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Nonlinear Brain Dynamics and Intention According to Aquinas

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Abstract

We humans and other animals continuously construct and maintain our grasp of the world by using astonishingly small snippets of sensory information. Recent studies in nonlinear brain dynamics have shown how this occurs: brains imagine possible futures and seek and use sensory stimulation to select among them as guides for chosen actions. On the one hand the scientific explanation of the dynamics is inaccessible to most of us. On the other hand the philosophical foundation from which the sciences grew is accessible through the work of one of its originators, Thomas Aquinas. The core concept of intention in Aquinas is the inviolable unity of mind, brain and body.

All that we know we have constructed within ourselves from the unintelligible fragments of energy impacting our senses as we move our bodies through the world. This process of intention is transitive in the outward thrust of the body in search of desired future states; it is intransitive in the dynamic construction of predictions of the states in the sensory cortices by which we recognize success or failure in achievement. The process is phenomenologically experienced in the action-perception cycle. Enactment is through the serial creation of neurodynamic activity patterns in brains, by which the self of mind-brain-body comes to know the world first by shaping the self to an approximation of the sought-for input, and then by assimilating those shapes into knowledge and meaning.

This conception of the self as closed, autonomous, and self-organizing, devised over 700 years ago and shelved by Descartes, Leibniz and Spinoza 300 years ago, is now re-emerging in philosophy and re-establishes the meaning of intention in its original sense. The core Aquinian concept of the unity of brain, body and soul/mind, which had been abandoned by mechanists and replaced by Brentano and Husserl using the duality inherent in representationalism, has been revived by Heidegger and Merleau-Ponty, but in phenomenological terms that are opaque to neuroscientists. In my experience there is no extant philosophical system than that of Aquinas that better fits with the new findings in nonlinear brain dynamics. Therefore, a detailed reading and transcription of basic terms is warranted, comparing in both directions the significance of key words across 700 years from medieval metaphysics to 21st century brain dynamics.

1. Introduction

There is a major cleavage that fuels debates on the nature of mind, deriving from the ancient Greeks: Is perception active or passive? According to Plato it is passive. He draws a distinction between intellect and sense, both being immaterial and belonging to the soul. The intellect is born with ideal forms of objects in the world, and the senses present imperfect copies of those forms. For each object the intellect seeks the corresponding subjective ideal form through the exercise of reason. Thus experiences of the world of objects and events are passively impressed onto the senses.

According to Aristotle, perception is active. There are no ideal forms in the mind. The actions of the intellect are to define and seek objects with its sensorimotor power, and with its cogitative power to construct forms of them by abstraction from the examples presented by the senses. The forms of mental contents from stimuli are inscribed by the intellect with its mnemonic power onto an initially blank slate, the *tabula rasa*.

In the early Middle Ages the Platonic view was dominant through the work of St. Augustine. In the 13th century the Aristotelian view came to the fore through the work of St. Thomas Aquinas, who transformed it by distinguishing will from intent, and by conceiving the imagination (*phantasia*) as the source of endogenous forms.

In the Renaissance, Western thought returned to Plato through the work of Descartes, who conceived a revolutionary approach of describing the world in terms of linear algebra and geometry, without place for the faculty of imagination. In an early expression of this view the animal machine in man was guided by the soul as its “pilot”, who sought knowledge through reasoning about the passive imprints of sensations in order to come to absolute mathematical truth. The soul was conceived to grasp the *habenulae*, referring to a pair of nerve cords on the upper wall of the third ventricle, which Descartes regarded as pulling on the pineal body like a ball valve controlling the flow of fluid into the Acqueduct of Sylvius into the fourth ventricle. Later Descartes abandoned this metaphor and conceived the operations of mind and matter as parallel without interactions, similar to those of Leibnizian monads.

In the era of modern science this last proposition has come to a dead end. The reasons usually given are either that the soul does not exist, or that the concept does not explain anything, or that the soul is a matter of personal belief, not a scientific principle. In the medical and biological sciences, explanations of the mind are sought in terms of the functions of the body through studies in behavior, and by analysis of the brain through chemistry and imaging.

But there is another and less clearly grasped reason for the decline in confidence in the Cartesian solution. For the past three centuries the func-

tions of mind and brain have been described in terms of dynamical laws, as started by Newton and Leibniz. The passive model of perception is entirely appropriate for unidirectional causality, in terms of conditioned and unconditioned reflexes, neural networks, and the chemistry of neuromodulators, because brain structures and operations are seen as determined by genes and developmental processes.

Perception is thought to work through the imprint of meaningless objects and events from the environment, called information processing. Mental contents are seen as formed by neural connections that are determined by genes, and modified by learning from stimuli, particularly during critical periods of growth. Representations of objects and events are stored in memory banks as ideal forms, each having attached to it a label as to its value for the organism, and they are used to classify new inputs by retrieval, cross-correlation, template matching, error reduction, modification of wiring in neural networks by Hebbian synapses, and assignment of value by passage through the emotional generators of the brain. Questions of how the brain can *a priori* create its own goals and then find the appropriate search images in its memory banks are not well handled. The loss of the Cartesian pilot has left a large gap in the theory, because no one wants a homunculus, but no one has a replacement.

In the first half of the 20th century some philosophers and psychologists (pragmatists, gestaltists and existentialists) broke from the Platonic tradition by incorporating concepts of the source of value in action, the importance of pre-existing goals and expectations, and the role of affordances in governing perceptions. Most neuroscientists have failed to respond to or accommodate these new schemes, in part because of their complexity, but in larger part because of the lack of a coherent theory of the deep origin of the goal structures in animals and humans.

However, in the second half of this century a sharp break in the mathematical, physical and chemical sciences has occurred with the development of nonlinear dynamics, which in part was made possible by the emergence of computer technology. Recognition of “dissipative structures” by Prigogine, of “macroscopic order parameters” by Haken, and of “positive entropic information flows” by various authors writing on self-organization in chaotic systems has opened new avenues to pursue the age-old question of how goals and their derivative expectancies arise in brains. Proposed new answers are expressed in terms of “circular causality”, which is a convenient term to address some intrinsic indeterminacy of feedback, by which the components of a system can in large part determine their own behavior.

There is a two-fold problem here. On the one hand, philosophers do not understand nonlinear brain dynamics well enough to adjudicate conflicting claims of neuroscientists working on opposing sides of the cleavage: linear-passive *versus* nonlinear-active perception. On the other hand,

most neuroscientists do not understand the philosophical foundations of brain theory well enough to focus their experimental questions in terms of the self-organization of brains in behavior, or even to know which side of the cleavage they are on, or that it exists.

My aim in this essay is to compare the language used in the theory of dynamical systems to describe active perception in experimental animals with the language used by an eminent philosopher to describe the process in humans. To this end I propose a glossary of some key terms that approximate the levels of description to be found in Aquinas and in the nonlinear brain dynamics that actualizes the action-perception cycle:

Aquinas	neurodynamics
<i>sensatio</i>	transduction, action potentials, sensory perception
<i>phantasmata</i>	accommodation, Hebbian nerve cell assembly, "raw sense data"
<i>abstractio</i>	adaptation, knowledge, sensory cortex, AM patterns
<i>sensus communis</i>	Gestalt, multisensory percept, limbic system
<i>imaginatio</i>	global wave packet, neocortex
<i>intellectio</i>	speech, symbolic cognition, human koniocortex ¹

My choice of Aquinas as the spokesperson is based on three considerations. Firstly, I was led to his work by pursuing to its roots the concept of intention, which I found necessary to fill the explanatory gap between my electrophysiological data and the goal-directed behavior of animals. Secondly, he was the chief architect of the Western world view before and leading to the Cartesian-Copernican-Newtonian revolution that enthroned linear dynamics. There is no better source of new insights than that offered by a mummified system of thought which preceded the present doctrines of linear causality and subject / object duality, whereby external "objects" cause internal "representations". And thirdly, his "Treatise on Man" in his master work, the "Summa Theologica", is now widely available through the *Encyclopedia Britannica* (Aquinas 1272).²

¹The term "koniocortex", from Greek *κονιος*, dust, denotes a type of neocortex found only in humans. It has amorphous distributions of nerve cell nuclei so numerous as to resemble grains of dust, and it has no direct connection to underlying basal ganglia (striatum and thalamus). Thus it is detached from sensory input to a degree not found in other animals.

²In my quotations below, "Q" will refer to a topic named as a Question, and "A" will refer to a more specific question followed by an answer. Page numbers are according to the pagination in Aquinas (1272).

Aquinas seems to be widely disparaged for having merely glossed Aristotle, propagandized church doctrines, and epitomized the Medieval scholastics, debating numerical estimates of angels on heads of pins. This is unjust. While most of his work is irrelevant to neuroscience, those parts in which he describes his ideas on phenomenology and the functions of bodies and brains in humans and animals are highly relevant.

His writing is well organized. He begins each topic with a question, gives a short answer, summarizes objections by predecessors and peers with citations to original sources, writes “I answer that ...”, and replies in full to the objections. He provides an excellent model for philosophical writing. The problems that he raises and the answers that he gives are hauntingly familiar and incredibly thought-provoking. It becomes clear that he laid the philosophical foundation for the growth of the middle class and the Western technology that made possible the Cartesian revolution.

I do not try to determine what Aquinas “meant” by his words. Whatever meaning he created within his mind has long since died with his body. His text supports multiple interpretations, which are found in abundance in commentaries on Aquinas that seem to reveal more about the commentators than about their topic. Instead I infer that he was attempting to express in words his experience with his world and his thoughts about it, just as I try to express my experience with words about my world, and I assume that in most aspects our respective worlds are alike.

The main differences between his and my worlds stem from his preoccupation with enabling humans to understand their relation to God and mine with being science into the service of humanity by understanding the internal dynamics of brains. These and other less salient differences have given us distinctive vocabularies. Hence this essay can be regarded as an annotated multilingual glossary, attempting to interrelate the words of 13th and 20th century philosophers with the words of 20th century neuroscientists. There can be no one-to-one mapping across such diverse intellectual structures, but the translations may encourage philosophers to understand new developments in nonlinear brain dynamics, and they may encourage scientists to design their neurobehavioral experiments in a broader philosophical context.

2. Relations Between Mind and Body

When discussing the brain Aquinas showed that he was clearly aware of its importance for the functions he analyzed. The passage reproduced in the following shows that he understood the relations of brain size to body size, the power and complexity of various organs in respect to their behavioral functions, a bit of cardiac dynamics, and the adaptation of body parts to what we call environmental niches. In this text the words

“God” and “nature” do not appear. Where they do in other texts they can be replaced by “evolution” without violating the sense and spirit of his remarks relating to Aristotle’s “unmoved mover” or his own Christian conception of God. His “Treatise on Man” (Aquinas 1272, Q 75 to 102) was dedicated to a philosophical anthropology, a biological text intended to facilitate fruitful theology. .

Another remarkable feature of his writing is how seldom the words “cause”, “causality” or “effect” appear. Unlike Aristotle, he made no overt appeal to “First Cause”. He wrote in several passages of the “turning back” of the intellect within itself (*reflectio*), suggesting that he comprehended and dealt with what is now often called “circular causality”. Some commentators on Aquinas in the linear causal tradition are sorely puzzled by his reference to recursion (Kenny 1976).

First Part, Q 91

The production of the first man’s body

A 3, response to the first objection: Whether the body of man was given a fitting disposition? [It was.] For man of all animals needs the largest brain compared to the body, both for his greater freedom of action in the interior powers required for the intellectual operations, as we have seen above (Q 84 A 7), and in order that the low temperature of the brain may modify the heat of the heart, which has to be considerable in man for him to be able to stand up erect. So that the size of the brain, by reason of its humidity, is an impediment to the smell, which requires dryness. In the same way, we may suggest a reason why some animals have a keener sight, and a more acute hearing than man; namely, on account of a hindrance to his senses arising necessarily from the perfect equability of his temperament.

A 3, response to the third objection: An upright stature was becoming to man for four reasons. First, because the senses are given to man, not only for the purpose of procuring the necessaries of life for which they are bestowed on other animals, but also for the purpose of knowledge. Hence, whereas the other animals take delight in the objects of the senses only as ordered to food and sex, man alone takes pleasure in the beauty of sensible objects for its own sake. Therefore, as the senses are situated chiefly in the face, other animals have the face turned to the ground, as it were for the purpose of seeking food and procuring a livelihood; but man has his face erect, in order that by the senses and chiefly by sight, which is more subtle and penetrates further into the differences of things, he may freely survey the sensible objects around him, both heavenly and earthly, so as to gather intelligible truth from all things. Secondly, for the greater freedom of the acts of the interior powers; the brain, wherein these actions are, in a way, performed, not being low down, but lifted up above other parts of the body. Thirdly, because if man’s stature were prone to the ground he would need to

use his hands as fore-feet, and thus their utility for other purposes would cease. Fourthly, because if man's stature were prone to the ground and he used his hands as fore-feet, he would be obliged to take hold of his food with his mouth. Thus he would have a protruding mouth, with thick and hard lips, and also a hard tongue, so as to keep it from being hurt by exterior things, as we see in other animals. Moreover, such an attitude would quite hinder speech, which is reason's proper operation. (p. 487)

Aquinas' initial concern was the mind-body problem. His approach is in striking contrast to the idealism of Plato and even more so to that of Descartes. The text below can easily be read as a modern description while substituting "mind" for "soul", and "material" for "corporeal".

First Part, Q 75

Of man, who is composed of a spiritual and a corporeal substance

A 1: Whether the soul is a body? [It is not.] To seek the nature of the soul, we must lay down first that the soul is defined as the first principle of life in those things which in our judgment live; for we call living things "animate" and those things which have no life, "inanimate". Now life is shown principally by two actions, knowledge and movement. ... Therefore the soul ... is not a body, but the act of a body; thus heat, which is the principle of making hot, is not a body, but an act of a body. (p. 378)

A 2: Whether the human soul is something subsistent? [It is.] It must necessarily be allowed that the principle of intellectual operation which we call the soul is a principle both incorporeal and subsistent. For it is clear that by means of the intellect man can know the natures of all corporeal things. Now whatever knows certain things cannot have any of them in its own nature, because that which is in it naturally would impede the knowledge of anything else. (p. 379)

This text introduces the distinction between matter, which has unique and individual forms, here and now, that are not accessible to knowledge *versus* intellect, which has classes of forms that are abstracted from matter, and that do not exist in matter. It is precisely the forms of material things that the intellect knows; it knows *what* each material being is, and each material thing is what it is because of its form.³

The last sentence in the quote above is difficult to grasp, but it is crucial, I believe, to the contribution of Aquinas. It says, I think, that the separate and immediate impacts of repeated stimuli onto receptors, and through them into the brain, do not establish in the brain either the

³"But the intellectual soul knows a thing in its nature absolutely; for instance, it knows a stone absolutely as a stone, and therefore the form of a stone absolutely, as to its own formal notion, is in the intellectual soul" (Aquinas 1272, first part, Q 75, 5).

actual forms of those stimuli or their derivatives as episodic memories. They are the individual and transient forms of matter. If the brain were to collect and save all of those impressions streaming in from all senses, the brain could not know anything. A significant part of the energy that brains expend is used for habituation, by which unwanted and irrelevant bombardment of the senses is attenuated.

Brains try to admit only that which serves them well. Brains operate on their inputs by creative acts that make abstract forms, which constitute their knowledge about the stimuli. But the forms of that knowledge do not exist in the stimuli or *vice versa*. Even the vivid images from “one-trial learning” under duress are records of the contexts of experiences, unlike photographs and tape recordings.

Thus, the forms in matter are not the same as the forms in the mind. Only the mode of existence of the forms is different: as signs in the mind and as formal principles (or causes) of material individual things in reality (Aquinas 1272, Q 85, p. 452). In fact, according to Aquinas, reality manifests itself in two modes: essentially, in the world, and intentionally, in the individual’s mind. The two manifestations are adequate to each other, due to the intelligible nature of everything that is: each thing in the world, by being, is intelligible; and human beings have the capacity to know it (*intellectio*). The two, reality and human capacity to know, converge in the process that Aquinas calls *adaequatio rei et intellectus*. For this reason, the forms in the mind should not be said to represent the forms of the matter, with the apparent exception of “phantasms” that mediate the creation of forms in the mind, and that are equally evanescent and unintelligible in their uniqueness and transience.

A 2: The body is necessary for the acting of the intellect not as its organ of action, but by reason of the object; for the phantasm is to the intellect what color is to the sight. Neither does such a dependence on the body prove the intellect to be non-subsistent; otherwise it would follow that an animal is non-subsistent, since it requires external sensible things in order to sense. (p. 380)

The meaning of “phantasm” has been translated by various commentators as “sense-experience” and “quale”. It appears to be closely related to “experience” as it is described by post-Heideggerian phenomenologists such as Merleau-Ponty (1945). There is a major difficulty for phenomenologists attempting to find neural correlates of such phenomena, because they obviously require awareness in order that they be subject to verbal description and logical analysis, but the neural mechanism of awareness is still unknown.

There should be the possibility of relating “phantasms” to neural events occurring in sensory and motor cortices at an early stage of perception and at a late stage of goal-directed movement, whether or not human

and other animal subjects are aware of them. Aquinas did not refer to “awareness” and “consciousness”, for which “phantasm” and “experience” sufficed.

All these difficulties are surmounted by identifying “phantasms” with microscopic sensory-driven action potentials which are unique, non-reproducible, and knowable only through time-locked averaging, which brains cannot do. Yet undeniably the integration of repeated collections of microscopic action potentials modify the synaptic webs of cortex in memory formation, and they recur in entirely new patterns on recognition and recall. But those patterns are mesoscopic and endogenous, not the filtered remnants of forms conceived and imposed by external observers, that is, representations. In brief, wave packets conform to Aquinas’ *abstractio* and not to “phantasms”. They are mental and not material.

A neurobiological example comes by comparing the pattern of response to an odorant of the olfactory receptors in the nose versus the pattern of neural activity that is created in the olfactory bulb, where the receptor axons end in the brain. What is the form of an odorant? We know that it is a chemical species that has an affinity for a subtype of chemoreceptor cell in the nose, of which there are thousands. Each inhalation excites a small fraction of the available number, but it is a different fraction with each breath. Through processes of learning the olfactory bulb constructs a pattern of synaptic connections, which links together the neurons in the bulb that were excited by the receptors on repeated trials. From that pattern the bulb generalizes over the class of available receptors, regardless of which of them are excited on any one sniff.

But it does more. The bulb combines all prior olfactory experience into each of its activity patterns on every sniff. The unique and individual odorant-driven activity patterns survive as “phantasms” only long enough to make a small contribution to the bulb, and then they are washed away. The central pattern does not represent any of the odorant presentations, which are not knowable and, in any case, of no further use. This interpretation of experimental data (Freeman 1992, 1995), derived by recording neural activity in behaving animals, is consistent with the following.

*A 5: Whether the soul is composed of matter and form? [It is *not*.] Now a thing is known in as far as its form is in the knower. But the intellectual soul knows a thing in its nature absolutely; for instance, it knows a stone absolutely as a stone, and therefore the form of a stone absolutely, as to its own formal notion, is in the intellectual soul. Therefore the intellectual soul itself is an absolute form, and not something composed of matter and form. For if the intellectual soul were composed of matter and form, the forms of things would be received into it as individuals, and so it would only know the individual; just as it happens with the sensitive powers which receive forms in a corporeal organ, since matter is the principle by which*

forms are individualized. It follows, therefore, that the intellectual soul, and every intellectual substance which has knowledge of forms absolutely, is without composition of matter and form. (p. 382)

A 5, response to first objection: For primary matter receives individual forms, whereas the intellect receives absolute forms. Hence the existence of such a potency in the intellectual soul does not prove that the soul is composed of matter and form. (p. 383)

A 5, response to fourth objection: But in intellectual substances, there is composition of act and potency, not, indeed, of matter and form, but of form and participated being. (p. 383)

Here Aquinas introduced the term “participated being” as the partner of “form”, apparently in preference to the term “function”.⁴ The value of the term derives from its evocation of cooperation and sharing of activity in both body and brain. The term “absolutely” in this context appears to refer to an invariant property that serves to define a class over the highly variable individual stimuli. This distinction is amplified in the following section.

First Part, Q 76

Of the union of body and soul

A 1: Whether the intellectual principle is united to the body as its form? [It is.] We must assert that the intellect which is the principle of intellectual operation is the form of the human body. For that whereby primarily anything acts is a form of the thing to which the act is to be attributed; for instance, that whereby a body is primarily healed is health, and that whereby the soul knows primarily is knowledge; hence health is a form of the body, and knowledge is a form of the soul. The reason is because nothing acts except so far as it is in act; hence a thing acts by that whereby it is in act. Now it is clear that the first thing by which the body lives is the soul. And as life appears through various operations in different degrees of living things, that whereby we primarily perform each of these vital actions is the soul. For the soul is the primary principle of our nourishment, sensation, and local movement; and likewise of our understanding. Therefore this principle by which we primarily understand, whether it be called the intellect or the intellectual soul, is the form of the body. This is the demonstration used by Aristotle. ... It is well to remark that if anyone holds that the soul is composed of matter and form, it would follow that in no way could the soul be of the form of the body. For since the form is an act, and matter is only a being in potency, that which is composed of matter and form cannot be the form of another by virtue of itself as a whole. (p. 386)

⁴He refers to the “composition” present in souls separated from their material principle (primary matter). Separated souls have potency, but not matter. Their potency consists in their form which stands in relation to the act of existence (as “participated being”) as potency to act.

The texts of Aquinas express pretty clearly that the intelligible species is only one (universal, abstracted) while the phantasms (particular, sensible images) are diverse (Aquinas 1272, Q 76, p. 389). They emphasize the uniqueness of each person (and animal) in the make-up of its intellectual soul (mind), owing to the creation of phantasms from personal experience and the composition of knowledge from them. Thus, the mental forms of the same external object are different within each intellect, and there can be no common intellect shared by all.

A 2: Whether the intellectual principle is multiplied according to the number of bodies? [It is.] It is absolutely impossible for one intellect to belong to all men. This is clear if, as Plato maintained, man in the intellect itself. For it would follow that Socrates and Plato are one man, and that they are not distinct from each other except by something outside the essence of each. ... However, it would be possible to distinguish my intellectual action from yours by the distinction of the phantasms - that is to say, were there one phantasm of a stone in me, and another in you - if the phantasm itself, as it is one thing in me and another in you, were a form of the possible intellect; because the same agent according to divers forms produces divers actions, just as according to divers forms of things with regard to the same eye there are divers visions. But the phantasm itself is not a form of the possible intellect, but rather the intelligible species abstracted from the phantasms. Now in one intellect, from different phantasms of the same species only one intelligible species is abstracted, as appears in one man, in whom there may be different phantasms of a stone; yet from all of them only one intelligible species of a stone is abstracted, by which the intellect of that one man, by one operation, understands the nature of a stone, notwithstanding the diversity of phantasms. Therefore, if there were one intellect for all men, the diversity of phantasms which are in this one and that one would not cause a diversity of intellectual operation in this man and that man as the Commentator teaches. It remains therefore, that it is altogether impossible and unreasonable to maintain that there exists one intellect for all men. ... For it is impossible that one same power belong to various substances. (p. 389)

The faculty of imagination, the “phantasia”, accounts for the diversity of apprehension that men have about objects, but also the commonality of knowledge that they reach through their intellects. It is the intellect that accounts for the commonality of knowledge. Even in one man, there may be many phantasms of a stone (perceptions of it from various angles, etc.), but there is only one concept “stone” (the universal). So in many men, there may be a variety of perceptions, but a common knowledge of what a stone is. Yet, knowledge is not identical in all men. Some men may

know what a stone is, and others have not yet learned it. This diversity of knowledge implies a diversity of intellects (one for each human being).⁵

A 5: Whether the intellectual soul is properly united to such a body? [It is.] The philosopher [Aristotle] says that “the soul is the act of a physical organic body having life potentially”. Since the form is not for the sake of matter, but rather the matter for the form, we must gather from the form the reason why matter is such as it is; and not conversely. ... But nature never fails in necessary things; therefore the intellectual soul has to be endowed not only with the power of understanding, but also with the power of feeling. Now the action of these senses is not performed without a corporeal instrument. Therefore the intellectual soul has to be united to a body which could be an adequate organ of sense. (p. 395)

Clearly Aquinas asserts the unity of reason and emotion through the body in action. Furthermore, his doctrine holds for “the uniqueness and inaccessibility of experience of each person” (Aquinas 1272, p. 389), so that we can never “know what it is like to be” (Nagel 1974) beyond what we learn and intuit through the body (Freeman 1995). The *species intelligibilis* (and also *sensibilis*) is not “what is understood” but an adaptation *by which* we come to know things. All knowledge is dynamically tending towards a maximum grip on reality (Merleau-Ponty 1945), until we can say “this is that” by a true predicament. Knower and reality co-act in a continuous dynamism towards a better understanding of what is, determined not only by what is outside, but by the appetites and goals of the individual that stretches forth the world where she or he abides. The separation means that we are not conscious of ourselves and of our images (and language) when they are in use – and then know things and speak about them. But we may also reconsider our verbal and iconic language and speak about them (cf. Aquinas 1272, p. 449)

Because the transient stimulus pattern is deleted, the knowledge about the stimulus can be abstracted from many equivalent sniffs; the transient selects the knowledge that pre-exists *in potentia* and is actualized into the AM pattern by convergence to an attractor. This is shown by the observation that the single-trial patterns of neural activity, driven by stimuli arriving at the cortex, serve to destabilize it. The cortex then creates a pattern of activity that actualizes or brings on line the knowledge of the stimulus for the animal: what it means and what to do about it. That creation is sent to other parts of the brain, whereas the stimulus-driven pattern is deleted. This indicates that everything that a human or other

⁵Averroes’ idea that the diversity of imagination(s)/ phantasm(s) in different individuals could account for some men knowing things that others do not, even if there were only one common human intellect, is not sound. Since a diversity of phantasms (many perceptions of many stones) does not give rise to a multiplicity of ideas, there is still only one universal concept “stone”.

animal can “know” about its world has been constructed within itself. However, multiple individuals can assimilate (make alike) their experiences through expressions of their feelings by representations, that is, by intentional actions that express their understandings and emotions.

Thus, a modern paraphrasing of Aquinas is that each individual has unique knowledge supported by synaptic changes in the brain; that individuals express their knowledge by creating and transmitting representations by manipulating their bodies and materials that can be grasped and shaped by hands, which constitute information given to the senses of others; that shared knowledge is created through the reception of information. Truth is in the reality, and simultaneously it is unveiled by the joint intentional activity of human cognitive powers in concert. The meanings of knowledge and information emerge through social interactions among intentional beings.

3. The Powers of the Intellect: Intention, Perception, Expectation

Aquinas invokes the usual division of the powers of the soul. Of particular interest is his concept of intention, accounting for the prior existence of expectancy of outcomes and anticipation of stimuli, and of the interpretations of stimuli in terms of the goals of humans and other animals.

First Part, Q 78

Of the powers of the soul in particular

A 1: Whether there are to be distinguished five genera of powers of the soul? [Yes: vegetative, sensitive, appetitive, locomotive, intellectual.] ... according as the soul itself has an inclination and tendency to something extrinsic ... there are again two kinds of powers in the soul: one – the appetitive – in respect of which the soul is related to something extrinsic as to a need, which is first in the intention; the other – the power of local movement – in respect of which the soul is related to something extrinsic as to the term [goal] of its operation and movement; for every animal is moved for the purpose of realizing its desires and intentions. (p. 407)

A 4: Whether the interior senses are suitably distinguished? [They are.] Avicenna assigns five interior sensitive powers, namely common sense, phantasy, imagination, and the estimative and memorative powers. ...[“The interior sense is called common not by predication, is if it were a genus, but as the common root and principle of the exterior senses.” (p. 413)] ... Now we must observe that for the life of a perfect animal, the animal should apprehend a thing not only at the actual time of sensation, but also when it is absent. ... Since the sensitive power is the act of a corporeal organ, it follows that the power which receives the species of sensible things must be distinct from the power which preserves them.

Again we must observe that if an animal were moved by pleasing and disagreeable things only as affecting the sense, there would be no need to suppose that an animal has a power besides the apprehension of those forms which the senses perceive., and in which the animal takes pleasure, or from which it shrinks with horror. But the animal needs to seek or to avoid certain things not only because they are pleasing or otherwise to the sense, but also on account of other advantages and uses, or disadvantages; just as the sheep runs away when it sees an approaching wolf not on account of its color or shape, but as a natural enemy, and again a bird gathers together straws, not because they are pleasant to the sense, but because they are useful for building its nest. Animals, therefore, need to perceive such intentions, which the exterior sense does not perceive. And some distinct principle is necessary for this, since the perception of sensible forms comes by a sensible change, which is not the case with the perception of the intentions spoken of. ... But for the retention and preservation of these forms, the phantasy [imagination] is appointed, which is as it were a storehouse of forms received through the senses. Furthermore, for the apprehension of intentions which are not received through the senses, the estimative power is appointed, and for the preservation of them, the memorative power, which is a storehouse of such intentions. ... And the very notion of the past, which memory considers, is to be reckoned among these intentions. ... There is a difference as to the above intentions. For other animals perceive these intentions only by some natural instinct, but man perceives them by means of a kind of comparing. Therefore the power which in other animals is called the natural estimative, in man is called the cogitative, which by some sort of gathering together and comparison discovers these intentions [this is Aristotelian induction, neurobiologically implemented in the construction of Hebbian assemblies in cumulative reinforcement learning by classical and instrumental conditioning]. Therefore it is also called "the particular reason", to which medical men assign a certain particular organ, namely, the middle part of the head [this doctrine is Arabic in origin, by Avicenna]; for it compares individual intentions, just as the intellectual reason compares universal intentions. As to the memorative power, man has not only memory, as other animals have in the sudden recollection of the past, but also reminiscence, by syllogistically, as it were, seeking for a recollection of the past by the application of individual intentions. (p. 412)

Here Aquinas described intention in terms of ends or goals to which animals are tending. The word is used here in the sense of purpose. In psychology it is commonly conflated with motivation, but not in law, where intent (an act that is or was to be done) is distinguished from motive (the reason, explanation or justification for the act).

Another important aspect of intention is the parallel between the “tending” of the intellect toward some desired or willed future state and the “tending” of the body to health, which is its natural form. This usage appears in modern surgery in the distinction (first used by LaFranchi in a surgical text published in 1306) between healing by first intention (clean with a small scar) and by second intention (pus with extensive scarring).

Aquinas frequently expressed concern for health and the healing process, giving a dimension to intention that is lacking in the contemporary usage of intentionality going back to Brentano (1874, 1889). This usage, contrasted with Aquinas’ by Brower and Brower-Toland (2008) in detail,⁶ designates the relation of mental forms to objects of believing and perceiving that hold in animate systems as opposed to inanimate ones.

In brief, Brentano re-conceives intentionality not as understanding the world by acting into it and assimilating to it but as attaching to mental symbols or representations of the world which is represented. Thus, he characterizes the difference between an animal that knows what it is doing and a machine that does not through the capacity to intend. For cognitivists this poses what Harnad (1990) called the “symbol grounding” problem.

First Part, Q 79

Of the intellectual powers

A 2: Whether the intellect is a passive power? But the human intellect, which is the lowest in the order of intellects and the most removed from the perfection of the Divine intellect, is in potency with regard to things intelligible, and is at first “like a clean tablet on which nothing is written,” as the philosopher says. This is made clear from the fact that at first we are only in potency to understand, and afterwards we are made to understand actually. (p. 415)

A 3: Whether there is an agent intellect? Now nothing is reduced from potency to act except by something in act; just as the senses are made actual by what is actually sensible. We must therefore assign on the part of the intellect some power to make things actually intelligible, by the abstraction of the species from material conditions. And such is the necessity for positing an agent intellect.

Aquinas used the metaphor of the intellect serving to light the phantasms within the self, and to contrast this opinion with that of Plato. The light played on the walls of Plato’s cave came from an external source,⁷ and it gave imperfect access to the forms of objects casting shadows. The intellect then cross-correlated the received images with its store of ideal forms to find the best match. For Aquinas the light is played across the

⁶Other critiques of the contemporary usage of the terms “representation” and “intentionality” are, for instance, due to Jordan and Ghin (2006).

⁷Actually the light source is a great fire in Plato’s Republic, Book VII.

interior of the self to access the forms already constructed within the self. No forms of matter came past the phantasms; new forms grew by abstraction in the intellect.

A 3, reply to second objection: There are two opinions as to the effect of light. For some say that light is required to make colors actually visible. And according to this the agent intellect is required for understanding, in like manner and for the same reason as light is required for seeing. But in the opinion of others, light is required for sight, “not for the colors to become actually visible, but in order that the medium may become actually luminous” ... (p. 416)

A 4: Whether the agent intellect is something in the soul? [It is.] Therefore we must say that in the soul is some power [that is] derived from a higher intellect, whereby it is able to light up the phantasms. And we know this by experience, since we perceive that we abstract universal forms from their particular conditions, which is to make them actuality intelligible. Now no action belongs to anything except through some principle formally inherent in it, as we have said above of the potential intellect. Therefore the power which is the principle of this action must be something in the soul. For this reason Aristotle compared the agent intellect to light, which is something received into the air, while Plato compared the separate intellect impressing the soul to the sun. (pp. 417f)

Again, the unity of the self precludes the union of one agent intellect with any other, or with all others. In this respect Aquinas departed from Aristotle, who proposed that the forms of objects were imported by the soul, because Aquinas thought that the forms in the material objects were replaced by the constructions in the mind, and the diversity of phantasms among diverse observers of the same object was the evidence that the singular form of the object is not accessed.

The relevant experimental observation here is that the microscopic stimulus-driven neural activity pattern in sensory cortex is replaced by a mesoscopic abstraction and generalization that is transmitted through the brain, while the unknowable material event is absorbed and expunged. This transition from matter to phantasm is the key to understanding the relevance of Thomist intention to nonlinear brain dynamics. I know of no other philosophical doctrine that captures so effectively the neurobiological substrate of this interface between matter and mind.

I have rephrased this insight by saying that action into the world by intention is unidirectional, in the sense that, by heating and cutting, the mind is entering into the world by imposing forms into matter. But the abstraction of forms is within the mind, because the material forms are not taken in from the exterior, but are melded into generalizations. In other words, the finite intellect can easily launch itself onto the infinite sea of the world. But it can only know the nature of the sea by the shape

of its hull (accommodation, assimilation, *adequatio*), in the building of a nerve cell assembly, followed by adaptation (*abstractio*), and the further synaptic modification that is required for the construction of the attractor that is selected by the activated nerve cell assembly and that governs the AM pattern that actualizes the category of knowledge.

A 5: Whether the agent intellect is one in all? [It is separate for each individual.] But if the agent intellect is something belonging to the soul, as one of its powers, we are bound to say that there are as many agent intellects as there are souls, which are multiplied according to the number of men ...

In the following passages Aquinas elaborates on the concept of phantasms, almost from a “phenomenological” point of view. I quote these passages extensively, to ensure that they speak for themselves in context.

First Part, Q 84

How the soul while united to the body understands corporeal things beneath it

A 7: Whether the intellect can actually understand through the intelligible species of which it is possessed, without turning to the phantasms? [It cannot.] In the present state of life in which the soul is united to a possible body, it is impossible for our intellect to understand anything actually except by turning to the phantasms. And of this there are two indications. First of all because the intellect, being a power that does not make use of a corporeal organ, would in no way be hindered in its act through the lesion of a corporeal organ if, for its act, there were not required the act of some power that does make use of a corporeal organ. Now sense, imagination, and the other powers belonging to the sensitive part make use of a corporeal organ. Therefore it is clear that for the intellect to understand actually, not only when it acquires fresh knowledge, but also when it uses knowledge already acquired, there is need for the act of the imagination and of the other powers. For when the act of the imagination is hindered by a lesion of the corporeal organ, for instance, in a case of frenzy, or when the act of the memory is hindered, as in the case of lethargy, we see that a man is hindered from actually understanding things of which he had a previous knowledge. Secondly, anyone can experience this of himself, that when he tries to understand something, he forms certain phantasms to serve him by way of examples, in which as it were he examines what he is striving to understand. It is for this reason that when we wish to make someone understand something, we lay examples before him, from which he can form phantasms for the purpose of understanding. ... Now we apprehend the individual through the sense and the imagination. And, therefore, for the intellect to understand actually its proper object, it must of necessity turn to the phantasms in order to examine the universal nature existing in the individual. But if the proper object

of our intellect were a separate form, or if, as the Platonists say, that natures of sensible things subsisted apart from the individual, there would be no need for the intellect to turn to the phantasms wherever it understands. ... The species preserved in the possible intellect exist there habitually when it does not understand them actually. ... Hence in order for us to understand actually, the fact that the species are preserved is not enough. We need further to make use of them in a manner befitting the things of which they are the species, which things are natures existing in individuals. Even the phantasm is the likeness of an individual thing; therefore the imagination does not need any further likeness of the individual, whereas the intellect does. Incorporeal things, of which there are no phantasms, are known to us by comparison with sensible bodies of which there are phantasms. Thus we understand truth by considering a thing of which we examine the truth... (p. 449)

First Part, Q 85

Of the mode and order of understanding

A 1: Whether our intellect understands corporeal and material things by abstraction from phantasms? Now there are three grades of knowing powers. For one knowing power, namely, the sense, is the act of a corporeal organ. And therefore the object of every sensitive power is a form as existing in corporeal matter. And since such matter is the principle of individuality, therefore every power of the sensitive part can only have knowledge of the individual. There is another grade of knowing power; ... such is the angelic intellect, the object of whose knowing power is therefore a form subsisting apart from matter ... But the human intellect ... is not the act of an organ, yet it is a power of the soul which is the form of the body [Q 76 A 1]. And therefore it is proper to it to know a form existing individually in corporeal matter, but not as existing in this individual matter. But to know what is in individual matter, not as existing in such matter, is to abstract the form from individual matter which is represented by the phantasms. Therefore we must say that our intellect understands material things by abstracting from the phantasms, and through material things thus considered we acquire some knowledge of immaterial things, just as, on the contrary, angels know material things through the immaterial. ... This is what we mean by abstracting the universal from the particular, or the intelligible species from the phantasm; that is, by considering the nature of the species apart from its individual principles, which are represented by the phantasms. ... For it is quite true that the mode of understanding, in one who understands, is not the same as the mode of a thing in being, since the thing understood is immaterially in the one who understands, according to the mode of the intellect, and not materially, according to the mode of a material thing. (p. 452)

The concept of phantasm plays a crucial role in Aquinas' sharp distinction between active and passive perception.

A 2: Whether the intelligible species abstracted from the phantasm is related to our intellect as that which is understood? Some have asserted that our intellectual powers know only the impressions made on them [Protagoras, Heraclitus], as, for example, the sense is cognizant only of the impression made on its own organ.

According to this theory, the intellect understands only its own impression, namely, the intelligible species which it has received, so that this species is what is understood. This is, however, manifestly false for two reasons. First, because the things we understand and the objects of science would then be the same. Therefore, if what we understand is merely the intelligible species in the soul, it would follow that every science would not be concerned with things outside the soul, but only with the intelligible species within the soul; thus, according to the teaching of the Platonists all science is about ideas, which they hold to be actually understood. Secondly, it is untrue, because it would lead to the opinion of the philosophers of antiquity who maintained that "whatever seems, is true", and that consequently contradictories are true simultaneously. ...

There are two kinds of action, one which remains in the agent [intransitive], for instance to see and to understand, and another [transitive] which passes into an external thing, for instance to heat and to cut; and each of these actions proceeds in virtue of some form. And as the form, from which an act tending [stretching forth] to something external proceeds [motor command directed toward an object], is the likeness of the object of the action [assimilation], as heat in the heater is a likeness of the thing being heated, so the form, from which an action remaining in the agent proceeds [efference copy], is the likeness of the object. Hence that by which the sight sees is the likeness of the visible thing; and the likeness of the thing understood, that is, the intelligible species, is the form by which the intellect understands. But since the intellect is turned back [*reflectitur*, re-entrance] upon itself, by the same reflection it understands both its own act of understanding and the species by which it understands. Thus the intelligible species is that which is understood secondarily [by second intention], but that which is primarily understood [by first intention] is the thing, of which the intelligible species is the likeness [*similitudo*].

The term "reflection" can be interpreted in terms of the process of refference (Freeman 1995), by which the actions to be undertaken by the intellect are made known to the self *a priori*. They are supported by multiple and massive feedback pathways that interlink all parts of the cerebral hemispheres and the brain stem. The extension of action into the external world while the sensory consequences of action are predicted in the

sensory cortices led Merleau-Ponty (1945) to his conception of the “intentional arc”, and Gibson (1979) to his concept of the “affordance”, which are modern versions of active perception.⁸ But let Aquinas continue:

This also appears from the opinion of the ancient philosophers [Empedocles, Plato], who said that “like is known by like”. For they said that the soul knows the earth outside itself by the earth within itself; and so of the rest. If, therefore, we take the species of the earth instead of the earth, according to Aristotle, who says that “a stone is not in the soul, but the likeness of the stone”, it follows that the soul knows the things which are outside of it, by means of its intelligible species.

The thing understood is in the one who understands by its own likeness, and it is in this sense that we say that the thing actually understood is the intellect in act, because the likeness of the thing understood is the form of the intellect, just as the likeness of a sensible thing is the form of the sense in act. Hence it does not follow that the intelligible species is what is actually understood, but rather that it is the likeness [assimilation] of it.

In these words “the thing actually understood” there is a twofold meaning: the thing which is understood, and the fact that it is understood. In like manner the words “abstract universal” imply two things [meanings], the nature of a thing, and its abstraction or universality. Therefore the nature itself that is to be understood, or to be abstracted, or to bear the intention of universality [to be classified] is only in individuals; but that it is understood, abstracted, or bears the intention of universality [the form of the class] is in the intellect.

There are two operations in the sensitive part. One is in regard to change only, and thus the operation of the senses takes place by the senses being changed by the sensible [the response to a stimulus]. The other is formation, according as the imagination forms for itself an image of an absent thing, or even of something never seen [expectancy, prediction]. Both of these operations are found in the intellect. For in the first place there is the passion of the possible intellect as informed by the intelligible species; and then the possible intellect thus informed forms a definition, or a division, or a composition, which is expressed by a word. Thus the notion signified by a word is its definition, and a proposition signifies the intellect’s division or composition. Words do not therefore signify the intelligible species themselves, but that which the intellect forms for itself for the purpose of judging of external things. (p. 454)

A 3: Whether the more universal is first in our intellectual knowledge? In our knowledge there are two things to be considered.

⁸On a similar line of reasoning see Manzotti (2006), who compares Gibson’s externalism with James’ radical empiricism, with Honderich’s neo-realism, and with process ontology à la Whitehead.

First, that intellectual knowledge in some degree arises from sensible knowledge. And, because sense has singular things for its object, and intellect has the universal for its object, it follows that our knowledge of the former comes before our knowledge of the latter. Secondly, we must consider that our intellect proceeds from a state of potency to a state of act. But everything which proceeds from potency to act comes first to an incomplete act, which is midway between potency and act, before achieving the perfect act. The perfect act of the intellect is complete knowledge [Merleau-Ponty's (1945) "maximum grip"], when the thing is distinctly and determinately known, where as the incomplete act is imperfect knowledge, when the thing is known indistinctly and as it were confusedly. (p. 455)

A 4: Whether we can understand many things at the same time? It is said [Aristotle] that "understanding is of one thing only, science is of many". The intellect can, indeed, understand many things as one, but not as many; that is to say, by one but not by many intelligible species. Therefore it is impossible for one and the same intellect to be perfected at the same time by different intelligible species so as actually to understand different things.

A 4, reply to first objection: The intellect is above that time which is the measure of the movement of corporeal things. But the multitude itself of intelligible species causes a certain change of intelligible operations, according as one operation 'succeeds another. And this change is called time ... (p. 457)

These passages demonstrate the unity of perception. They are consistent with the global organization of perceptions demonstrated by Gestalt psychologists, and of the chaotic electroencephalographic activity patterns in the primary sensory areas of the cerebral hemispheres in the alpha and gamma ranges (Freeman 1995, Barrie *et al.* 1996).

First Part, Q 86

What our intellect knows in material things

A 1: Whether our intellect knows singulars? Our intellect cannot know the singular in material things directly and primarily. The reason of this is that the principle of singularity in material things is individual matter, while our intellect understand by abstracting the intelligible species from such matter. Now what is abstracted from individual matter is the universal. Hence our intellect knows directly the universal only. But indirectly, and as it were by a kind of turning back [reflectio], it can know the singular, because even after abstracting the intelligible species the intellect, in order to understand actually, needs to turn to the phantasms in which it understands the species. Therefore it understands the universal directly through the intelligible species, and indirectly the singulars represented by the phantasms. And thus it forms the proposition, "Socrates is a man". (p. 461)

The passage above conforms neatly to a basic conception in nonlinear dynamics, concerning the circular causality between microscopic neurons as particles and macroscopic neuron populations as fluids. For each ensemble there exists a “universal” state which is called an “order parameter” (Haken 1983). The universal is created from the actions of the “singular” neurons, and in turn it shapes or “enslaves” the particles into cooperation. Sensations provide the singulars; perceptions come from the universals.

First Part, Q 87

How the intellectual soul knows itself and all within itself

A 1: Whether the intellectual soul knows itself by its essence? Everything is knowable so far as it is in act, and not according as it is in potency, for a thing is a being, and is true, and therefore knowable, according as it is actual. ... Now the human intellect is only a being in potency in the genus of intelligible beings, just as primary matter is in potency in the genus of sensible beings, and hence it is called ‘possible’. Therefore considered in its essence the human mind is potentially understanding. Hence it has in itself the power to understand, but not to be understood, except as it is made actual. ... Therefore the intellect knows itself not by its essence, but by its act.

This happens in two ways. In the first place, in a particular manner as when Socrates or Plato [or Descartes] perceives that he has an intellectual soul because he perceives that he understands. In the second place, in a universal manner, as when we consider the nature of the human mind from the act of understanding.

There is, however, a difference between these two kinds of knowledge, and it consists in this that the mere presence of the mind suffices for the first; for the mind itself is the principle of action whereby it perceives itself, and hence it is said to know itself by its own presence [“*cogito, ergo sum*”]. But as regards the second kind of knowledge, the mere presence of the mind does not suffice, and there is further required a careful and subtle inquiry. Hence many are ignorant of the soul’s nature, and many have erred about it. (p. 465)

Observations of the electrical activity of the brains of human subjects has shown that changes in brain state linked to an act occur prior to the execution of a self-paced (voluntary) act, and even half a second before the subjects express awareness that they are about to move (Libet 1994). This finding conforms to Aquinas’ doctrine that humans know themselves by their actions, not by their thoughts.

4. Intention and Will

In the final sections that I am going to quote Aquinas elaborates on the distinctions between will, desire, and intention, with remarks concern-

ing their applicability to other animals (note always the “other”). In this context a most interesting phenomenon is pain, which is willed by sadists, desired by masochists, but treated by analytic philosophers as being unintentional. In Aquinas’ conception pain is essential for the healing process, by which the unity of the body is recovered after mishap. Pain is also essential for assimilation, because it gives the signal when the intellect has failed in its intent to achieve its likeness to some aspect of the world.

Second Part, Q 1

Of man’s last end [happiness]

A 3: Whether human acts are specified by their ends? Each thing receives its species in respect of an act and not in respect of potency; therefore things composed of matter and form are established in their respective species by their own forms. And this is also to be observed in proper movements. For since movements are, in a way, divided into action and passion, each of these receives its species from an act; action indeed from the act which is the principle of acting, and passion from the act which is the term of the movement. And so heating as an action is nothing other than a certain movement proceeding from heat, while heating as a passion is nothing other than a movement towards heat; and it is the definition that shows the specific nature. And either way, human acts, whether they be considered as actions or as passions, receive their species from the end. For human acts can be considered in both ways, since man moves himself, and is moved by himself. (p. 611)

Second Part, Q 8

Of the will, in regard to what it wills

Prologue: ... there are three acts of the will in reference to the end; namely, volition [which includes choice and inaction], enjoyment [fruition, appetitive power], and intention [action of the will]: In I-II, Q.12, a.1, Aquinas explicitly says that intention is “properly speaking an act of the will.” (p. 655)

Second Part, Q 9

Of what moves the will

A 3: Whether the will moves itself? [It does.] ... it pertains to the will to move the other powers by reason of the end which is the will’s object. ... But it is evident that the intellect, through its knowledge of the principle, reduces itself from potency to act, as to its knowledge of the conclusions; and thus it moves itself. And, in like manner, the will, through willing the end, moves itself to will the means.

A 4: Whether the will is moved by an exterior principle? For everything that is at one time an agent actually, and at another time an agent in potency, needs to be moved by a mover. Now it is evident that the will begins to will something, whereas previously it did not will it. Therefore it must, of necessity be moved by something to will it. And, indeed, it moves itself, as stated above (A 3), in so

far as through willing the end it reduces itself to the act of willing the means. Now it cannot do this without the aid of counsel. For when a man wills to be healed, he begins to reflect how this can be attained, and through this reflection he comes to the conclusion that he can be healed by a physician, and he wills this. But since he did not always actually will to have health, he must, of necessity, have begun, though something moving him, to will to be healed. And if the will moved itself to will this, it must of necessity have done this with the aid of counsel following some previous volition. But this process could not go on to infinity. Therefore we must of necessity suppose that the will advanced to its first movement in virtue of the impulse of some exterior mover, as Aristotle concludes in a chapter of the Eudemian Ethics. ... It pertains to the notion of the voluntary act that its principle be within the agent, but it is not necessary that this inward principle be the first principle unmoved by another. And so though the voluntary act has an inward proximate principle, nevertheless its first principle is from without. Thus, too, the first principle of the natural movement is from without, that, namely which moves nature" [God, evolution]. (p. 660)

A key aspect of intentional behavior is that an action is preceded by the goal that shapes the action, and the perception of a stimulus is preceded by attentive awareness that prefigures the stimulus. Unintentional actions are not preceded or shaped by goals, and they give rise to unexpected stimuli. Unanticipated stimuli from outside likewise are not preceded by anticipatory shaping of the sensory cortices. The organism has a catch-all form of intentional behavior to deal with the sensory consequences of unintended behaviors, such as slips of the tongue, emotional outbursts, mistakes and misjudgments, and unintended stimuli such as flashes of lightning, gunshots, warning calls, odors of smoke and bitterness of taste.

This form is the orienting response, also called the "What is It?" reaction, including the startle response, by which the body is non-specifically readied to move in any direction, and by which the sense organs are opened wide and moved in search of the unknown. This orienting response is often called a reflex, but it has a cognitive component directed toward future knowing that makes it intentional, though it is neither willed nor desired.

Second Part, Q 12

Of intention

A 1: Whether intention is an act of the intellect or of the will? Intention, as the very word denotes, means to tend to something. Now both the action of the mover and the movement of the thing moved tend to something. But that the movement of the thing moved tends to anything is due to the action of the mover. Consequently intention belongs first and principally to that which moves to the end; hence we say that an architect or anyone who is in

authority, by his command moves others to that which he intends. Now the will moves all the other powers of the soul to the end. Therefore it is evident that intention, properly speaking, is an act of the will ...

A 1, reply to fourth objection: Now the will stands in a threefold relation to the end. First, absolutely. And in this way we have volition, whereby we will absolutely to have health and so forth. Secondly, it considers the end, as its place of rest. And in this way enjoyment regards the end. Thirdly, it considers the end as the term towards which something is ordered; and thus intention regards the end. For when we speak of intending to have health, we mean not only that we will to have it, but that we will to have it by means of something else.

A 4: Whether intention of the end is the same act as the volition of the means? [They are not.] Accordingly, in so far as the movement of the will is to the means, as ordered to the end, it is called choice; but the movement of the will to the end as acquired by the means, is called intention. A sign of this is that we can have intention of the end without having determined the means which are the object of choice.

The following passages establish the way in which Aquinas' doctrine of intentionality can be said to hold for other animals as well as man, and within what limits excluding choice, which he identified with free will. These passages are exceedingly important for those of us who seek for the forms of intention in other animals, and the evolution by which it reached its most elaborate form in the human animal.

A 5: Whether intention is appropriate to irrational animals? [It is, by nature.] Irrational animals are moved to an end, not as though they thought that they can gain the end by this movement, for this belongs to the one that intends; but through desiring the end by natural instinct, they are moved to an end, moved, as it were, by another, like other things that are moved naturally. (p. 672)

Second Part, Q 13

Of choice, which is an act of the will in respect to means

A 2: Whether choice is to be found in irrational animals? [No.] Now the difference between the sensitive appetite and the will is that ... the sensitive appetite is determined to one particularly thing, according to the order of nature; but the will, although determined to one thing in general, namely, the good, according to the order of nature, is nevertheless indeterminate in respect of particular goods. Consequently choice belongs properly to the will, and not to the sensitive appetite, which is all that irrational animals have. Therefore irrational animals are not able to choose. (p. 674)

Intentionality was clearly foreshadowed by Aristotle in his biological concept of the tending of each animal to maturity in its natural form. The

main accomplishment of Aquinas was to split off the concept of the will as a power of the Christian soul. His restricted doctrine of intention took root in secular science and medicine, and a case can be made that the explosive growth in education enabled the technical and managerial middle class of his time to adopt his concept of the will with its opportunities for choices and its responsibilities for its actions.

Thereby emerged the metaphor of the body as a machine, which was crucial for the mathematization of human function by Descartes. The result of the Cartesian revolution for neuroscience was the distinction between automatic (reflex) and “voluntary” behavior drawn in 1558 by Sir Thomas Willis, the English neuroanatomist remembered by all medical doctors everywhere for his discovery of the “Circle of Willis” at the base of the brain. Textbooks in neurobiology and neurology carry these labels into the present day, even though they have been noted by Dewey (1914) and others to have religious rather than scientific origins.

We need to revise our understandings of these terms in the light of the emerging science of nonlinear brain dynamics. This can be facilitated through cooperation of neuroscientists and philosophers, in the light of new readings of the works of Aquinas.

5. Conclusion

Recent advances in technology have opened a flood of new data that provide images of brain activity that occurs in conjunction with intentional and voluntary behaviors. These developments offer an opportunity that is unique in the history of human endeavor to investigate and understand the neural mechanisms of the brain, thereby resolving the paradox of the system understanding itself. In the same time period there has accrued an armamentarium of new intellectual tools and systems with which to analyze these new data, including nonlinear dynamics, far-from-equilibrium thermodynamics, random graph theory, and renormalization group theory. What is needed are philosophical concepts for systematizing behavioral analysis in forms that are compatible with the new data and techniques. The systems for mechanization of brain function that were introduced by Descartes, Leibniz, Spinoza and Willis in the 17th century have served well for the design and development of the measurement systems and tools providing new data, but the machine metaphors of computation, representation, and information processing are incompatible with these data. The key point of breakdown is the lack of invariance of spatial patterns of mesoscopic brain activity in sensory cortices elicited in association with fixed learned stimuli for which the context and significance are changed.

The philosophical system that most clearly and unequivocally conforms to this experimental finding is that of Thomas Aquinas. The suppo-

sition that his conception of the unity of mind-body-brain stemmed from the religious conception of rapture, the ascent to heaven of body and soul together at the final day, is irrelevant to the concept itself, which necessitates the role of self-determined creation of each individual's knowledge of the self and the world by directed actions of the body and the registration and internalization of the results of the extension. To be sure, the doctrines of Aquinas were themselves syntheses of ancient Greek and Roman learning, modified by Arabic scholars in the light of insights provided by themselves as well as those of equally ancient Indian and Chinese philosophers. The infusion of ideas from Islamic scholarship into Italy and Spain in the later Middle Ages is often undervalued and inadequately credited. This core concept of unity has repeatedly been touched upon and newly developed over the centuries by Orestes Brownson, Charles Peirce, and John Dewey among other pragmatists; by Husserl, Heidegger and Merleau-Ponty among other phenomenologists; by Köhler, Koffka and Gibson among other Gestalt psychologists; and by Varela, Rosch, and Dreyfus among other embodied cognitivists.

What has been lacking is the crystallization by which the new data and the new technologies for analysis can be focused onto a compatible and comprehensive system of behavioral description. The compatibility of the Aquinian doctrine is assured by the centrality of the concepts of intentionality and imagination: intentionality by the unity of mind and body in action into the world, imagination by the appeal to the creation by each individual of the self through constructive choice. The comprehensiveness is assured by the full range of the Aquinian doctrine, embedded as it was in the world view of his century. Therefore, neuroscientists may learn the perils and opportunities of philosophy, and philosophers may learn the essential features of the new conceptions of brain dynamics without having to acquire first the mathematical and technical languages of the contexts in which the discoveries are being made.

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