Memes and their Themata

Willard L. Miranker
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Willard L. Miranker
Yale University
Department of Computer Science

Abstract- A meme is characterized as a phenotype when it is instantiated as a neuronal state. A thema is an instantiation of a meme as a conscious experience (a thought-meme). It is an ideal Platonic primitive to which no location may be attributed, and it serves as a canonical representative of a class of memes. The memes in such a class may have physical and/or ideal Platonic instantiations. The pairing of this memetic phenotype characterization with the ideal thematic primitive is an example of other pairings in nature that we identify, and in particular, it informs a description of the pairing of the unconscious and manifestations of consciousness. The interrelationship of these pairings is what illuminates aspects of each of them. These constructs support the introduction of a consciousness thesis and then a notion of a dynamical self-referential grammar that generates what we call a growing consciousness repertoire. A methodology and an example are given that shows how a neuronal state generates a specific concept (thema).

1. Introduction

We show that biotic constructs (such as phenotypes and genotypes) and Darwinian processes (such as competition, selection and reproduction) are characteristic of natural processes of which customary Darwinian evolution forms but one example domain. Memes, neuronal arrays and mind (conscious or unconscious) each furnish other such domains. Increase of understanding of those domains flows from analogies between them that we identify. Analogizing constituents of a scientific domain with those of a cultural one generates a conceptual fertility. By way of example of this assertion note that the contemporary development of memetics flows from Dawkins 1979 who analogizes between genetic based biotic evolution and the culturally based evolution of concepts in just such a way. This fertility stems from the avoidance of narrowly constructed correspondences between the constituents and function within these domains, as we shall see. Our use of an analogy between the pairings within both memetic and genetic constructs has a forerunner in the work of Lomsden, Wilson 1981, Wilson 1999 where a correspondence between fundamental units of culture and of neural networks is discussed.

We begin by describing a correspondence between the pairing of synaptic functioning with neuronal functioning and the pairing characterized by the customary biotic genotype-phenotype relationship. An extension is made to an analogous pairing correspondence within memetics. Development of such pairing within the study of memetics is an active and controversial area with no commonly accepted model. A meme is an idea or concept as well as any instantiation of that idea or concept

[Dawkins 1979, Blackmore 1999, Henson, on line]. Its customary characterization is that of a selfish replicator, spreading culturally from brain to brain. Dawkins expected that the meme could form the basis of an explanation of human behavior and cultural evolution. We pursue this intuition, starting with a modification of this customary replicator characterization that characterizes the meme as a phenotype when it is instantiated as a neuronal state, that is, a cerebral neuronal circuit at an instant of time. Such a memetic instantiation may be real, that is, a literal neuronal state, or it may be ideal (Platonic), possibly corresponding to an abstract model of that state. Taken together, these pairings inform a description of the unconscious mind and manifestations of consciousness as a corresponding pairing between a neuronal state and what we call a thema. A thema is an instantiation of a meme as a conscious experience, that is, as a thought, a thought-meme. It is an ideal Platonic primitive to which no location may be attributed. The thema serves as a canonical representative of the memes belonging to a specific class, and so, it can be viewed as the subject, the literal theme of that class. Semon 1904 introduced the concept of a unit of social evolution that he called a nmeme. While there is no agreement on what makes up one unit of cultural transmission, the thema can be viewed as a feasible candidate thereof. Our proposed constructs support the introduction of a consciousness thesis. Upon asserting that consciousness is a learned capability of the unconscious, a notion of a dynamic self-referential grammar for consciousness upon which that learning supervenes is introduced. Earlier attempts to deal with a theory of mind by employing memes are found in Blackmore 1999 and Sheehan 2006.

We propose a methodology for constructing themata as mathematical abstractions. This is done by employing a model neural net and results of axiomatic set theory [Aczel 1988, Zuckerman, Miranker 2008a]. Unboundedly many variants of such a construction are possible, and a particular meme may correspond to any of the corresponding neuronal states. An example, a neuronal structure corresponding to the thema of the class of memes that correspond to the concept of a particular natural number is developed. This example connects our development to a set of fundamental constructs (the natural numbers) upon which the development of mathematical thought supervenes. Indeed to Kronecker we owe the remark, "God created the integers, all else is the work of man." This example is all the more appropriate, since the concept of a natural number is fundamental to human thought. Additional and more elaborate examples are found in Miranker, Zuckernan 2008b.

Note the relationship of classes of memes and their themata to the class of the archetypical representations of Jung 1981 and Jung's archetypes themselves. Note also the relationship of our Platonic themata with both Jung's Platonic eidola[1] as well as with the monads of Leibniz 1714.

In Sect. 2, we describe neuronal firing to be the result of a competition with selection among neurons, thereby enabling characterization of the pairing of synaptic with neuronal functioning as a genotype-phenotype correspondence. (Compare this to the neural Darwinism of Edelman 1978.) The dendritic synapses (afferents) that are

[1] The author is grateful to an anonymous reader for these observations concerning Jung.

assigned the role of the genotype of a successful neuron (one that fires) are selectively strengthened by a Hebbian process [Hebb 1946, 1949, Haykin 2007]. This process is characterized as a competitive survival or propagation effect for both the neuron (the phenotype) and its afferents (the genotype). It is the strengthening of a synapse (the increasing of the synaptic weight) that is taken as the analog of gene replication, that genetic replication interpreted correspondingly as a form of strengthening, as we shall see. We view this synaptic-neuronal interaction as a process at increasing scales: synapse-neuron-neuronal assemblies of increasing size.

In Sect. 3, we observe that a meme instantiated as an input to a neuronal assembly generates a recording of information in the afferent synaptic weights, that information record likewise instantiating that meme. Such information representations inform a competition among neurons for firing, and so they inform as well, a process of selection among afferents for differential strengthening, that strengthening characterized by Hebb's law. For this reason the meme's neuronal representation array is viewed as a memetic analog of a phenotype. We see that the meme is instantiated (encoded) as a particular associative memory, which is recorded in the neuronal array whose synaptic weights embody the encoding. So the collection of memetic instantiations, one of which is this neuronal array, is identified as a collection of phenotypes. To the relevant array of afferent synaptic weights, we assign the role of the memetic genome, and so in analogy to the gene, to this array's recorded information (a meme), we attribute the status of a replicator. Indeed the flow of information into and out of a neuron informs the movement of information from genome (that neuron's afferent synaptic weights at a fixed instant of time) to a second neuron (a phenotype) via the latter's afferents (the latter's memetic genome).

In Sect. 4, the various pairings discussed so far are related to aspects of the appearance and evolution of biotic matter, including the associated appearance and evolution of consciousness. We then ask if the pairing of the two different and specialized mind agencies of consciousness and the unconscious supplies a favorable quality for that evolution. Themata are introduced to address this question. A notion of a winning thema is introduced and with it a consciousness thesis. Interpretations and observations regarding this thesis are developed. In particular, the relationship between a thema and a consciousness manifestation is described. We propose existence of a dynamic (expanding) self-referential grammar that frames development of a (growing) consciousness repertoire, the latter consisting of the class of formal sentences (memes) that can be generated, alternatively parsed by that grammar.

In Sect. 5, we formalize our study of memes by employing the construct of an accessible pointed graph and its labeled decoration [Aczel 1988]. We use a result for associating the state of a neural network at an instant of time with such a construct [Miranker, Zuckerman 2008a]. Such constructs generate an abstract set associated with a class of neural network states. That set is the Platonic thema of the memes associated with the corresponding class of neuronal states. Using these developments, we frame an example of a class of memes (with both physical and Platonic members) and its Platonic thema. The notion of a neural correlate of a consciousness manifestation (equivalently of a thema) is introduced. Finally we sketch a connection of the pairing of memes and themata both to genetics on a proteomic scale and to a pairing characterization arising in embryonic differentiation.

Perceptual speciation: We expect biotic differentiation through its analogical connection to memetics and consciousness developed here to inform other natural constructs. One of these is a notion of perceptual speciation; namely a branching of forms of perception/consciousness analogous to the literal branching of species in nature. We refer to Miranker 2005 and Miranker, Zuckerman 2008b for ongoing development.

2. The selfish synapse

2.1 A synapse strengthening as an information conveyance analogy to a gene replicating

Both genes and synapses have the role of information conveying agents. While the gene has been described as a replicator, a selfish replicator, the synapse has not. However both genetic replication and synaptic strengthening are processes that increase the effectiveness of an information conveying agent, the gene or synapse, as the case may be. We take the view, that the stronger the synapse, that is, the greater its synaptic weight, the more effective it is. Genes don't strengthen; rather they express their effectiveness through replication. When synapses are joined in a cohort, increasing effectiveness of the cohort is accomplished cooperatively, usually by strengthening some of its members while possibly weakening others. So we view genetic replication and synaptic strengthening as special cases (examples) of increasing the effectiveness of information conveying agents in nature. (There are corresponding artificial agents, an example of which arises in the study of genetic algorithms [Fogel 2000].)

2.2 A neuron firing corresponds to a phenotype succeeding

A gene has fulfilled its role, so to speak, if the phenotype it is a part of succeeds at a competition for survival and reproduces, thereby replicating the gene. Correspondingly we say that a synapse fulfills its role if the neuron of which it is an active afferent fires. On this view the neuron takes the role of a phenotype. It is deemed to be successful in a competition with other neurons in its environment (the latter specified by neuronal connectivity and activity) for being able to fire if and when it does fire. So we view the two examples, biotic reproduction and neuronal firing as special cases of success in competition for survival (and so informing a selection process, albeit on different scales). (See the comment on neuronal apoptosis in the Sect. 2.3.)

2.3 Selection

According to Hebb's rule, an afferent synapse increases/decreases in strength if that synapse's activation is positively/negatively correlated with its neuron's firing. We claim that this characterizes a selection process. As noted in Sect. 2.2, we say that the neuron is successful as a phenotype if it fires. If an afferent synapse correlates with the firing we say that the synapse has fulfilled its role in contributing to the production of a successful phenotype. Such synapses are selected from among all the neuron's afferents to be strengthened according to Hebb's rule. An afferent that is negatively correlated with the firing decreases in strength, also according to Hebb's rule. Repeated decreases may lead to the elimination of that synapse. Sustained quietude of a neuron (an expression of persistent

lack of success in competing to fire) can likewise lead to that neuron's elimination (apoptosis). So we shall view this Hebbian strengthening/weakening protocol of a synapse as part of a neuronal process of natural selection on its appropriate scale.

2.4 Propagation of information

We characterize these observations by saying that successful synapses propagate in the sense that they strengthen and endure as information conveyers. The synapses that propagate increase their influence on the neuron's functioning in the sense that the neuronal inputs and the array of afferents, counting strength (these features constituting the neuronal analog of the environment of a customary biotic phenotype) informs neuronal firing. That is, the stronger a synapse is, the greater its ability to influence firing. This is in analogy to how the genes that propagate shape the corresponding phenotype's form or functioning during development, thereby informing the phenotype's ability to achieve success, as we shall see in Sect. 3.

2.5 Recording and processing of information in a neuronal assembly

Genes and groupings thereof represent the recording of information at different scales[2]. Analogously we view the synaptic-neuronal interaction that we have been describing as a process at increasing scales: synapse-neuron-neuronal assemblies of increasing size. It is known that the strengthening or weakening of synapses informs a process of recording of information at these different scales. Associative memories stored in the brain are taken to be recorded in just this way. Moreover movement and modification of information by a neuronal assembly is a processing of neuronal activity flowing through the assembly, that processing informed by the neuronal environment.

3. Memes

3.1 The meme as phenotype, jumping memes

A meme may be instantiated as a distributed input encoded and stored in a neuronal assembly, that encoding generating a recording of information representing that meme at one or another scale (as described in Sect. 2.5), the scale depending on the meme's complexity. This information array, the recording in the neuronal assembly, specifically an encoding in terms of the synaptic weights, is a distributed representation of the meme. We have seen in Sect. 2 that such representations play a key role in the competition among neurons for firing, and that these features inform a selection process among synapses for strengthening/weakening, as the case may be. So the meme's neuronal representation array may be viewed as a memetic analog of a phenotype at one or another scale. The synaptic weights in this array can also be viewed as a memetic analog of a genome, since just as the information recorded in the biotic genome is both part of and informs specification for the biotic phenotype, the information stored in the synaptic component (via the weights) of the neuronal array (that recording constituting what we shall call the *memetic genome*) both encodes and can be exploited for reproduction, that is, for retrieving information in order to copy the meme[3]. So we shall view

[2] In malarial infections hundreds of genes participate in such a grouping [Su, Wellems 1996].
[3] This is reminiscent of the role of messenger RNA in protein manufacture. See Sect. 5.3.

the memetic genome as a replicator. The copy, also a phenotype, may take one of many different forms (memetic instantiations), such as another neuronal construct, an utterance of speech, a sample of writing...

Consider the case where the copy is a speech utterance. The latter provides the input to a second individual, and so via that by now familiar Hebbian mechanism, enables the meme to jump and be recorded by that second individual. There is the customary blurring of the genotype-phenotype relationship[4] in the meme-neuronal pairing, that is, somewhat of a sharing of the genotype/phenotype roles. Competition and survival for memes are not specified as they are in the customary biotic context. This is necessitated in part by a difference of both temporal and spatial scales at which the respective associated dynamics (replication and/or instantiation) develop. This blurring feature persists as we progress with our descriptions. *We stress that it is the absence of narrowly constructed equivalences of the analogs among pairings that promote understanding of the phenomena within those pairings.*

3.2 Storage and retrieval of memetic information

The distributed nature of synaptic storage of memetic information constitutes an associative memory. This makes for a richer context than the one found in customary biotic genome-phenotype arrangement; the latter may be likened to an addressable memory (usually but not accurately called a RAM). The neuronal assembly supporting a memetic genotype-phenotype arrangement may be multiplexed to record other inputs, that is, to record other memes. So, a number of different memes may share a single neuronal array, that is, they may share a memetic genome and phenotype. While genes may be viewed as fixed[5], their memetic counterparts, the synaptic strengths are in flux. On the other hand, while we certainly do not now know how the biotic phenotype is constructed given its genome, we may expect to recover, that is, read out the meme from the memetic phenotype, more explicitly, from the memetic genome encoded synaptically in the relevant neuronal information array. As a read out from an associative memory, this process requires that an approximation to the encoding of the meme be used as an input cue to that array. Although genes comprise a kind of RAM, we could ask if there is an epigenetic correspondent to this neuronal cuing that is involved in activating and/or deactivating the genes thereby supplying the information that drives embryonic development (another possible analogy, an analogy of function)?

3.3 The memetic replicator

The meme is customarily described as sharing with the gene the characteristic of being a selfish replicator. From Sect. 3.2, we see that the memetic replicator is made manifest in the associative memory, explicitly in the class of synaptic weights that encodes the meme. On this picture, all of the possible memetic instantiations, one of which is the relevant neuronal array, are phenotypes and not replicators. As suggested in Sect. 2, we assign to the memetic

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[4] While the biotic genotype and phenotype are regarded as complementary, the former is in fact a material part of the latter.

[5] Both genetic replication and Hebbian synaptic dynamics are subject to disturbances. Mutation is the term given to the former and noise to the latter. Of course, genes may be exchanged in reproduction (cross-over). Genes are known to change their location within a DNA sequence.

genome, the relevant associated array of synaptic weights, the status of a replicator in analogy to the genetic case.

4. Scales, mind, themata, a thesis and a grammar for consciousness

4.1 Scales in evolution, genomic-phenotypic pairing

Biotic matter first appeared four billion years ago at the molecular scale with simple proteins[6]. With evolution, the complexity in the biotic organization increases until the simplest form with a partitioning into a genome and phenotype pairing is arrived at. This pairing could be identified with the appearance of eukaryotic cells two billion years ago[7]. We can conclude by appealing to Darwinian principles that the separation and specialization of roles characterized by this pairing appeared and endured through competition and selection as a favorable arrangement for survival and propagation. Memes may be admitted to the picture when the biotic complexity increases to the level of neurons (memetic phenotypes) and their afferent synaptic arrays (memetic genomes), as we have seen. The pairing of a neuron and its afferent synapses also comprises an evolved partitioning of roles (phenotype and genome or alternatively, information processing and instantiation of that information as described in Sect.1) likely favorable to the selection process of evolution. Did memes appear in primitive neuronal organizations or only when assemblies of an adequately elaborated such pairing structure developed? Could memes appear before neurons?

4.2 Mind and its consciousness manifestations, other pairings

The mind could be described as the workings (layers of information processing at appropriate scales) within the brain. We shall for reasons of clarity start with the conventional view that mind supervenes on brain. However we shall see that it is the entire physical body and in some sense the environment as well (some take an even grander frame [Chalmers 1996]) that is in play. These mind workings are the processing and movement of information in some neuronal assembly(ies). As this assembly increases in complexity so may the relevant workings. This is a picture of operation at various scales, and we ask what degree of complexity in the unconscious workings in brain-mind is required for the emergence of the manifestations associated with consciousness? Examples of such manifestations are
A notion of self, intentionality and qualia, with three examples of the last being: Vision: three-space with its illusion of depth, colors, textures, shadings… Touch: pain, wetness, cold… Feelings: fear, joy, love, hope…

We do not rule out the possibility that consciousness in some form could arise with the organization of the first biotic matter [Sheets-Johnstone 1998, Miranker 2005], that is, prior to the appearance of brains. Is there a favorable quality obtained for evolution (for selection, strengthening/replication) by such a separation and specialization of function of the two mind

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[6] Some consider crystalline structures and prions to be primitive or proto biotic forms [Belkin 2003].
[7] Symbiosis among eukaryotes is viewed as critical in the formation of eukaryotes [Margulis 1991]. Can we not view the constituents of our pairings as symbiants?

agencies of consciousness and the unconscious[8]? For example, are the manifestations of consciousness a representation of information in a form to make the storage (encoding) and processing of that information more efficient and/or more robust? Can the pairing of these two mind agencies be described as another variant of the genotype-phenotype relationship that we are propounding? If so, what is the concomitant competitive-selection advantage for the underlying agents (phenotypes and their associated genotypes)? What, in particular, are the replicators, and what is the process of their strengthening? Will evolution go beyond consciousness and the unconscious with this paradigm of pairings? To start to address these questions, we turn to the notion of themata.

4.3 Themata, competition, a winning thema, a consciousness thesis

Consider the information being processed in a neuronal array that we referred to as a component of the mind in Sect. 4.2. We use the term *thema* (thought-meme; see Sect. 1) to describe this information as a virtual construct, that is, as a Platonic and not physical object. A thema might be viewed as a kind of virtual photographic negative of a meme, and the meme's associated instantiating neuronal array, a phenotype, may be viewed as a kind of print of that negative. (This notion of a metaphoric print is formalized in Sect. 5.2.) An exogenous stimulus supplies the input required to initiate a Hebbian synaptic altering process of the synapses of the neuronal array (phenotype) that instantiates (stores) the meme upon which the Platonic thema supervenes. We shall see in Sect. 5 that the relationship between meme and thema has a reflexive aspect. This associative storage of information is multiplexed (Sect. 3.2), and so, the strengthening of one memory record, that is, of one meme may degrade others. This type of tradeoff is present at the lower synaptic scale also, where in a collection of synapses, such as the memetic/thematic genome corresponding to the meme being stored, some synapses increase in strength during memetic encoding/recording while the strength of others might decrease (Sect. 2.1).

Themata compete to be strengthened, which is their way of propagating (as with synapses in Sect. 2). Let us propose that there is a winning thema. For definiteness, say the one that corresponds to the array with the most firing neurons, this being one measure of the currently most active or most successful memetic phenotype. We take consciousness to be an ideal quality (a Platonic primitive), and we propose the following consciousness thesis based upon this hypothesized competition among themata.

> **Consciousness thesis:** The winning thema generates a manifestation of consciousness representative of that thema.

4.4 Consciousness as an agency for propagating the mind, neural correlates

Generation of a manifestation of consciousness requires an appropriate cue, an exogenous sensory input (as do the retrievals from an associative memory as described in Sect. 3.2). So the mind supervenes not only on the entire physical body, but on the environment as well, the latter being the usual source of the cue. If this cue produces a winning thema, then according to the consciousness thesis, the winner's phenotype, a neuronal array that we shall call this

[8] Consciousness and the unconscious may each represent layers of differentiated agencies of the mind.

thema's *neural correlate* generates a representative manifestation of consciousness. Because of this manifestation's form as an awareness of an aspect of the environment, we propose that the neural correlate takes this secondary awareness to be a supplementary sensory input[9]. We suppose that this putative input cues and reinitiates the neuronal processing in question, and so further strengthens that thema through its memetic genome (the relevant synapses) via Hebbian processes (as in Sect. 2.3). That is, the underlying meme is further strengthened (or as we say, propagated.) In this scenario, we see that as an evolutionary development,

a function of consciousness is to act as an agency for strengthening and enlarging the unconscious, that is, as an agency for propagating the mind.

4.5 Grammatical thesis for consciousness, observations on consciousness manifestations

Our considerations motivate introduction of the following thesis. (Compare Chomsky 1953.)

Grammatical thesis for consciousness: There is an intrinsic dynamically increasing self-referential grammar that supports the development of a consciousness repertoire.

We claim that creating the manifestations of consciousness (through the cued memetic retrieval from neural correlates described in Sect. 4.4) is a learned ability informed by this grammar. This creating ability is used repeatedly to develop a repertoire of interpretable manifestations of consciousness. The repertoire grows and consolidates with use. The creating ability itself improves with repetition. Referring to the photographic negative-print metaphor of Sect. 4.3, the prints (memes) that are the constituents of the repertoire are stored multiplexed within various neuronal arrays as associative memories. The corresponding themata, being Platonic primitives, have no attributable location. Even adults with a highly developed consciousness manifestation creating ability and a corresponding repertoire can be presented with a sensory cue that is not readily, indeed if at all resolvable. That is, the information in such a cue defies being parsed by the grammar into an understandable or logical concept (see Sect. 3.3). In formal jargon, the cue is not a (currently) legal sentence of the consciousness grammar. Such a grammar, becoming more robust and more efficient with learning, can be used to parse an increasing range of concepts (sentences of the grammar). That is, the grammar increases its effectiveness as an augmenter of the consciousness repertoire. We project that the learning that underlies the dynamic aspects of the grammar is an example of self-reference analogous to the ability of a stored program in a contemporary computer to operate on itself. Self-reference is the key logical feature of foundations of consciousness described in Miranker, Zuckerman 2008a.

O. Sacks' patient Virgil supplies an illustration of these dynamical features [Sacks 1995]. Blinded as a child, a surgery restored Virgil's sight when he was in his fifties. At first, he was unable to fathom (parse) the cues (light flashes and colors) that were presented to his newly functioning visual system. Slowly he developed some of the requisite abilities and a related repertoire of manifestations ("sentences") of visual consciousness but never to the degree of a

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[9] Similar reentrant perceptual like processes are described by O. Sacks 2007, one example of which is referred to as "release" hallucinations, a second as cross activation.

normally sighted individual. He never became comfortable with his reacquired visual ability, preferring to sit in the dark using Braille and preferring to rely on his cane to get about.

The machinery of memes and their themata, including the competition in which they engage, is an evolved and evolving apparatus. This machinery that we have characterized as functioning by employing an expanding self-referential grammar is used in the development of the repertoire of manifestations of consciousness. Natural selection pressures induce our being invested at building such a repertoire and learning how to manipulate it. The rare cases of feral children demonstrate some of the subtleties of and limitations to this process. Language reveals another aspect. Some speakers of one language cannot hear certain sounds used in another language. Such sounds cannot be heard in a conceptual sense, that is, their corresponding memes (sentences) cannot be parsed. How the manifestations of consciousness in the repertoire take the forms of the qualia so familiar to us remains an open question.

5. A representative for a thema, the concept of natural numbers, genetics

We now employ set theory to introduce formalism into our study of memes and themata. A given meme may have many forms (phenotypes), both physical and Platonic. The thema, being Platonic, could have a virtual representative. In this section we present a method for generating such a representative and develop an example. Although this example corresponds to one of the fundamental concepts of thought, the natural numbers, it has a particularly simple form.

5.1 Themata and APGs

An accessible pointed graph (APG) is a construct consisting of two classes of primitives: nodes and directed edges between certain pairs of those nodes. There is a distinguished node called the point of the APG. Accessibility means that every node in the graph is reachable from the point by a connected path composed of directed edges. (See Fig. 5.1b for an example of such an APG.) Each instantiation of a meme can be made to correspond to an APG, the graph depicting a kind of parsing of that meme. A node is called the parent of its children, namely of those other nodes in the APG that are linked to the parent by a directed edge from the parent. So the children of a node correspond to memes upon which the parent's meme supervenes. Leaves of the APG are those nodes that have no children. So leaves might be considered to be memetic primitives. Decorating an APG is a formal process that associates a unique class of sets (the decoration) with the APG, one set of the decoration with each node. Call Θ the set in the decoration that corresponds to the point. The decorated APG is called a picture (since it is a kind of representation) of the set Θ. See Aczel 1988 for details among which is the assertion that the APG in Fig 5.1b is a particular representation of the concept of the Von Neumann ordinal 2. While to each APG there corresponds a unique decoration, there are in general infinitely many different APGs with a common set Θ decorating their point. So these possibly infinitely many APGs will represent different phenotypes of a common meme. Θ, a Platonic representative of these memetic phenotypes is the construct representative) for the thema we seek. In fact, all of these constructs are Platonic, but as we shall see, some decorated APGs are models of a neural state, namely are

examples of a model of a neural network at a moment of time. The neural state being modeled is a corresponding physical instantiation of the meme in question. Of course, memetic phenotypes may correspond to physical instantiations other than those provided by a neural state.

5.2 Example

Consider the model neural network composed of three McCulloch-Pitts model neurons, *a*, *b*, *c* with the synaptic weights w_{ba}, w_{ca}, w_{bc} shown in Fig. 5.1a [Haykin 2007]. Neuron *a is* firing, but neurons *b* and *c* are quiescent. That is, for the neurons' output activities we have $v(a)=1$, and $v(b)=v(c)=0$. With these data specifications, the network becomes what we have called a neural state. The decorated APG corresponding to this neural state, shown in Fig 5.1b, is a picture of a set Θ. In particular, $\Theta=\{B,C\}$, where the set $B=\varnothing$ and the set $C=\{\varnothing\}$. Here $\{\varnothing\}$ denotes the set whose only element is $\varnothing$, the empty set. $\{B,C\}$ denotes the set with the two elements *B* and *C*. See Zuckerman, Miranker 2008 for details and other examples.

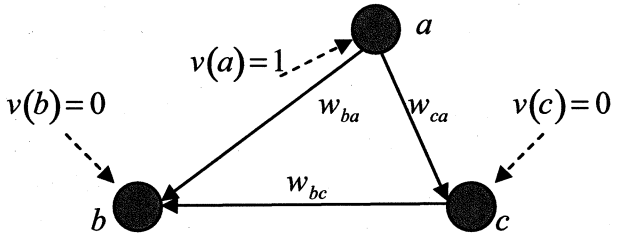

Fig 5.1a: Neural state with neurons *a*, *b*, *c*

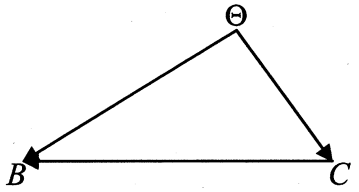

Fig 5.1b: Corresponding APG with point Θ and leaf B

Memes and their thema, neural correlate: The diagram in Fig 5.1b, illustrating a decorated APG, arises from the neural state shown in Fig. 5.1a. Since this APG is a representation of the Von Neumann ordinal 2, *it is an instantiation of the concept (the meme) of the integer 2. The set* Θ *decorating the point is the thema of this meme.* The thema Θ along with the diagram in Fig. 5.1b are Platonic instantiations. The corresponding actual neural state being modeled (such as by the model in Fig. 5.1a), also a meme is a physical instantiation of that meme. *Then such a physical neural state is a player in the competition for generating the manifestation of consciousness (see the consciousness thesis in Sect. 4.3) of the concept of the integer 2.* We shall say that a winning neural state with thema Θ is the latter's *neural correlate.* Then the neural state schematized in Fig 5.1a is a neural correlate of the concept (of the meme) of the natural number 2. (We do not preclude the possibility of a cohort of winners that might result in an extensive neural correlate.) Recall that a single thema such as the example Θ may correspond to any element of an infinite class of neural circuits (memes). The neural state (such as the one in Fig. 5.1a) and the APG (such as the one in Fig. 5.1b) are examples of a potentially infinite number of neuronal assemblies and corresponding APGs that can have this same thema Θ. So we say by analogy that each meme in the class whose thema is Θ is a picture of that Θ. In terms of the photographic negative and print metaphor in Sect. 4.3, we view such a picture as a print.

5.3 Memes and genetics

We conclude with observations that connect genetics and differentiation in embryonic development to memes and themata.

Memes and chromosomes: Take a chromosome to correspond to the point of an APG. Take the point's children to be the chromosome's primary constituent groupings of genes. (See footnote 2.) This arrangement along with the decoration of the APG generates a set, set-element relationship. Such groupings, which have a temporally changing character, are specified by the biology. To layers of such genetic groupings, there correspond layers of parent-child relationships in the APG. Moreover, genes or a grouping thereof have a time varying state of activity/inactivity. Other genes and epigenetic processes turn them on/off. This generates dynamics defined on the of associated APGs, since genes or groupings thereof corresponding to nodes in the APG could be taken to be present only when that gene or grouping is active. This induces dynamics on the associated decorations [Miranker, Zuckerman 2008b]. These dynamics may cause an associated appearance/disappearance of loops of edges inside such APGs, that is, a selected flipping among the associated sets' types (possibly a flipping of these sets between being what are called well-founded and non-well-founded [Aczel 1988]). Compare these loops with Sheehans's looping pathways by means of which he asserts that patterns can iteratively propagate, mutate and evolve. For Sheehan 2006, these pathways collectively work toward creation of an intelligent mind. The appearance of these two set types suggests a connection of the present framework with a development of mathematical foundations of consciousness of Miranker, Zuckerman 2008a. These authors show that those neural assemblies that may form a candidate neural correlate of a meme, generate in turn a class of decorated APGs each of which serves as an ideal memetic phenotype. As noted in Sect. 5.1, the set Θ in the decoration that corresponds to the point of such an APG is a Platonic representative of the thema corresponding to the class of memes in question. Indeed we asserted (Sect. 5.2) that this set Θ is the thema itself.

Differentiation in development: The messenger RNA and the proteins encoded by the genes (or groupings thereof) are also characterizable within this framework. Such proteins, constituting a first stage in the production of the associated biotic phenotype, correspond to a leaf in an APG, the latter graph characterizing a hierarchy in the differentiated embryonic development of the phenotype that ensues. See Sect. 3.3, and in particular footnote 3.

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