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Aristotle and Modern Cognitive Psychology and Neuroscience: An Analysis of Similarities and Differences

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Aristotle extended his hylomorphic theory of reality to formulate an account of human psychology. This essay examines parallels and differences between Aristotle's account and that of modern day cognitive psychology and neuroscience. Most similarities appear to exist in the areas of sensation, perception, and memory; however, at the levels of higher cognitive functioning, Aristotle would assert the need for a dualist ontology.

Keywords: Aristotle, dualism, cognitive psychology, neuroscience

Aristotle's formulation of human psychology is presented primarily in his major work, De Anima (trans. 1907). As pointed out by Shields (2003), Aristotle's psychology is an extension of his general metaphysical position, hylomorphism, which postulates an understanding of reality by means of the four causes: efficient, material, formal, and final. The efficient cause is the agency generating a particular thing. The material cause is that from which something is generated. The formal cause is the structure the matter becomes, that which specifies what it is. The final cause is the purpose or end of the object, its function. A classic example of the four causes is Aristotle's commentary on sculpting a statue. The efficient cause is the sculptor and his sculpting; the material cause is the block of marble; the formal cause is the image to be sculpted, e.g., a statue of Hermes which specifies the "what it is" of the statue; and the final cause is the purpose, to create and

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exhibit art. Aristotle also used the concept of final cause at the intentional or mental level to describe the agent's plan for the work and purpose of the work.[1]

An important principle of the hylomorphic theory is the distinction between substantial and accidental forms. Substantial form is essential to the thing and accidental form is a quality of (inhering in) the substantial form but not essential to it. In the statue example, its substantial form would be that of a statue or depiction of someone or something. Accidental forms are such qualities as color, height, type of material, and such.

Aristotle applied hylomorphic theory in his analysis of human cognitive capacities, using the term soul (psyche) to describe the formal cause of that which makes a human, human. However, he did not start at the highest level of human cognitive capacities. Rather he described several capacities or faculties of the psyche, many of which are shared with other forms of life. Hence, he begins with nutrition and locomotion and proceeds on to perception and mind. For our purposes, I will focus on the faculties of perception and mind. For Aristotle, the capacity for perception marks the demarcation line between animals and plants.

Aristotle's explanation of perception relies on an extension of the hylomorphic theory of change. Shields (2003) states:

> Aristotle treats perception as a case of interaction between two suitable agents: objects capable of acting and capacities capable of being affected. Aristotle is happy to speak of the affected thing as receiving the form of the agent which affects it and of the change as consisting in the affected thing's "becoming like" the agent. (p. 11)

It is important to note that the receiving perceptual capacity must be attuned to receive the forms of the sending object. Hence, although reflected light waves from the book in front of me are impacting every other object in my office, only my eyes and related brain structures are capable of perceiving, that is, capable of receiving the sensory forms carried in the light waves resulting in visual perception. Light waves impacting my file cabinet do not result in perception.

Aristotle's consideration of perception focused on the five senses, shared in common by man and animals known at the time. However, he also described imagination, noted both in man and most animals, as a distinct faculty which produces, stores, and recalls images. Hence, he included a capacity for memory

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[1]For the most part, psychology has ignored Aristotle's hylomorphic theory. The most notable exception is the work Rychlak (1973) who incorporated hylomorphic theory in his formulation of personality and later made extensive use of Aristotle's concept of final cause in his development of logical learning theory (Rychlak, 1994). However, very recently, Spalding and Gagne (2013) made a forceful argument for use of the Aristotelian–Thomistic view of concepts as a theoretical framework capable of unifying competing theories in cognitive psychology. Their views complement one of the conclusions expressed in this essay, namely, that a Aristotelian meta-theory could serve as an organizing framework for cognitive psychology.

processes; and, as noted by Shields (2003), described these stored images as likenesses or copies of external objects. Later medieval philosophers (Avicenna, Aquinas), building on Aristotle, described five "internal" senses: the common sense, which receives and arranges all sense data; the phantasia or phantasm, which retains the sense data; the imagination which combines and reassembles images from the phantasia; the estimative faculty, which gauges the dangerousness of the sensed object; and the memory, which retains the sensory level images or representations for later use.

For Aristotle, it is mind or intellect which, in fact, creates the demarcation line between man and other animals. Aristotle defines humans as rational animals, sharing many capacities with other animals but not mind. It is this faculty or capacity in man that allows for understanding. Aristotle's position regarding mind in relation to that of cognitive psychology and neuroscience will be presented in more detail later.

Aristotle, Cognitive Psychology, and Neuroscience

The Mechanisms and Models

Cognitive psychology is concerned with multiple phenomena: sensation, perception, memory, and higher cognitive functions, such as category formation, thinking, decision making and the like. At every level, cognitive psychology employs psychological constructs, now often referred to as mechanisms or models, as essential components in theories designed to explain the phenomena in question. These mechanisms or models appear to be equivalent in philosophy of science terms to hypothetical constructs. McCorquodale and Meehl (1948) noted that psychological constructs, such as intelligence and motivation, contain surplus meaning not exhausted by single observable referents and were (and are) essential in formulating explanatory theories in all branches of psychology. Later, Cronbach and Meehl (1955) attempted to extend the conceptual meaning of hypothetical constructs via the notions of construct validity and the nomological network. They asserted that the meaning of, or at least the usefulness of, a hypothetical construct, such as intelligence, could be established by its ability to predict a wide range of behaviors and by its functional relationships in a network of other constructs. As cognitive psychology has aligned itself more with neuroscience and the computational model employed by most of neuroscience, the hypothetical constructs of cognitive psychology and neuroscience have been reduced in number but have not been eliminated.

Hypothetical constructs contain varying degrees of surplus meaning and meaning claims. Hypothetical constructs appear in at least two forms, those referring to "entity-like" structures used in explanatory accounts and those referring to hypothesized processes explaining how the entity-like structures

proceed or interact. Examples from the cognitive psychology and neuroscience literature will help clarify the point.

Perception. E. Roy John (2002) employs the construct of perceptual frames to explain perceptual binding:

> A degree of consistency must persist across a sequence of perceptual frames, analogous to a "sliding comparator." Adaptive response to the environment requires that sensory information be evaluated in the context of the previous frame, as well as working and episodic memories. (p. 5)

Although in John's schema the perceptual frame is anchored in brain structures, still this construct serves as the explanatory mechanism over and above those brain structures and even is claimed to have evaluative powers, tying the frames together and to other hypothetical cognitive structures involved in working and episodic memory. Hence, John's perceptual frame is an example an explanatory hypothetical construct having both an "entity-like" structure and hypothesized interactive processes with other "entity-like" structures.

Memory. Theories of memory require multiple hypothetical constructs, often tied together in a nomological network fashion. Baddeley and Hitch's (1974) model of working memory is a well-known example in which a master construct, the central executive, "acts as a supervisory system" controlling the flow of information into three lower-level "slave system" constructs: the phonological loop, the visuo-spacial sketchpad, and the episodic buffer. The theory holds that interaction among these systems accounts for empirical data observed in studies of normal subjects as well as those with brain lesions. Although these constructs have been increasingly identified with neuroscience and the computational model, they still have the ontological status of constructs and are, in fact, tied together in nomological network fashion.

Higher cognitive functions. Explanatory accounts of higher-order cognitive phenomena are replete with hypothetical constructs, usually presented in a multi-construct, nomological network fashion. For example, Smith, Patalano, and Jonides (1998), discussing cognitive psychology's four theoretical approaches used to explain category formation, focused on the two most prominent: rule application and exemplar similarity. In their discussion of rule application, Smith et al. state that individuals must abstract elements and then evaluate them in reference to the "representation of the test object." Additionally, individuals must keep the rule and the comparison elements in working memory. Here we see examples of a hypothesized process and two "entity-like" constructs (the representation and the working memory). With regard to the exemplar similarity theory, Smith et al. speak of "entity-like" structures, the exemplar and the exemplar as a representation. The hypothesized process of matching is facilitated by interaction with working memory. As with perception and memory, these constructs have increasingly been discussed within a neuroscience framework

in an attempt to weave together cognitive constructs and underlying brain structures (see Smith and Jonides, 2000).

Increasingly, neuroscience has attempted explanatory accounts that are primarily brain based. In a paper on categorization, Seger (2008) describes the basal ganglia and its corticostriatal loops as prominent in accounting for visual categorization. The discussion is primarily related to brain structures; however, the term representation is utilized in the account, suggesting that at least one hypothetical construct must be retained.

Aristotle recognized the need for hypothetical explanatory structures similar to the mechanisms and models utilized by modern cognitive psychology and neuroscience. Indeed, as will be elaborated later, he postulated mental mechanisms to explain observed phenomena in perception, memory, and especially higher-order cognitive events, such as abstraction, category formation, reasoning, and so on. After all, Aristotle himself was an empiricist, observing behavioral evidence of what plants, animals, and humans actually did. He was not an "arm chair" philosopher and broke with his mentor, Plato, over Plato's other worldliness as the basis of reality.

Aristotle not only recognized the need for mental mechanisms but also thought that these mechanisms interact in a nomological network manner. For example, he asserted that perception and the intellect interact in a network fashion and, although he did not comment on the issue directly, his assertion that perception is tied to the material body would lead him to agree that variations or damage at lower levels (sensation and the brain) impact functions of the intellect. Of course, his is a much simpler set of mechanisms than employed in modern cognitive psychology and neuroscience explanatory systems; however, the basic idea is the same.

Specifics of Aristotle's Account

Aristotle's Account of Sensation and Perception

Aristotle's position was that all knowledge is grounded in the senses (De Anima, trans. 1907):

> But, since apart from sensible magnitudes there is nothing, as it would seem, independently existent, it is in the sensible forms that the intelligible forms exist. And for this reason, as without sensation, a man would not learn or understand anything. (Book 3, Chapter 8, p. 145)

Physics and biochemistry have outlined the mechanisms of the five external senses; and, in conjunction with those basic sciences, cognitive psychology and neuroscience have extended discovery into the brain itself. All of these findings are consistent with Aristotle's view of the senses. Sensory and perceptual models,

such as perceptual binding, are also consistent with Aristotle's' views, in that he recognized we perceive reality as seamless, despite the fact that sense data are received in discrete units. In fact, given his general reliance on the hylomorphic theory to explain perception, it seems reasonable to think that he would interpret these descriptive advances as enhancing knowledge regarding how the receiving sense faculty operates, as it receives sensible forms from objects in the environment.

However, Aristotle encounters an initial difficulty over the adequacy of computational causative theory espoused by most of cognitive psychology and neuroscience. This is the ontological and epistemological position which asserts that mental representations at all levels are fully explained by brain architecture and neural networking (Pitt, 2008). Still, Aristotle might not object to computational ontology at the level of sensation and perceptual binding, as long as the neural networks simply described the underpinnings of organs capable of receiving sensible forms. In fact, the medieval philosophers, Avicenna and Aquinas, might well have accepted the computational model for the *sensus communis* (the common sense) and the phantasm, again with the stipulation that these computer-like neural structures were only elaborate descriptions of the "internal senses" and their ability to receive and assemble sensible forms.

Then there are the philosophical disputes over the qualia, that is, whether our ability to perceive the color red can be fully accounted for by neurochemical events in the CNS. Of course, modern philosophers of mind claim both the "yes" and "no" positions. Aristotle, again applying the hylomorphic model to the issue, could ignore the dispute and claim only that the organs involved can receive sensible forms such as red.

Aristotle's Account of Memory

Aristotle takes up memory, which he called the imagination, in Book 3, Chapter 3 of De Anima (trans. 1907) and describes its characteristics as he distinguishes memory from the external senses and from thought. He describes memory primarily as recall through images: "Imagination, in fact, is something different from both perception and thought . . . whenever we please, we can represent an object before our eyes, as do those who arrange things under mnemonic headings and picture them to themselves" (p. 123). As mentioned, the medieval philosophers, following Aristotle, went on to subdivide imagination into the five "internal senses," subdivisions, in many ways, similar to modern parsing.

Cognitive psychology and neuroscience have many impressive findings regarding memory: models of diffuse storage of long-term memory elements throughout the brain, molecular findings that short-term memory depends on existing synaptic connections, the growth of new synaptic connections facilitated by learning, genetic variations associated with memory, and on and on. Of course,

Aristotle had no detailed scientific data to consider; however, these models and findings are consistent with the hylomorphic theory in that they serve as the physical basis for receiving and storing sensible forms. When certain sensory or brain areas are damaged, sensible forms can no longer be received and stored. His later medieval commentators followed suit and, in fact, already had speculated on brain locations for the internal senses.

Aristotle's account of memory is presented within the hylomorphic framework. He does not discuss memory, which he calls imagination, in detail but does take pains to distinguish it from both perception and mind. He does assert that the imagination produces, stores, and recalls images. As such, his account, if formulated in accord with modern models and data, would require a good number of hypothetical constructs, assembled in networks, to explain findings. For example, he might adopt something like Baddeley and Hitch's (1974) construct model for working memory and would modify the model as new empirical data emerged. If this or similar models were ever closely tied to brain architecture at varying levels, such that a computer-like storage and assembly process began to emerge as a physically based explanation, Aristotle would understand this as an elaboration of the general mechanisms of memory, as memory manipulates sensible forms of particular, existing objects received first through the senses.

But would Aristotle completely abandon his "copy" theory of memory? The answer is no because modern cognitive psychology and neuroscience cannot do without the concept either; it is now referred to as the representation. Everything described above must finally end up as an image. For example, if I perform an act of episodic memory regarding my tackling Johnny Elam in the 1953 Lockhart–Luling football game, I have a visual image or representation involving shoving off the center, Elam coming right at me in the three hole, and the massive collision that occurred. The representation is primarily visual but involves action and is vivid. Like most vividly recalled life events, it was associated with a high degree of emotion. Hence, Aristotle, considering the facts of memory in 350 BC, recognized that, whatever is happening in the body, the result is ultimately a copy-like image. He referred to this image as an abstracted sensible form. Modern cognitive psychology and neuroscience call the image a representation and postulate a neural assembly process, not totally dissimilar to abstraction, to account for it.

Aristotle's Account of Higher Cognitive Functions

Cognitive psychology and neuroscience position a number of processes under higher cognitive functioning, including categorization, object recognition, decision making, theory of mind, mental imagery, knowledge of self, thinking, social exchange, and consciousness itself. To explain these phenomena, cognitive psychology and especially neuroscience advocate what has come to be known

as the computational theory of mind which holds that the brain is a form of computer and that cognitive events and processes at all levels are computations conducted by the brain. However, to say that cognitive psychology and neuroscience advocate this ontology is somewhat misleading because those disciplines rarely state this as their underlying ontology. They simply proceed with brain-based causal explanations.

As Pitt (2008) points out in his review of consciousness, at the theoretical or philosophical level, the computational theory of mind splits into two camps, the classicists and the connectionists. Cognitive psychology and neuroscience appear to fall almost exclusively under the connectionist sway. Connectionists claim that (1) mental representations develop from distributions of weights and connections at neural network levels; (2) the connection network is learned by repeated exposures with network growth and rearrangement occurring during learning; and (3) mental representations are lost or degraded if these networks are damaged. Hence, all events and processes of sensation, perception, and higher cognitive functions find their causal explanations within connectionist ontology. Further, this ontology is a materialist monism, implicitly or explicitly denying any form of dualism.

The following quote from Koch's (2004, p. 1107) introduction to a section on consciousness in a prominent neuroscience text illustrates the point: "The researchers represented in this section take the problem of consciousness, the first person perspective, as a given and assume that brain activity is both necessary and sufficient for biological creatures to experience something." The point can be further illustrated by recent books, such as *The Ethical Brain*, in which (Gazzaniga, 2005) asserts that all moral reasoning can be explained by brain function alone and by the works of philosophers of mind (Carruthers, 2000; Dretske, 1995) who draw on findings from cognitive psychology and neuroscience to assert that mind is no more than brain.

Aristotle parts company with cognitive psychology and neuroscience at this level, and the argument would center on ontology and causes. Aristotle's explanation of the list of phenomena under higher-order functions would be couched within hylomorphic ontology and involve the reception of intelligible forms by the intellect, regarded as the faculty uniquely able to abstract the common properties of objects. As Aristotle states in Book III, Chapter 4 of De Anima (trans. 1907):

> Thus, then, the part of the soul which we call intellect (and by intellect I mean that whereby the soul thinks and conceives of forms) is nothing at all actually before it thinks. Hence, too, we cannot reasonably conceive it to be mixed with the body, for in that case, it would acquire some particular quality, cold or heat, or would even have some organ, as the perceptive faculty has. But as a matter of fact it has none. (p. 131)

Later, in discussing the distinction between the sense organs and the mind, Aristotle states:

> Observation of the sense-organs and their employment reveals a distinction between the impassibility of the sensitive and that of the intellective faculty. The sense loses its power to perceive, if the sensible object has been too intense: thus, after very loud noises, and after too powerful colors and odors, it can neither see or smell. But, the intellect, when it has been thinking on an object of intense thought, is not less, but even more able to think of inferior objects. For the perceptive faculty is not independent of body, whereas the intellect is separable. (p. 131)

Reception of forms by the intellect occurs in the following manner. First, objects of thought enter as particular perceptions via the senses, are organized by the internal sense as described above, and are then "presented" to the intellect. The intellect abstracts common features of the objects as structural universals. Objects stored in the imagination as particular memories (as the example above — the grass, the football field, the people involved, and the action) can also be presented to the intellect for abstraction.

Hylomorphic theory requires that other phenomena of higher-order cognition be categorized as subdivisions of the hylomorphic framework. For example, categorization and object recognition are descriptions of the intellect's abstracting universal common properties of objects. Thinking is the formation of propositions involving universals and particulars, as in the proposition "John is a human being." Knowledge of self is an extension related to the capacity of the rational animal to think about its thinking.

Aristotle describes the mind or intellect (*nous*) as a capacity or faculty of the soul or psyche capable of receiving intelligible forms. As with the sense faculties, the intellectual faculty must be suitability qualified to receive intelligible forms. Shields (2003) summarizes: ". . . thinking consists in a mind's becoming enformed by some object of thought, so that actual thinking occurs whenever some suitably prepared mind is 'made like' its object by being affected by it" (p. 13). According to this model, thinking consists in a mind's becoming enformed by form.

This analysis implies an isomorphism between the intellect and object known — but what sort of isomorphism? Aristotle asserts that the isomorphism is between the intellect and the form of the known object. Thus, when one thinks of dogs in general (as opposed to perceiving a particular dog), the intellect grasps generalities about canines in an abstract and universal way. The universal concept of dog will be somewhat like a blueprint or structural model applicable to all dogs. This isomorphism is accomplished by the process of abstraction in which the mind can extrapolate the form of particular objects and produce a predicating judgment, such as "all dogs are animals." Knowing, then, can take

place at two levels: one tied to the particular sensed object (this dog Tippy) and the other knowing the common features of all canines (all dogs).

It should be noted that the product of the abstracting intellect is the concept which is universal and is described as a rational entity. The concept is a creature of the intellect, having no material properties.

Cognitive psychology and neuroscience and Aristotle's system hold different ontologies, leading to differing casual analysis. Cognitive psychology and neuroscience are committed to physical monism; Aristotle advocates a dualist ontology in which the higher-order cognitive functions of mind cannot be reduced to the physical, and the product of abstraction is the universal concept, also not reducible to the physical. To illustrate this point, consider how each position would explain my ability to utter the proposition "All dogs are animals."

The computational theory of mind claims that my brain, first of all, perceived and stored singular examples of dogs and singular examples of animals. Then, the brain instantaneously assembles all of these singularly stored representations to form the higher-level representations of "all dogs" and "all animals." At each stage of assembly, the mental representations are nothing more than the "distributions of weights and connections at neural network levels," as described by Pitt. My personal awareness of the elements of the proposition, "all dogs" and "all animals," and the connection between them is solely a product of brain neurochemistry and neural networks.

The hylomorphic claim is that sensory and perceptual experiences with singular existing dogs, both immediate and stored in memory, give rise to a universal concept of "all dogs" by the process of abstraction in which elements common to canines are realized by the intellect. As expressed by Shields, the intellect (mind) is enformed by the universal form of canineness. The same process would occur with other perceived animals in the sensory world, starting with numerous encounters with singular existing varieties of animals. By the process of abstraction, the mind becomes enformed with the elements common to "all animals." My personal awareness of uttering the proposition is simply the intellect's observed ability to reflect back on its own activity and consider the content and process.

Hylomorphic ontology requires dualism as opposed to the physical monism of the computational theory of mind. Neither the abstracted, universal concept nor the intellect as a faculty is reducible to physical events. But what type of dualism? This has been a source of controversy: was Aristotle advocating a Cartesian substance dualism literally postulating two separate substances, mind and body? Many think not. Perhaps Aristotle would advocate some version of property dualism, claiming that the existence of conscious properties are not identical with nor can they be reduced to physical properties.

Summary and Conclusions

It is reasonable to assert that Aristotle would be rather enthusiastic about many of the findings of cognitive psychology and neuroscience at the levels of sensation, perception, and memory. He might be more attracted to one set of explanatory constructs about these processes than to another; however, being empirically oriented himself, he would choose the models with the most convincing data.

Aristotle would oppose the computational theory of mind as being an ontological error. After all, physical monism had its proponents in ancient Greece (Thales, Anaximenes), and Aristotle opposed their ontology. Aristotle asserted that the superior position is dualism, principally because physical monisms, like the computational theory of mind, stretch credibility. Can we really believe that each time I utter "All dogs are animals," my whirring computer (the brain) assembles all of the components necessary for dogs (all dogs, not one dog) and animals (all animals, not one animal) and the connection between them, "are"? Then, of course, there is my conscious awareness of my utterance and ability to reflect on it. This has been labeled as the "hard problem" by Chalmers (1995) who argues that the gap between CNS neurochemical events and my conscious experience cannot be bridged. Aristotle and Chalmers agree on that that point.

Finally, it is interesting to speculate what might happen if, by some miracle, cognitive psychology and neuroscience abandoned the computational theory of mind and accepted the hylomorphic model. If such a paradigm shift occurred, neuroscience would behave in an ontologically different manner and claim its territory up through the "internal senses" only. Cognitive psychology would do the same but could also offer psychological data and theory related to the process of abstraction and the manipulation of concepts.

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