philosophies

MDPI

Article

Hylomorphism Extended: Dynamical Forms and Minds

Włodzisław Duch

Cognitive Science Department, Faculty of Humanities, and Neurocognitive Laboratory, Nicolaus Copernicus University, 87-100 Toruń, Poland; wduch@is.umk.pl

Received: 17 September 2018; Accepted: 15 November 2018; Published: 19 November 2018

Abstract: Physical objects are compounds of matter and form, as stated by Aristotle in his hylomorphism theory. The concept of "form" in this theory refers to physical structures or organizational structures. However, mental processes are not of this kind, they do not change physical arrangement of neurons, but change their states. To cover all natural processes hylomorphism should acknowledge differences between three kinds of forms: Form as physical structure, form as function resulting from organization and interactions between constituent parts, and dynamical form as state transitions that change functions of structures without changing their physical organization. Dynamical forms, patterns of energy activation that change the flow of information without changing the structure of matter, are the key to understand minds of rational animals.

Keywords: hylomorphism; mind; form; matter; neurodynamics

1. Introduction

Identity of physical objects has been conceptualized in history of philosophy in various ways. The most obvious distinction that has been made is between matter and form. Abhidharma Buddhist tradition acknowledges the material form or body (rūpa) as the basic type of aggregate, and adds four types of aggregates to characterize mental level: sensations, apperception, volitions or dispositional formations, and consciousness [1,2]. In ancient Western philosophy Aristotle in *Physics* has introduced distinction between form and matter that considered together characterize physical and mental objects. This idea, called hylomorphism, became the foundation of Thomist philosophy in the 13th century [3]. Hylomorphism has been quite influential philosophical theory since antiquity, and is still frequently discussed in contemporary analytical philosophy and theology [4,5], including mechanistic philosophy of biology and neuroscience [6,7]. In preface to the book "Neo-Aristotelian Perspectives on Contemporary Science" John Haldane writes about "shared sense that Aristotelian ideas have much to offer", and the introduction, written by the editors of this book, starts with a claim "A recent revival in (neo-)Aristotelian philosophy is beginning to transform the landscape of contemporary analytic philosophy" [8].

Form and matter establish properties of physical objects. Frequently form has simple interpretation as structure, arrangement of constituting elements, such as bricks in the building or atoms in molecules. It unifies matter into objects that have specific properties, determining interactions with other objects. Form may also refer to the organizational structure based on interactions between elements that define the identity of the whole. Aristotle has extended hylomorphic concept into the animal and human realm in his *Metaphysics* and other works. In *De Anima* he describes body and soul as a special case of matter and form. Living organism is not identified on the basis of anatomy, but also all functions that characterize it. The form of a dead body is different than living body although the arrangement of atoms may be quite similar. In *Metaphysics* "form" is presented as an essence of things composed of "substance", making the concept of hylomorphism more abstract. Form is not restricted to physical structure, functional organization, nor dynamical states of matter, it is the stable essence that endows substances with particular properties, making different types of things. This idea has been linked to the *phenotypic plasticity* by Austin and Marmodoro [8] (Chapter 7 and 8), continuous dynamically connected landscape that unfolds in morphological space, maintaining the identity of evolving organisms.

Ancient philosophers have been struggling to adapt the concept of form to describe living beings and in particular humans. The substantial form of a material body, called in Thomist philosophy "soul", was understood as the animating essence of plants, animals and rational humans. De Haan [7] calls this approach "hylomorphic animalism" (HMA): Animals are complex unified psychosomatic substances endowed with integrated biological and psychological attributes. Explanation how this animated principle relates to sensory and intellectual powers was of course well beyond the capability of ancient and medieval philosophers. Full description of mechanisms responsible for the structure and behavior of animals requires development of phenomics at many levels: genetic, molecular, cellular, network and tissues, organs and organisms, interactions with other organisms and ecosystems at different spatial and temporal scales. The Research Domain Criteria of the National Institute of Mental Health, developed to understand mental disorders, are the first step in this direction [9], but achieving this goal will take many decades. Mechanisms explain how component elements forming structures at some level are organized, how they interact, creating various phenomena such as gene expression, binding of neurotransmitters to receptors, or activating brain structures that lead to phobias. These mechanisms may be stochastic, distributed, and may refer to irreducible multi-level organization.

This paper has been written in an attempt to understand better the concept of form and to distinguish between different kinds of forms. Form may be understood as physical structure or as functional organization that involves interacting physical entities. The third kind of form, called here "a dynamical form", has not been clearly distinguished from other two types, but seems to be vital for understanding brain-mind connections. Characterization of different kinds of forms should help to develop hylomorphic ideas further.

2. Different Kinds of Forms

Hylomorphism is based on the conviction that substance and form are basic ontological and explanatory principles. Modern science is concerned with matter, energy and information. Matter and energy may be connected to substance and form, but information has no counterpart. Physical entities are composed of elements: atoms, molecules, or more complex structures arranged in some ways. Matter is a form of energy, interactions between elements lead to formation of physical structures, some transient and some stable. The most common sense of "form" is relatively stable physical structure.

Physical form of objects may not be sufficient to determine specific ontological category. A unique chair may have many attributes defining its shape and materials that it is made from. However, general ontological concept of a "chair" cannot be defined listing various shapes and material compositions. It cannot also be understood by its function, as one may sit on the bench, stool, tabouret and many other types of pieces of furniture. Moreover, natural concepts are understood in a different way by people, depending on their age and culture [10]. Still, we can say about each particular chair that it has specific shape and it is built from some kind of matter. Form may substantially change, but the category of the object may still be preserved. Here we are touching on the problem of categorization in cognitive psychology and the definition of ontological concepts (cf. Handbook of Categorization in Cognitive Science [11]). The exemplar theory of categorization defines "a chair" as an object that may be used to sit on, and is similar to some examples of objects known as chairs. Hylomorphism simply says that real objects are irreducible unified form-matter wholes, with specific organization of material components, but it does not help to define ontological categories.

Some objects do not have permanent or definite form. Clouds behave in chaotic way. Kinetic sculptures moved by the wind may demonstrate various structures that change in unpredictable way. Molecules oscillate between various conformations, have vibrating and rotating fragments, taking several shapes that have different properties. **Flexible forms** may have finite number of spatial arrangements if local structures are preserved (chemical bonds, snowflakes), or an infinite number of possible shapes (clouds).

How stable are forms? Larger objects change much slower, enabling reification, naming of objects that preserve their forms for a longer time. At the microscopic level everything is moving incredibly fast, atoms vibrate and interact changing their arrangements at the timescale of picoseconds. Complex molecules, such as amino acids, are formed even in deep space. The $C_{25}H_{52}$ molecule has 25 carbons and 52 hydrogens, but these atoms may be arranged in about 36 million of different spatial forms, or isomers. Each spatial structure may be in many different dynamical states (electronic, vibrational and rotational excited states), most of which are stable only for a very short time. Each dynamical state has different properties, such as probability of interactions with other molecules or interactions with light, responsible for the absorption and emission spectra. Small molecules at quantum level may assume many discrete dynamical forms, influencing structural form to various degrees. For larger molecules or for highly excited states there are so many similar transient forms that in practice there is a continuum of possible structures.

Form may also be understood **as a process** that changes physical structure in a way that is typical for some objects. Transitions between specific forms may be slow, preserving the identity of objects for some time, or may have character of rapid phase transitions, like changing water into ice or vapor. Form can also change in a stochastic way. Each snowflake has unique form coming from the crystallization of water. The theory of dynamical systems describes different kinds of system behavior using the concept of attractors: point attractors leading to stable structures, limit cycles, strange attractors that characterize chaotic movements. Objects may change form, or have multiple forms, but preserve their identity and be categorized in the same way.

The concept of form as structure applied to biological processes results from reification based on perception in short time scales of common characteristics that are roughly preserved. Organisms have specific, relatively stable organization at macroscopic level, that relies on dynamic processes supporting life at the microscopic (cellular and genetic) levels. Structure of adult organisms at macroscopic level may change slowly and there are many developmental pathways that lead to the relatively stable structures. Conrad Waddington wrote 20 books illustrating how gene regulation modulates development, using the metaphor of "epigenetic landscape". The idea that organisms are processes, has been recently emphasized in the philosophy of biology [12]. Evolutionary biology has Metamorphosis is quite common in animal kingdom, leading to a fast complete change into another structural form. Caterpillars change into butterflies, various insects change from larvae to very different forms, tadpoles change into frogs and tunicates start as swimming animals and end up as filter feeders. Fish can change their sex and even size in relatively short time. In the lifetime of animals structural stability is observed only in some time windows, where form as a structure can be applied. Quick growth from a single cell, metamorphosis and decay are better characterized by understanding form as a process. Even in the period of relative stability at the macroscopic level, structure at the cellular level may change quickly: New cells replace old ones within days, outer layer of skin is replaced every two weeks, and the whole human skeleton is renewed in a decade. Identity of structural form depends on the time window and the tolerance for small differences that are always present. Changes at the atomic level are always taking place, so one may claim that there are no static structural forms. As all natural concepts "structural form" is only an approximation that has limited applicability.

Form as a process represents regularities of transitions between structural forms, developmental path, but it is still based on rearrangement of physical elements. However, there are processes that do not require such rearrangements even at atomic level. In electronic circuits structure of connections does not change at all, atoms are not moved, but patterns of electrical activations bind different elements without changing physical structures. Information in computers flows through different pathways, engaging multiple threads in complex processors, or recruiting a number of processors in parallel. Internet networks send information through different routes. **Dynamical forms** emerge at the macroscopic level and are qualitatively different from other types of forms [13]. Although spatial arrangement of atoms is not changed electric potentials create various patterns that can be measured. Information stored in computer memory does not occupy space. Magnetic moments of atoms are used to store information, gates in semiconductors direct currents without moving any physical structures, light intensities in optoelectronic devices decide on the light patterns. Such changes are based on internal states of atoms, but do not require their physical movements.

One can imagine intermediate cases where distinction between dynamical forms, and forms as processes based on physical rearrangement is blurred. Time scale for changes of brain structure (learning, aging) and changes of mental processes (perceptions, thoughts) allow for clear distinction of forms that are almost static physical structures, and rapidly changing dynamical forms. Connectomes, specific sets of connections between different brain areas, offer unique individual fingerprints explaining intellectual and sensory power of animals, including humans [14]. The structure of these connections is changed due to neuroplasticity at different time scales, so the brain anatomical form and functions are constantly changing. Mental phenomena are a result of dynamical processes taking place on networks defined by connectomes, creating patterns of quasi-stable bioelectrical activations.

The functional connectome has been intensively studied in the last decade [15]. Functional connections are formed on a network of structural connections, but do not change in a significant way their physical form in the short time scale. Percepts, thoughts and feelings result from activations that change states of groups of neurons, exciting or inhibiting them, but there is no new arrangement of matter involved. Dynamical forms in the brain are observed at the macroscopic level using electrophysiological and neuroimaging methods. Minute changes at the atomic level are not relevant to understand emerging global activation patterns.

The concept of **form** may be applied to population of entities **at different level of abstraction**. Biological taxonomy is based on a selection of distinctive properties in a hierarchical way, from species to domains, with more general taxa having fewer properties. This is not the same as the form understood as the essence of organism capturing its whole organization. Characterization of species is not based on accidents, all properties at this level belong to the essence of biological organisms. At the rank of domains very few properties are left. The essence of the abstract concept of eukaryotes is based on cells that have a nucleus enclosed within membranes.

Amorphic hylomorphism [16] searches for the essence of objects not in their physical form, but in "how they come to exist and what their functions are (the coincidence of formal, final, and efficient causes)". Intention of agents creating artefacts from their initial matter to perform specific function gives them identity. Evolution may act in similar way as agents that creates organisms.

Various approaches to hylomorphism are based on different concept of "form": Physical static or flexible structures, processes that have distinct stages, dynamical forms based on activation patterns, highly abstract categories, or intentions of agents behind creation of artefacts or organisms. "Form" is thus a very general concept that refers to quite different phenomena. The should be clearly recognized in discussions on hylomorphism.

3. Mental States as Dynamical Forms

Since hylomorphism assumes complete integration of form and matter there is no place for the mind-body separation, and thus there is no mind-body problem. It is the organizational structure of the animal that animates it. Mental properties are simply attributes of the whole organization of form-matter complex. They are implemented by lower level mechanisms, but it is the whole animal that has sensory powers, perception, memory, emotions and volition, grounded in its ecosystem [7]. Physical, chemical, molecular properties evolved to maintain "efficient animation", leading to organization of the organism that helped it to survive.

Environment may have critical influence on the form of brain activity, leading to the ideas of extended mind [17,18], embodiment and enactivity [19]. In case of strong coupling between organism and environment form should encompass whole organism and the part of the world that has influence on this organism. On some accounts it should even be extended to encompass the whole evolutionary history [16]. Since everything in the Universe is interdependent boundaries between different forms of objects are always approximate. At the microscopic level this becomes a serious problem because in quantum mechanics there is no way to describe separate objects that have interacted in the past [20].

Relation of the hylomorphic view to strong emergence have recently been discussed by de Haan [7]. He has used distinction between mechanistic organization and psychological organization. Mechanistic organization "explains the way psychosomatic powers, their operations, and diverse forms of psychological organization among these powers and operations are constituted from and enabled by the organized sub-psychological level interactions among neural and other biological components". "Psychological organization explains the psychological level interactions between the animal's psychosomatic powers and objects in the animal's environment". From the point of view of phenomics [9,21] this corresponds to mechanisms at the level of genes, molecules, cells, circuits, and physiology responsible for "mechanistic organization", identifying behavioral level with "psychological organization". Constructs used in neuropsychology include also self-reports, subjective aspects of phenomenal experience, that only partially are manifested in behavior.

The physical brain structures are a substrate in which dynamical forms arise. Structural connectivity is also called anatomical, because it is based on direct structural connections between neurons, axons interconnecting brain regions. Such connections may be traced using magnetic resonance imaging fiber tractography methods and observed using various forms of microscopy. However, neurons that are anatomically connected are not always functionally connected. On anatomical networks sparse, rapidly changing patterns of activation arise, creating virtual subnetworks that are needed to accomplish various functions. Each neuron may be a member of one subnetwork and a moment later of another subnetwork. These patterns are correlated with subjective experiences. **Mental states supervene on dynamical forms**.

Aristotle described perception as the reception of form without matter. Perception of sensory or mental events needs a substrate of brain matter, but (at least in the short time scale) does not require structural changes in the brain. Most of the things that appear briefly in our short-term memory do not leave permanent traces in brain structures. The same physical structure of computer circuits may carry an infinite number of dynamical patterns, some of them appearing as different images on the screen. The meaning of these patterns is analyzed internally in the computer system or by biological brains. Results are expressed through activation of effectors: images on the screen, sounds from speakers, transmission of internet signals, robot movements, gestures and speech. Animals express their mental states on the "canvas of the body", as Damasio [22] has put it.

Dynamical forms are based on energy flow in complex networks, rather than rearrangement of material elements. Neuroimaging and EEG/MEG studies allow for decomposition of brain states into basic patterns that correspond to affective and cognitive psychological factors [23]. Objects that people see or imagine can be reconstructed from brain activity using functional magnetic resonance [24]. Detailed images of faces seen by a monkey have been reconstructed from just 205 electrodes measuring spiking activity of neurons in visual cortex [25]. Our ability to reconstruct mental states, such as intentions, decisions, memory, emotions or imagery, from analysis of brain activity has been greatly improved in recent years and is used now in brain-computer interfaces.

At molecular level every neuron and other cells change constantly, but at the macroscopic level these changes are not visible. This fact may be called "**stochastic stability**" of structural forms. Form of the brain includes organization of matter that has different temporal dynamics: connectivity, neuronal structures, biochemistry, signaling pathways, genetics. The concept of form refers to structural phenotypes that involve multiple levels of description. **Dynamical form** that rapidly changes in time and is the basis of mental states and behavioral functions may be defined at different structural levels, from the activity of single neurons to the activity of large brain regions. Anatomical form is observed using structural imaging techniques (such as MRI), while dynamical form is observed using functional neuroimaging techniques (such as fMRI). On a longer time scale changes of the structural connectome must precede new dynamical forms that can be observed in functional connectomics [26].

Computers may run infinite number of different programs that support quite different functionality. Their dynamics may be emulated on other computers, all processes may be repeated in the exactly the same way. Although a computer chip may contain billions of elements and perform many complex functions its whole organization does not support spatiotemporal states that are similar to those created by biological neural networks [27]. In case of brains only neurodynamical states that can be distinguished from noise (in agreement with the signal detection theory [28]) may become percepts. These continuous dynamical processes differ in a fundamental way from those of a Turing machine. They include seeds of many new accessible brain states that may follow. History, context and stochastic processes determine next brain state, dynamical pattern that contributes to a new interpretation of meaning of mental state.

Brains that have the same physical form, structure of connections and properties of neurons, may support huge number of functional, neurodynamical states. A large number of processes go on in parallel in computers and brains, but only a few are change behavior in a noticeable way, either by activating effectors (motor actions) or by facilitating internal recognition, interpretation and memory processes. Psychological organization is based on dynamical forms that arise in the space of possible activations of the brain or sufficiently complex brain-like artificial networks. Mental states arising in this space are constraint by knowledge embedded in the structure of neural networks, following certain associative logic between accessible brain patterns. Each mental event—a thought, feeling or intention—changes this dynamical structure without changing the form of physical brain structures in a perceivable way. Brain dynamics cannot be replicated in exactly the same way by other brains, but also cannot repeat itself exactly in identical way in the same brain. The basic structure of the brain is genetically encoded and develops later through neuroplasticity as a result of learning, repeated interactions with the environment and one's own body. Describing all these phenomena requires detailed analysis of different types of structures, processes, and dynamical forms.

Because the brain neurodynamics contains much more than conscious mental processes (unconscious regulations of huge number of bodily processes, precise muscle coordination etc.) one can justify the metaphor "**mind is a shadow of neurodynamics**" [29]. Words and gestures point at some brain activations and processes at the mental level facilitating transmission of meaningful information, creating a kind of resonance of mental forms. Only recently it has been shown using information theory that macroscale description (symbolic) can be more informative than detailed microscale description (neural activity). This phenomenon has been called the "**causal emergence**" [30]. Knowledge contained in the whole structure cannot be derived from knowledge contained in separate parts that constitute some structures. The mathematical apparatus of quantum theory has been applied to various aspects of psychology (see [31]). There is no assumption that real quantum effects are needed to understand cognition. Holistic approach offered by quantum mechanics is used to describe some counter-intuitive results in the psychology of decision-making without involving internal mechanisms.

Conscious processes engage a large groups of neurons leading to activations of specific subnetworks that are sufficiently strong to be identified and distinguished from noise, in agreement with the signal detection theory, one of the most influential of all psychological theories [28]. Conscious processes may be viewed as perceptions of dynamical forms, synchronous activations, that arise in the brain. Scientists search for neural correlates of conscious processes [32,33], trying to characterize which patterns are perceived as conscious and which will decay unnoticed. Learning processes change physical connections in the brain and thus change patterns activated by neurodynamics. Studying such processes tells us which mental states (dynamical forms) are potentially accessible for brains that have specific structure, depending on the individual connectome and other factors (neural properties, ion channel types and their distribution, neurotransmitter release etc.).

Mental processes are supported by the brain that provides a substrate in which what is potentially possible may be actualized, influence behavior and become conscious experience. Dynamical form is an information process that changes the state of matter, but not the matter itself. Mind is thus truly non-materialistic, based on dynamical forms that are actualized by neurodynamics in a way that depends on many circumstances, including personal history.

4. Conclusions

Psychological and philosophical constructs are high-level abstractions that may help to understand phenomena only if they reflect the relevant scientific knowledge [11]. Otherwise we shall abide in the sea of abstract concepts that are disconnected from reality, but allow to produce wise statements that have little meaning. In case of hylomorphism the concept of "form" has been used to describe quite different phenomena that should be clearly distinguished: static structures of physical objects, evolving structures that rearrange physical elements, amorphic forms based on intentions, dynamical forms that change states of matter without changes of physical structures.

Recognizing many ways in which the concept of form is used should help to clarify and develop further hylomorphic ideas. In particular dynamical forms have not been distinguished clearly from other types of forms. They arise in the networks that send streams of information to the distributed devices, computational systems that relay on patterns of coordinated activity between their processors, and the brain neural networks that show complex patterns of activations. In all these cases patterns of active elements change rapidly without physical changes of network structures. The anatomical connections in the brain create a substrate in which huge number of dynamical forms may arise. The functional connectome shows these dynamical patterns that arise in the brain resting state and task-dependent patterns arising in different experimental conditions. There is a lot of evidence that all mental states supervene on these dynamical forms [14,15]. They seem to provide a natural bridge between mental and physical states. Therefore dynamical forms are an important concept that should be included in discussions of the hylomorphic theory and the mind-body problem in general.

Funding: This research received no external funding.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Ronkin, N. Abhidharma. In *The Stanford Encyclopedia of Philosophy (Summer 2018)*; Zalta, E.N., Ed.; Metaphysics Research Lab, Stanford University: Stanford, CA, USA, 2018.
2. Coseru, C. Mind in Indian Buddhist Philosophy. In *The Stanford Encyclopedia of Philosophy*; Zalta, E.N., Ed.; Metaphysics Research Lab, Stanford University: Stanford, CA, USA, 2017.
3. McInerny, R.; O'Callaghan, J. Saint Thomas Aquinas. In *The Stanford Encyclopedia of Philosophy (Summer 2018)*; Zalta, E.N., Ed.; Metaphysics Research Lab, Stanford University: Stanford, CA, USA, 2018.
4. Ainsworth, T. Form vs. Matter. In *The Stanford Encyclopedia of Philosophy*; Zalta, E.N., Ed.; Metaphysics Research Lab, Stanford University: Stanford, CA, USA, 2016.
5. Jaworski, W. *Structure and the Metaphysics of Mind: How Hylomorphism Solves the Mind-Body Problem*; Oxford University Press: Oxford, UK, 2016.
6. Craver, C.F. *Explaining the Brain: Mechanisms and the Mosaic Unity of Neuroscience*; Oxford University Press: Oxford, UK, 2007.
7. De Haan, D.D. Hylomorphic Animalism, Emergentism, and the challenge of the New Mechanist Philosophy of Neuroscience. *SetF* **2017**, *5*, 9–38. [CrossRef]
8. Simpson, W.M.R.; Koons, R.C.; Teh, N.J. (Eds.) *Neo-Aristotelian Perspectives on Contemporary Science*; Routledge: Abingdon, UK, 2017.
9. Insel, T.; Cuthbert, B.; Garvey, M. Research Domain Criteria (RDoC): Toward a new classification framework for research on mental disorders. *Am. J. Psychiatry* **2010**, *167*, 748–751. [CrossRef] [PubMed]
10. Carey, S. *The Origin of Concepts*; Oxford University Press: Oxford, UK, 2009.

11. Cohen, H.; Lefebvre, C. (Eds.) *Handbook of Categorization in Cognitive Science*, 2nd ed.; Elsevier: Amsterdam, The Netherlands, 2017.
12. Nicholson, D.J.; Dupré, J. (Eds.) *Everything Flows: Towards a Processual Philosophy of Biology*; Oxford University Press: Oxford, UK, 2018.
13. Duch, W. Why minds cannot be received, but are created by brains. *SetF* **2017**, *5*, 171–198. [CrossRef]
14. Mišić, B.; Sporns, O. From regions to connections and networks: New bridges between brain and behavior. *Curr. Opin. Neurobiol.* **2016**, *40*, 1–7. [CrossRef] [PubMed]
15. Preti, M.G.; Bolton, T.A.; Van De Ville, D. The dynamic functional connectome: State-of-the-art and perspectives. *NeuroImage* **2017**, *160*, 41–54. [CrossRef] [PubMed]
16. Evnine, S.J. *Making Objects and Events: A Hylomorphic Theory of Artifacts, Actions, and Organisms*; Oxford University Press: Oxford, UK, 2016.
17. Clark, A.; Chalmers, D.J. The extended mind. *Analysis* **1998**, *58*, 7–19. [CrossRef]
18. Menary, R. (Ed.) *The Extended Mind*; MIT Press: Cambridge, MA, USA, 2010.
19. Thompson, E. *Mind in Life: Biology, Phenomenology, and the Sciences of Mind*; Harvard University Press: Cambridge, MA, USA, 2007.
20. Duch, W. Synchronicity, mind and matter. *Int. J. Transpers. Stud.* **2003**, *21*, 155–170. [CrossRef]
21. Duch, W. Brains and education: Towards neurocognitive phenomics. In *Learning While We Are Connected*; Reynolds, N., Webb, M., Sysło, M.M., Dagiene, V., Eds.; Nicolaus Copernicus University Press: Toruń, Poland, 2013; Volume 3, pp. 12–23.
22. Damasio, A. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*; Mariner Books: San Diego, CA, USA, 2000.
23. Nishida, S.; Nishimoto, S. Decoding naturalistic experiences from human brain activity via distributed representations of words. *NeuroImage* **2018**, *180*, 232–242. [CrossRef] [PubMed]
24. Horikawa, T.; Kamitani, Y. Generic decoding of seen and imagined objects using hierarchical visual features. *Nat. Commun.* **2017**, *8*, 15037. [CrossRef] [PubMed]
25. Lee, H.; Kuhl, B.A. Reconstructing perceived and retrieved faces from activity patterns in lateral parietal cortex. *J. Neurosci.* **2016**, *36*, 6069–6082. [CrossRef] [PubMed]
26. Zuo, X.-N.; He, Y.; Betzel, R.F.; Colcombe, S.; Sporns, O.; Milham, M.P. Human Connectomics across the Life Span. *Trends Cogn. Sci.* **2017**, *21*, 32–45. [CrossRef] [PubMed]
27. Duch, W. Brain-inspired conscious computing architecture. *J. Mind Behav.* **2005**, *26*, 1–22.
28. Green, D.M.; Swets, J.A. *Signal Detection Theory and Psychophysics*; Wiley: New York, NY, USA, 1966.
29. Duch, W. Mind-Brain Relations, Geometric Perspective and Neurophenomenology. *Am. Philos. Assoc. Newsl.* **2012**, *12*, 1–7.
30. Hoel, E.P. When the Map Is Better Than the Territory. *Entropy* **2017**, *19*, 188. [CrossRef]
31. Pothos, E.M.; Busemeyer, J.R. Quantum principles in psychology: The debate, the evidence, and the future. *Behav. Brain Sci.* **2013**, *36*, 310–327. [CrossRef] [PubMed]
32. Koch, C.; Massimini, M.; Boly, M.; Tononi, G. Neural correlates of consciousness: Progress and problems. *Nat. Rev. Neurosci.* **2016**, *17*, 307–321. [CrossRef] [PubMed]
33. O'Regan, J.K.; Noë, A. A sensorimotor account of vision and visual consciousness. *Behav. Brain Sci.* **2001**, *24*, 939–1011. [CrossRef] [PubMed]