaphor that recurs frequently in his writings, precisely to express the dual idea – visual and conceptual – of the unity, at once organic and composite, of what is to be analysed. The image chosen is that of the human body as a 'statue':

> Just as someone who wants to show the parts of a human being must first present the whole, composed and formed, instead of presenting the individual parts that contribute to it and are known one by one, so before teaching we must first acquire all things and prescribe to take possession of the book that contains them all.[37]

[34] *Ibid.*, 26: "Non igitur falsa, sed altior quam a triviali Peripateticorum sensu perceptibilis, fuit illa Xenophanis et Parmenidis sententia: Ens unum, immobile, quod in rei veritate idem et principium et principiatum; sicut substantialiter praeter unitatem nihil est numerus; quod non est unum, nihil est; ergo unum est ens, unum est verum, multitudo vero relinquitur ut accidens, ut vanitas, ut non ens: ita intelliges ubi Monadis vocem audies SUM QUOD EST. [...] Ut ergo praeter Monadem nihil est, praeter atomos et puncta nullum est quantum, ita et praeter minimi portionem et definitionem nulla est mensura, nullus est geometra et nulla consequenter philosophia". On Bruno's monism, cf. Tirinnanzi, *La monade e le sue ombre nell'ʻars memoriae' di Giordano Bruno*; Blum, *Auf dem Weg zur Prozessmetaphysik: die Funktion der Monaden in Giordano Brunos Philosophie*; Zaffino, *Totum et unum. Giordano Bruno e il pensiero antico*.

[35] Bruno, *Articuli adversus mathematicos*, 26: "Dantibus minimum omnia sunt commensurabilia, sequitur ratio continui discreti rationem necessario; ut ergo vel numerus vel unitas communis est ratio omnium numerorum, ita in proposito".

[36] *Ibid.*, 19: "Figuras ergo tres omniparentes (quamvis adhuc earum fabricandarum ratio non sit adducta) docturus ante oculos obiicio, ut in ipsis universos artis huiusce terminos aperiam".

[37] *Ibid.*: "Ita eum qui partes hominis indicare decrevit, prius universum compositum atque formatum obiectet oportet, quam quae sygillatim in ipso concurrunt atque comperiuntur insinuet, sicut antequam doceamus, omnia nos praehabere oportet, et librum omnia continentem assumere praecipimus".

This metaphor, it has been said, also appears frequently in other Brunian writings. In *De umbris idearum*, for example, it has a purely methodological function:

> When you move from a confused plurality to a clear unity, then you will truly discover and experience that you have completed the itinerary we have described. [...] The hand joined to the arm, the foot to the ankle, and the eye to the forehead, when placed together, have the capacity to be known more clearly than when placed separately; likewise, since none of the parts and configurations of the universe are placed separately and without order – which in the first mind is the simplest, the most perfect, and independent of number – if we construct our concepts by joining the different parts and uniting them according to reason, what is it that we will not be able to understand, remember, and do?[38]

The idea of an image as a semantically active composition, because of its structural complexity, also has a mnemotechnical value, not only because what is well organised is best remembered, but because the organic unity of a composition can inevitably act as a visual pathway for information, in short, it is a local system contracted into a single complex image (as indeed the mnemonic tradition already did). In *Explicatio triginta sigillorum*, Bruno proposes a specific mnemotechnical device for this purpose, entitled "Phidias or the Sculptor". It consisted of a system of images arranged within the same "common substratum" – i.e. a room – "so that [...] certain figures, in contact with different wandering images, emit a different sound", i.e. that such figures are "activated" within the *locum* in such a way that "with different postures and placements, and after having considered the substratum in relation to the various parts and according to the various relations, it will make the consonant letters multiply the five vowels".[39] In this way, he can visually and symbolically express the value of a syllable or a word, a technique proper to (and also 'typical' of) the *memoria verborum*. In general, as we learn from the explanation of the seal, this specific expedient is based on a particular conception of imaginative action, since the phantasy can be metaphorically compared to a sculptor:

[38] Bruno, *De umbris idearum*, 100-101: "Talem quidem progressum tunc te vere facere comperies et experieris, cum a confusa pluralitate ad distinctam unitatem per te fiat accessio. [...] Sicut manus brachio iuncta pesque cruri et oculus fronti, cum sunt composita, maiorem subeunt cognoscibilitatem quam posita seorsum, ita, cum de partibus et universi speciebus nil sit seorsum positum et exemptum ab ordine – qui simplicissimus, perfectissimus et citra numerum est in prima mente –, si alias aliis connectendo et pro ratione uniendo concipimus, quid est quod non possimus intelligere, memorari et agere?"

[39] Bruno, *Explicatio triginta sigillorum*, 58-59: "In proprias sedes subiectum commune atque totale distinxi, quae quidem easdem in sua domo perpetuo immorantes imagines quasdam retineant, quo diversorum peregrinantium attactu diversimode sonent. Ibi forma subiecto adveniens, penes locales situalesque differentias nec non per varias partes et secundum varias habitudines considerato, consistentia per subsistentia quinque multiplicare faciet elementa".

> It is it [phantasy] which erected the famous statue of Nebuchadnezzar, and which described in signs the orderly sequence of the fortunes of the kingdom; it is it which fabricates the succession of rhetorical figures, and it is it which describes, in a precise order and in the same sequence as we wish to recall them, the conditions of the physical appearance of some sensible subject about whom and in whom it describes many things metaphorically.[40]

The three archetypal images thus fulfil the 'technical' – methodological and mnemonic – function described in this specific seal (the thirteenth of the thirty proposed by Bruno): they show a system of references that are different but united by a common theoretical background; moreover, in the articulated and systematic organicity of the figures, they help the reader to remember as well as to understand the concepts gathered in them. The reference to the sculptor's seal, however, not only helps us to have a clearer reference to their function, but also shows us that the three archetypal images, read precisely in their mnemotechnical specificity, are themselves "seals", i.e. one of the various 'semiotic' typologies that Bruno identifies in order to define the relationship between content and mnemonic sign. Bruno treats this in detail in the first part of *Ars memoriae* annexed to *De umbris idearum*, in the pages where he describes the "twelve substrata of garments", namely "species, forms, simulacra, exemplars, spectres, traces, hints, signs, notes, characters and seals".[41] Seals belong to the last group, along with "signs", "notes" and "characters", those that "seem so appropriate to the mode of art [of memory] that in all these cases it seems to support natural realities"; indeed, with "signs, notes, characters and seals [...] art acquires such great power that it seems to act outside of nature, above nature and even – if the task requires it – against nature".[42] "To the lastmentioned", Bruno continues, "the art resorts when it cannot produce figures and images, because the contents in question do not belong to the genre of realities susceptible to fantastic representation or depiction".[43] Signs, notes, characters and seals therefore serve to visually and mnemonically represent information that is more abstract, precisely because they are essentially symbolic and 'graphic' in their nature, and not superficially 'mimetic'. Therefore, if "species, form, simulacrum,

[40] *Ibid.*, 122-125: "Haec est statuarius ille, qui famosam Nabuchodonosoris statuam erexit, haec ordinatam fortunae regni successionem descripsit, haec tropologiarum fabricat discursus, haec formae conditiones in aliquo sensibili, circa quod et in quo pleraque metaphorice delineat, certo quodam ordine ea demque qua meminisse volumus serie describit".

[41] Bruno, *De umbris idearum*, 136-137: "Habes in libro Clavis magnae duodecim indumentorum subiecta: species, formas, simulachra, imagines, spectra, exemplaria, vestigia, indicia, signa, notas, characteres et sigillos".

[42] *Ibid.*: "Quaedam vero adeo arti videntur appropriata, ut in eisdem videatur naturalibus omnino suffragari: haec sunt signa, notae, characteres et sygilli, in quibus tantum potest, ut videatur agere praeter naturam, supra naturam et, si negotium requirat, contra naturam".

[43] *Ibid.*: "Hisce succurrit ubi figuras et imagines reddere non potest, cum in imaginabilium vel figurabilium genere non versentur".

exemplar and specter thus represent Mercury" – this is the example Bruno gives – "notes, characters and seals instead represent the substance, essence, goodness, justice and wisdom of Mercury".[44]

Finally, let us look in detail at the three images, how they are defined and formed, and the theoretical level and geometrical applications to which they refer. The first of them is called the Figure of the Mind (*Figura Mentis*) by Bruno and, in the pages of *Articuli adversus mathematicos* in which its explanatory use is recalled, it is designated by the astronomical symbol of the Sun. Geometrically, it "consists of four circles placed side by side, which penetrate and intertwine through the centres" (Fig. 2),[45] and it is called Mind because it "contains all things and gathers them into a kind of unity".[46] The main meaning of this illustration, therefore, lies in the concept of unity, symbolised by the fact that the circles, triangles and quadrilaterals drawn in the illustration manifest their geometric properties and their mutual relationships by virtue of the main circle that encloses them all and from which they derive. From a technical point of view, however, this image does not occur in many of the constructions in the text and is used mainly to illustrate the procedures relating to the line and triangles, although it is also evoked in some pages dealing with regular polygons.

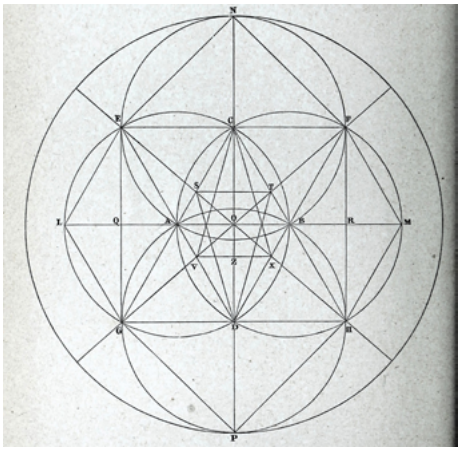

Fig. 2. *Figura Mentis. Articuli adversus mathematicos*, 78.

The second figure, which "consists of seven circles touching each other at certain points, so that they cannot penetrate or intersect each other" (Fig. 3), is called the Figure of Intellect (*Figura Intellectus*), because it "distinguishes all things and orders them according to the reasons of each";[47] the graphic/astronomical symbol representing it

[44] *Ibid.*, 138-139: "Mercurium ergo praesentat species, forma, simulachrum, exemplar et spectrum. Mercurii vero substantiam, essentiam, bonitatem, iustitiam et sapientiam praesentant notae, characteres et sigilli".

[45] Cf. Bruno, *Articuli adversus mathematicos*, 21.

[46] *Ibid.*, 20: "prima, quae quatuor circulis mutuo se per centra penetrantibus, implicantibus atque coinsitis perficitur, figura Mentis universa continentis et in unitate quadam implicantis appelletur".

[47] *Ibid.*, 20: "Secunda, constans septem se attingentibus circulis, nempe in punctis quo mutuo non penetrent et intersecent, figura Intellectus omnia distinguentis propriisque rationibus distribuentis appellatur".

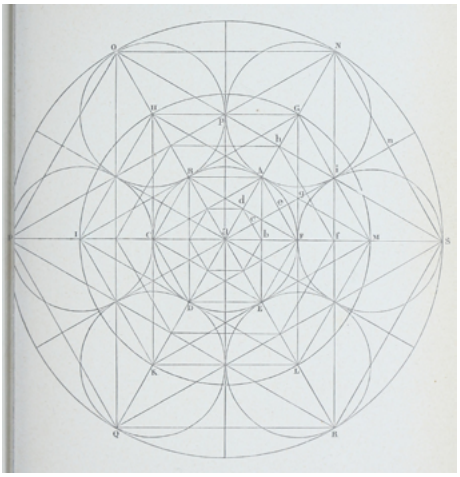

Fig. 3. *Figura Intellectus. Articuli adversus mathematicos*, 79.

is that of the Moon. It is perhaps the most important figure from a theoretical point of view and with regard to the particular atomistic geometry postulated by Bruno: it is formed by six tangent circles arranged so as to touch a central one, according to a hexagonal and compact pattern, which in fact constitutes the primary matrix of all material reality, both in the physical and geometric sense. This form is the basis of the composition of the minima, so that all geometric figures are composed by this fundamental schematism, but also the physical bodies respond to this configuration, since the atoms have a spherical, minimal form and therefore, in forming the earth element, the densest and most solid, they compact according to this pattern. Obviously, the circles, equilateral triangles, hexagons and circles derived from this main composition have an important function in describing and explaining geometric constructions, which is why it is referred to so often (more than the other two) in the pages of *Articuli adversus mathematicos*, especially in the theorems relating to line, angle, triangle, polygon and, above all, circle. The reference to the symbolism of the Intellect/Son as the first 'emanation' of the Mind/Father[48] is finally symbolically justified by the fact that this figure "is also formed by three concentric circles – since their centre is the same and unique individual, which is the first circle, and no less unique is also the last circumference, which is the outermost circle", so "it is rightly said to be a figure of that which embraces and unites all things".[49]

The third and final archetypal figure – graphically symbolised by a star – "unfolds in circles, now intersecting, now tangent" (Fig. 4) and is called the Figure of Love (*Figura Amoris*), "because, as the substance of all things is both contrary and concordant, it perpetually preserves concord in opposition and opposition in concord, distinction in union and union in distinction, the multiplicity in unity and unity in the multiplicity".[50] Made up of four mutually tangent and secant circles, plus numerous inscribed

[48] Cf. Carannante, *Unigenita natura*, 93-209; Id., *Giordano Bruno e la filosofia moderna*, 225-252.

[49] *Ibid.*, 20: "Tribus etiam concentricis efformata circulis, utpote quorum idem et unum individuum est centrum, quod est primum, unica quoque non minus est ultima circumferentia, quae est extremum, figura certe omnia complectentis et unientis dicitur".

[50] *Ibid.*, 21: "Tertia tandem, quae tum attingentibus tum intersecantibus se circulis explicatur,

squares and a total of sixteen squares forming a larger grid that surrounds the entire figure, it symbolises the close relationship between arc and chord, curved and straight, and thus, from a theoretical point of view, the union and complementarity of opposites (especially the minimum and the term/vacuum, which are present in everything and in all figures). From a geometrical point of view, it is recalled mainly in demonstrations related to quadrilaterals and other regular polygons: in particular, in the pages related to the square, it is used to solve problems related to the gnomon and other operations of algebraic geometry, that is, the construction of equivalent rectangles or multiples of squares.

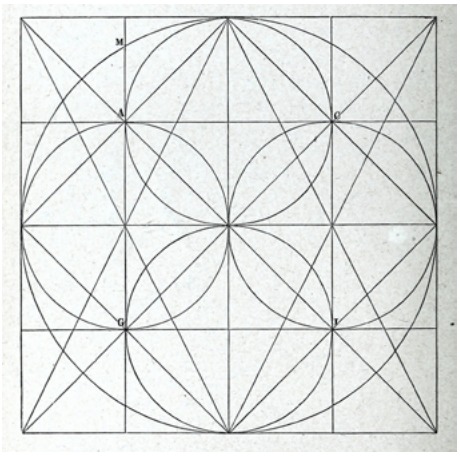

Fig. 4. *Figura Amoris. Articuli adversus mathematicos*, 80.

Conclusions

Although *Articuli adversus mathematicos* is not a mnemonic text per se, both the context in which it was conceived and published – the German period of Bruno's *peregrinatio* and, in particular, his stay in Prague with the Spanish ambassador and among the circle of intellectuals close to Rudolph II's court – and the presence of these three important mnemonic passages, offer an unprecedented and original mnemonic implication, especially considering that it is a geometry text. Specifically, we have seen how the rich set of ancillary images that close the text (the thirty *figurae subalternae*) is opened by an image with a very clear mnemotechnical value, since it represents the typical structuring for mnemotechnical places provided in the traditional *ars memoriae*, and not only in that of Bruno. Furthermore, in one of the most important sections of the text, devoted to the particular technique of measuring astronomical distances that Bruno developed, the explicit choice is made to describe the dense and recursive fractioning of the circumference by means of a metaphor that visually recalls precisely the system of dividing places into virtual spaces

> Amoris figura noncupatur, quandoquidem substantia universi tum contraria est, tum quoque concors, utpote in contrarietate concordiam et in concordia contrarietatem, in unione distinctionem in distinctione unionem, in unitate multitudinem in multitudine unitatem perpetuo reservans".

that are subordinate to each other. Again, this is a rather unusual application – undoubtedly of more metaphorical and symbolic than technical value – of mnemotechnical instrumentation to a field that is anything but humanistic. To conclude, the value of the three archetypal figures is shown to be both methodological and mnemonic: in this case, the recourse to the mnemonic technique is certainly more explicit than in the other two cases examined, but no less original. It should be noted, however, that at this point Bruno creates three veritable mnemonic 'seals', according to the 'semiotic' division and definition of mnemonic signs elaborated in *De umbris idearum*: firstly, by creating images specifically designed to describe and represent the various abstract contents, i.e. the geometric constructions appearing in the text; secondly, by offering the reader a concrete and visual means of memorising, enabling him to review in each figure, easily and all at once, the numerous geometric patterns of which it is composed; finally, to symbolise and remind us of the no less important philosophical considerations that run beneath the surface of the entire text of the *Articuli adversus mathematicos* and which constitute its inescapable theoretical foundation.

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