THE ARCHETYPAL HYPOTHESIS OF C.G. JUNG AND W. PAULI AND THE NUMBER ARCHETYPES: AN EXTENSION OF THE CONCEPT TO THE GOLDEN NUMBER[1]

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This article is dedicated to the memory of Marie-Louise von Franz

Abstract
According to the archetypal hypothesis (AH) of Jung and Pauli, physis and psyche may be seen as complementary aspects of the same reality. At the basis of all physical and mental phenomena, there exist primal ordering archetypes which operate as fundamental dynamical patterns of behaviour. Jung expressed an interest in the archetypes associated with the small natural numbers, and research into number archetypes has been carried out in depth by M.-L. von Franz. Pauli felt that not only the infinite series of integers but also the geometrical continuum has an archetypal nature; however this idea has not been further elaborated as yet. The present work is a first attempt to extend the concept of number archetype beyond the small integers to the Golden Number that is derived from the Golden Section or Mean. This number archetype in various representations is present in certain physical and mental phenomena as an optimal structuring pattern with an inherent dynamism. It also has an affective charge and numinosity. Consequently the Golden Number bears all the essential features of a fundamental archetype, thus adding a qualitatively different type to the range of number archetypes.

Key words: number archetype, golden number, analytical psychology

1. THE ARCHETYPAL HYPOTHESIS OF JUNG AND PAULI

An extraordinary collaboration between Carl Gustav Jung, one of the originators of twentieth century psychology and founder of analytical psychology, and Wolfgang Pauli, a brilliant Nobel Prize-winning quantum physicist, led to the formulation of the so-called archetypal hypothesis (AH). Jung and Pauli were ultimately brought to the archetypal hypothesis as the result of perceiving parallel developments in depth psychology and quantum physics. Jung noticed that research into the behaviour of the psyche led to an encounter with certain "irrepresentables", the archetypes, while quantum physics similarly had led to "irrepresentables", namely the elementary particles which constitute matter but for which no complete space-time description is possible. He concluded that since physis, the realm of matter, and psyche, the realm of the mind, "...are contained in one and the same world and moreover are in continuous contact with one another and ultimately rest on irrepresentable, transcendent factors, it is not only possible but fairly probable, even, that

psyche and matter are two different aspects of one and the same thing,"the unus mundus" (Card, 1996). The idea of unus mundus is founded "...on the assumption that the multiplicity of the empirical world rests on an underlying unity, and that not two or more fundamentally different worlds exist side by side or are mingled with one another." (Jung, 1958). Pauli postulated the existence of "...a cosmic order independent of our choice and distinct from the world of phenomena." (Jung and Pauli, 1954) The propositions articulated by Jung and Pauli that eventually were to constitute the archetypal hypothesis may be summarised as follows (Card, 1996):

1) Physis and psyche represent complementary aspects of the same transcendental unitary reality, the unus mundus.
2) Archetypes act as fundamental dynamical patterns whose various representations characterise all processes whether mental or physical.
3) Archetypes acting simultaneously in both the realms of matter and mind account for synchronistic phenomena.

The unus mundus contains all of the preconditions which determine the form of empirical phenomena, both mental and physical. These preconditions are archetypal in nature and are, therefore, completely non-perceptual, pregeometrical, and prelogical. When they reach psychic perception, they take on specific representations in the form of images of geometric or numerical structures. Such preconditions, i.e. archetypes, are the mediating factors of the unus mundus: when they operate in the realm of psyche, they are the dynamical organizers of images and ideas; when operating in the realm of physis they are the patterning principles of matter and energy (Card 1996).

2. NUMBER ARCHETYPES AND THE GENERAL ARCHETYPAL HYPOTHESIS

Jung and Pauli formulated their archetypal hypothesis in the late years of their lives, so their heritage mainly consists of broad ideas and leading principles. Jung realised that associated with the set of discrete small natural numbers were some of the most primitive archetypes, i.e. the number archetypes. According to Jung: "...I always come upon the enigma of the natural number. I have a distinct feeling that number is a key to the mystery, since it is just as much discovered as it is invented. It is quantity as well as meaning" (von Franz, 1974). He held that: "...[number] may well be the most primitive element of order in the human mind...thus we define number psychologically as an archetype of order which has become conscious" (von Franz, 1974).

Pauli was interested in developing a more general concept of archetype. This "...should be understood in such a way that included within it is the 'mathematical primal intuition' which expresses itself, among other ways, in arithmetic, in the idea of the infinite series of integers, and in geometry, in the idea of the continuum...I think it would be of interest to work out more precisely the specific qualities of the 'archetypal ideas' which form the basis of the mathematics in comparison with more general archetypal concepts." (Pauli, 1964)

Research into the archetypal nature of numbers was significantly advanced by Marie-Louise von Franz (1974), who had worked closely with both Jung and Pauli throughout their collaboration. She came to conclude that, "natural numbers appear to represent the typical universally recurring, common motion patterns of both psychic and physical energy." As a result, "...the human mind can, on the whole, grasp the phenomena of the outer world....The

existence of such numerical nature constants in the outer world, on the one hand, and in the preconscious psyche, on the other...is probably what makes all conscious knowledge of nature possible." (von Franz 1974; Card 1996).

Following her investigations, Card (1996) has restated the original hypothesis as a general archetypal hypothesis:

1) All mental and physical phenomena are complementary aspects of the same unitary, transcendental reality.
2) At the basis of all physical and mental phenomena there exist certain fundamental dynamical forms or patterns of behaviour called number archetypes.
3) Any specific process, physical or mental, is a particular representation of certain of these archetypes. In particular the number archetypes provide the basis for all possible symbolic expression.
4) It is possible that a neutral language formulated from abstract symbolic representations of the number archetypes may provide highly unified, although not unique, descriptions of all mental and physical phenomena.

In Number and Time, von Franz was primarily concerned with describing the characteristics of a quaternio of archetypes that are associated with the first four integers. Up to the present, no substantial arguments have been made which further extend the number archetype concept, particularly in the directions suggested by Pauli. In the following sections it will be argued that the Golden Number, which derives from the Golden Section or Mean, must be considered to be a number archetype as well. This represents a limited task in terms of Pauli's more comprehensive agenda, yet it is qualitatively distinct from the quaternio of number archetypes explored by von Franz, because the Golden Number, as an irrational number, represents something quite different archetypally from the small integers.

3.EXTENDING THE CONCEPT OF NUMBER ARCHETYPE TO THE GOLDEN NUMBER

When a segment of straight line is divided into two unequal portions such that the ratio of the lengths of the larger portion to the smaller is the same as the ratio of the original segment to the larger portion, then the Golden Section (or Golden Mean, Golden Ratio, or Divine Proportion) has been obtained. The numerical value of the ratio of the larger portion to the smaller portion can be shown to be an irrational number (1.61803...) and is often denoted by the Greek letter, Phi, and referred to as the Golden Number. The Golden Section was known in antiquity, and its mathematical properties have been subjected to an extraordinarily broad scrutiny from the time of Pythagoras up to the present day. Because of its ubiquitous presence within geometry, art, architecture, and the morphology of certain natural objects, plants, and animals, the Golden Number has a long and celebrated history of unrivalled status as an enigmatic mathematical curiosity.

Previous authors have sensed the fundamental significance of the Golden Number for nature and man and have referred to it as an archetype (Huntley, 1970; Ghyka, 1927, 1931, 1977; Reading, 1997). However, no real analysis has been performed in terms of a detailed assessment of the properties of the Golden Number to determine if it truly possesses the essential characteristics of a number archetype. To accomplish this, a set of criteria,

consistent with the work of Jung and von Franz and encompassing the essential elements of the archetype concept, has been established:

a) The number archetype functions as a primal ordering archetype whose representations should appear in both the realms of psyche and of matter. In the psyche, the representations should appear both in manifestations of the unconscious and as the objects of conscious deliberation.
b) No single representation of a number archetype expresses the full nature of the archetype. There is a necessary distinction between the archetype-as-such and any particular representation of the archetype. Consequently, representations of the archetype may present themselves in novel and surprising ways.
c) The number archetype has an inherent dynamism.
d) The number archetype has an affective charge and numinosity.

We shall proceed with a systematic analysis of the Golden Number according to the above criteria.

3.1. The Manifold Representations of the Golden Number

3.1.1 Manifestations in the unconscious psyche.

Some of the most remarkable and universal evidence demonstrating the role of the Golden Number or Golden Section as an unconscious ordering operator in the human psyche comes from the analysis of archaeological or ethnographic artefacts which display proportions of the Golden Section or proportions related to this Section. Several recent studies of pottery and other clay artefacts from the Neolithic period or from antiquity reveal the ubiquitous presence of the Golden Section in their proportions (Morariu et al. 1990; Morariu, 1996a; Morariu 1996b; also various books on the history of arts, for example Tatarkiewicz, 1978; or literature cited by Neuveux,1995). For example the harmonic analysis of a clay cup of the Neolithic Age (Millennium 5 BC) found near Cluj-Napoca, in the middle of Transylvania, Romania (in the collections of the National Museum of Transylvania, Cluj-Napoca) reveals that the ratio of the height/width is the Golden Section. Also the harmonic analysis reveals the main details of the cup as well as the positioning of the painting are clearly related to the Golden Section. More examples of the presence of Golden Section as the main proportion or into other details of the shape or decorative motifs of archaeological or ethnographic artefacts may refer to: Neolithic pottery (5000 BC), Iclod culture (province of Transylvania, Romania); Cucuteni culture (province of Moldavia, Romania); Neolithic clay idols (Cucuteni culture) ; Neolithic dwellings (mud huts) and mud sanctuary (province of, south-western Romania); pottery of Roman Empire; (province of Transylvania, Romania); clay rushlights, Roman Empire (Transylvania); bronze surgical instruments

Roman Empire (Transylvania); wooden carved gate, 19 th century, Romania (Transylvania); wooden carved spoons, 19 th century, Romania (Transylvania). All these examples are collected from the following references: Morariu et al. 1990; Morariu 1996a, 1996b, 1998 and Morariu, unpublished work.

These examples show that widely different artefacts have in common the Golden Number proportion. At the same time the suggestion that these findings might imply the conscious use of an art canon involving the Golden Number may be easily dismissed. The subtle geometry

of the vases and anthropomorphic figures from the Neolithic period is amazing, even more because it is beyond doubt that such forms have been made without the use not only of advanced knowledge of mathematics and design but of even the most modest level of conceptualisation; the artefacts have been simply created as a result of an "inner force" or inspiration. The same surprising geometry can be seen, as well, in the artefacts such as carved wooden spoons, gates, etc., of the traditional rural communities of the Romanian peasants of the 19th century of Transylvania (Morariu, 1998).

On the other hand it is doubtless that the artefact makers transmitted from one generation to another some concepts, motives, stiles, and technical rules. However to the best of our knowledge it cannot be demonstrated that either the main proportions or the details of an artefact, above mentioned, have been deliberately made by obeying quantitative rules, particularly proportions represented by irrational numbers. On the other hand the proportions represented by rational numbers render themselves easily to measurement, drafting, and planning at a simple level of knowledge of elementary mathematics.

While the examples above come from several studies limited to a small region of Europe over about seven thousand years of prehistory and history, many similar examples may be expected to exist around the world regardless of place and time. However it should be clearly stated that the present work does not intend to make a exhaustive report on the presence of the Golden Number in artefacts all over the world and during the whole mankind history.

3.1.2 Manifestations of conscious deliberation.

At some time in the antiquity, the Greeks realised the aesthetic value of the Golden Section and deliberately transformed this knowledge into a canon, i.e. a basic rule to be consciously applied to the creation of the art and architecture. The Parthenon, for example, was constructed using the proportions of the Golden Section. At a later stage even the minor arts such as pottery may have followed this rule, thus explaining the Golden Proportion found in the masterpieces of antique pottery manufactured in the advanced workshops of the time (see for example, Tatarkiewicz, 1978). Even to the present day, this rule is well known to contemporary artists and is a part of their basic instruction.

No one can say exactly how, when and where the canonisation of the Golden Section occurred. One can only guess that through long empirical experience, the Greeks came to realise that such a proportion is an expression of beauty and harmony and therefore made of it a precise rule which was later taken over by the Romans and passed along to the present. However, only with the development of mathematics in the Middle Ages did the special mathematical properties of this proportion come to light. The coming of the Golden Section into human consciousness is a good illustration of how the archetypal representations evolve and develop from an initial stage of unconscious representation (the pure action of the "inner force"), through the stage of conscious representation as an empirical rule (based on the intuitive feeling of its numinous value), to the final stage of conscious representation based upon a profound mathematical and intellectual understanding of the concept.

The Golden Section is however not the absolute rule for harmony and beauty. The human preference is in fact a very complex phenomenon and besides the Golden Section we may find other key proportions such as $\sqrt{\phi}$ or proportions based on irrational numbers: $\sqrt{\phi}$, $\sqrt{2}$, $\sqrt{3}$, $\sqrt{5}$, $\sqrt{5}/2$ (Ghyka, 1977) , or even more complicated proportions based on powers of ϕ (

Morariu et al, 1990). More recently we can find an elegant study concerning the preference for chaotic figures which are quantified in terms of fractal dimension and Lyapunov coefficients (Aks and Sprott, 1996). Why such various preferences do exist in no terms of Golden Number, is a question which may only show the complexity of the problem. Therefore by no means the value of the Golden Number should be absolutized as the only one valuable paradigm.

Although we have presented here evidence in support of the Golden Number at both unconscious and conscious levels in separate sections, it is of no intention to support the romantic oposition between "le bon sauvage" and the helpless, intellectual man. In fact all along history since the scientific knowledge has been developed both the unconscious and conscious use of the Golden Number was ever present in the mankind's work and this represents an important evidence in support of our claim.

3.1.3 The presence of the Golden Number in the living world

In the natural world the role of the Golden Number as a characteristic proportion for living creatures regardless of their position on the evolutionary scale is so well known that the very presence of the Golden Number as a proportion is regarded as a fundamental characteristic of the living world and its spatial and temporal characteristics. The basic morphological structures of many plants, insects, animals and man have many general and detailed features which correspond to the Golden Proportion (for examples, see: Ghyka, 1927, 1931, 1977; Ciofu, 1994; Reading, 1997).

Beauty and harmony are usually associated with the Golden Proportion. For example, despite the great diversity of human faces, the average "portrait" of a human face that results from the superposition of many individual photos is an ideal face which obeys the Golden rectangle rule--i.e., it can be inscribed in a Golden Rectangle (the ratio height/width = Phi). Furthermore, many of the details of the face can be easily found to be located at strict geometrical sections or cross points resulting from the harmonic analysis of the Golden Rectangle, and the human eye can readily detect minute departures from such a harmonic structure (Ghyka, 1977). This is a relevant example of how living nature works archetypally. In fact, it reveals the archetype's statistical mode of behaviour--it is an "average" rule, not an "absolute " rule. It permits diversity and a certain degree of randomness, while it keeps such variances within certain limits.

As well as the presence of the Golden Number in the proportions of morphological characteristics of living creatures, similar proportions can be found at the cellular or biochemical levels. Consider the following examples (Ciofu,1992):

a) the percentage of the globulin fractions (alpha 1, alpha 2, beta and gamma) is an increasing series progressing with a factor of $\sqrt{\phi}$;
b) the ratio of the minimal to maximal concentration in urine of urea and glucose respectively is $\sqrt{\phi}$;
c) the ratio of monocites, neutrophiles and erythrocytes respectively in the human blood represent terms of a progression series with a factor of $\sqrt{\phi}$. The same type of series also represents:
d) the ratios of the oxygen partial pressure in the venous blood, in the arterial blood and in the atmosphere respectively;

e) the partial pressure of the carbon dioxide in the following series: in atmosphere, in the expired air, in the arterial blood and in the venous blood respectively.

These kind of examples may appear as unusual or just simple coincidences compared to those found widely exposed to the eye i.e. whole organisms or part of the organisms. While the presence of such a proportion is common in the anatomical structure even into some details, it is not unreasonable to seek it at cellular level or in physiological properties. However it remains to be established what are the advantages of these spatial or temporal ordering at this level of the living matter or how could be described the principle lying behind such a rule.

The presence of the Golden Number has also been discovered in other areas of biology, including physiology, neurophysiology, epidemiology, and also in the biological rhythms (Ciofu, 1994). In psychology and sociology, occurrences of Golden Number proportions appear in studies of reaction times, memory and learning, IQ, behavioural simulation, subjective, projective and interpretative evaluations, etc. (Ciofu, 1994).

3.1.4 The Golden Number in the physical universe

Less known is the presence of the Golden Number as an ordering principle in the physical universe, in both the micro and macrocosms. This circumstance is not surprising because the aesthetic value of the Golden Section was the first to be realised, and this stage remained for about two thousand years. Only with the later development of science from the time of Kepler onwards has the ubiquity of the Golden Number in the physical world become evident. At present, examples of the Golden Number may be found in the physics of elementary particles, ionising radiation, atomic phenomena, chemical processes and structures, the periodic system of elements, and the temporal and spatial structure of the universe (Ciofu, 1994). More specific examples refer to: the ratio of the distances to the Sun of two neighbouring planets; the sideral period of revolution of the planets; the ratio of the average speed on the orbit of the Moon and Earth; the equatorial radius of the six satellites of Saturn; the ratio of the shortest path to the longest path of alpha particles emitted by Uranium and Actinium series respectively; the periodic table: the place of the elements in groups and periods; the boiling points of helium, hydrogen, nitrogen and oxygen; the ratio of the carbon dioxide, oxygen and nitrogen percentages in atmosphere; the burning of a candle: various structural and caloric details. All these examples are discussed into some details in Ciofu's book (1994). However these examples seem to be less spectacular than in the living world and the more frequent proportion refer to $\sqrt{\phi}$ and quite rarely the phi itself. A more careful investigation in the area of physics and chemistry is needed. At present this area of evidence seem the most in need of new and well documented examples.

Just as in the case of the evidence coming from physiology or cellular biology, it is necessary to seek a basic principle behind these observations. At a very general level the Golden Number is seen as an expression of the principle of minimum action (Ghyka, 1977; Ciofu, 1994). On the other hand we know that physics text books tell nothing about Golden Number or its significance for its basic laws. Some isolated findings mention the presence of Golden Number in non-linear phenomena, chaos and aperiodic crystals (Shibayama, 1984; Reading, 1997)

3.2. The Incompleteness of Golden Number Representations

When the lengths of the two portions of the Golden Section are compared, they are found to be incommensurable. When the Golden Number is evaluated, it is found to be an irrational number-a never-ending, never-repeating decimal. The Golden Number appears in many guises that seem to bear no relationship to each other, such as the geometry of the pentangle, the logarithmic spiral patterns of the chambered nautilus or the seeds of the sunflower, structure of the cosmos, the trajectory of a moth approaching a candle flame, or the shape of a human face.

It emerges again and again from the pattern of numbers that Fibonacci first discovered when considering the growth of a population of rabbits but which also appear in the arrangement of leaves on a branch or petals in a flower, in the arrangement of "bulbs" on the Mandelbrot set, in the multiple reflections of light from glass plates, in the patterns of transition of electrons in atoms, and a multitude of other examples. Thus, no single representation of the Golden Number can be said to completely characterise its essence, and the consequence of this is that after more than two millennia it continues to be discovered in new and surprising circumstances. Most recently it has been discovered in various aspects of chaos theory where it, "...characterises something like the last barrier of order before chaos sets in." (Peitgen, Juergens and Saupe, 1992)

3.3 The Dynamical Character of the Golden Number

The Golden Number has an intrinsic dynamical character--it acts as a condition for harmonious balance between part and whole. Fibonacci's series, for example, describes many types of growth in populations of plants and animals in which the Golden Number appears as a characteristic constant of this growth.

If one looks at the whole range of representations o the Golden Number, then one discovers that the Golden Number is related to what "happens", "flows", "evolves", "develops", or to what has a " relative beginning and an end". This is in contradistinction to timeless structures such as the periodic crystals which do not contain the Golden Number.

Aestheticians have conceptualised this difference through the distinction of static proportions from dynamic proportions. According to Jay Hambidge (cited by Ghyka, 1927, 1970), static proportions refer to rational numbers such as 4/3; 4/1; 3/2; 3/1 (it should be noticed that there is a fundamental distinction between a periodic yet rational number, versus an irrational number). The dynamical proportions are represented by irrational numbers resulting from ratios like: $\sqrt{2}/1$; $\sqrt{3}/1$; $\sqrt{5}/1$; $\sqrt{5}/2$; $(\sqrt{5} + 1)/2 = 1.618...$ A particular case is the ratio 1/1 or 2/1 which is has both static and dynamical properties. Hambidge's classification may be regarded as an empirical, broader basis of what static and dynamic qualities may signify within an archetypal theory. This might represent the seeds to a further widening of the archetypal significance of continuum in respect to our present understanding.

3.4 The Affective Character and Numinosity of the Golden Number

The Golden Number has long been associated with the aesthetic judgement of harmonious proportion. This aspect of the Golden Number has, in fact, been the subject of several psychological experiments, and the outcome in each case confirmed its unique aesthetic character. In 1876, the German psychologist Gustav Fechner conducted experiments in which variously shaped rectangles were presented to a number of individuals who were asked to give their preference for the most aesthetically pleasing rectangle.

Fechner found that as the relative proportions of the sides of the rectangle approached those of the Golden Proportion, the frequency of selection of the rectangle increased. Conversely, when the subjects were asked to select their least favoured rectangular shape, the Golden Rectangle shape was selected least frequently. Fechner's experiments were later repeated by Witmar, Lalo, and Thorndike, and in each case similar results to Fechner's were obtained (Huntley, 1970).

These results help to provide a psychological basis for understanding why there has been a long history of reverence for the Golden Number by artists, architects, mathematicians, and others, evoking from them typical responses of pleasure, surprise, and awe. For some it has even become the inspiration for a mystical attitude, in which the Golden Number in its various representations takes on a sacred character. These responses are all testimony to the numinosity of the Golden Number, an aspect which helps to confirm its archetypal nature. There are even occasions when the numinosity of the Golden Number has led to a pathological fascination (as may occur with all deeply affecting archetypes) whereby an individual has become fixated upon it at the cost of reasoned judgement.

In Summary

The Golden Number appears to satisfy the above criteria, and if these criteria are indeed sufficient to characterise number archetypes, then the Golden Number must be considered to be a number archetype. Clearly, it is an archetype "of a different feather" from the quaternio of number archetypes studied by von Franz. Those four archetypes are primarily concerned with the patterns of behaviour that are involved with the coming into existence of any object, whereas the Golden Number is concerned with the harmonious relationship of part to whole. In its various representations, the Golden Number appears in the properties of certain infinite sequences of numbers and in the relationship of proportional sections of the geometrical continuum. As such, it simultaneously touches upon the two areas of mathematics in which Wolfgang Pauli had intuited the presence of archetypes. Hopefully, the emergence of the Golden Number as archetype helps to clarify the nature of the extraordinary properties of the Golden Number and provides an explanation for the singular role that it has sustained for millennia, while at the same time leading to a wider understanding and appreciation of the importance and relevance of von Franz's work on number archetypes.

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Notes:

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