ARTICLES

Science by Conceptual Analysis: The Genius of the Late Scholastics

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The late scholastics—from the fourteenth to the seventeenth centuries—have suffered from a severe reputational problem. Attacked by every major thinker from Descartes to the Encyclopedists, they were a favourite target of abuse for Enlightenment rewritings of intellectual history, representing the darkness from which the Enlightened offered to rescue humanity. When scholasticism did revive in the late nineteenth century, it was largely Thomist, and twentieth-century neo-Thomism was fond of blaming the "decadent scholastics" and their "Suarezian errors" for the decline of Catholic philosophy. Their works are still mostly untranslated, so with the loss of Latin as a widely-read language, their thought has become increasingly inaccessible.[1]

That failure of understanding applies not only to the late scholastics' strictly philosophical views, but to the contributions they made to wider spheres of thought by the deployment of their skills of conceptual analysis to topics other than philosophy. Their contributions are in many cases "known" to experts in the history of particular fields, but somehow not generally understood outside each field, and hence invisible "in the mass". The purpose of this article is to give a short overview of some of their main achievements that have proved to be lasting contributions to intellectual history. The article aims at breadth rather than depth but provides substantial references for further study.

[1] Survey of the later period in D. D. Novotný, "In defense of Baroque scholasticism", *Studia Neoaristotelica* 6 (2009): 209–233.

Section 1: The natural and mathematical sciences

The scholastics adopted the Aristotelian ideal of the intellectual enterprise, as described in Aristotle's *Posterior Analytics* and implemented in Euclid's *Elements*: that certain knowledge could be gained by the intellect's reflection on experience, and organised as a deductive structure following from simple axioms known with certainty.[2] They added to that ideal a training in argument designed to reveal the true axioms and to refute errors, and an embodiment of the result in a textual tradition and an institution designed to carry the tradition forward from generation to generation, the university.

Not all branches of knowledge are well adapted to that mode of discovery and transmission. What is remarkable, as the late scholastics showed, is how many are.

1.1 Mathematics: The analysis of continuous change

The work of the fourteenth-century "Merton School" and its French collaborators Jean Buridan (c. 1300–c. 1359) and Nicole Oresme (c. 1322–1382) has been well-known since Duhem and has been intensively studied by Maier, Sylla and others and well displayed in many selections in Grant's *Source Book in Medieval Science*.[3] It has been highlighted again in Hannam's recent book on the medieval roots of modern science, *God's Philosophers*.[4] However it has usually been thought of as part of physics, and the scholastics have been regarded as "forerunners of Galileo" (in the title of Maier's book[5]). That is true as far as it goes, but it distracts attention from their achievements in the pure analysis of continuity and change. Their discoveries are better explained in Boyer's *History of Calculus*, where they are recognised as an essential part of the process of the analysis of rates and change that was completed by the calculus of Newton and Leibniz.[6]

[2] R. D. McKirahan, *Principles and Proofs: Aristotle's theory of demonstrative science* (Princeton: Princeton University Press, 1992).

[3] A. Maier & S. D. Sargent, *On the Threshold of Exact Science: Selected Writings of Anneliese Maier on Late Medieval Natural Philosophy* (Philadelphia: University of Pennsylvania Press, 1982); E. D. Sylla, *The Oxford Calculators and the Mathematics of Motion, 1320–1350: Physics and Measurement by Latitudes* (Cambridge, Mass: Harvard University Press, 1970); G. Molland, *Mathematics and the Medieval Ancestry of Physics* (Aldershot: Variorum, 1995); survey in E. Sylla, "The Oxford Calculators", in *The Cambridge History of Later Medieval Philosophy*, ed. N. Kretzmann, A. Kenny & J. Pinborg (Cambridge: Cambridge University Press, 1982), ch. 27; selections in E. Grant, *A Source Book in Medieval Science* (Cambridge, Mass: Harvard University Press, 1974), especially §§ 26, 41, 51.

[4] J. Hannam, *God's Philosophers: How the Medieval World Laid the Foundations of Modern Science* (London: Icon, 2009), chs 11–12.

[5] A. Maier, *Die Vorläufer Galileis im 14. Jahrhundert: Studien zur Naturphilosophie der Spätscholastik* (Rome: Edizioni di Storia e Letteratura, 1949).

[6] C. B. Boyer, *The History of the Calculus and its Conceptual Development* (New York: Dover, 1959) ch. 3.

Mathematics is usually thought to be a model of absolute clarity of thought, achieved with the use of symbols, and hence no place for scholastics to be delving in. But a pre-requisite of most mathematics is analysis of concepts confusedly present in experience, and in this the scholastics were masters. Ancient mathematics, mainly mathematical astronomy, had some understanding of large-scale uniform motions and their combinations, but there was no understanding of small-scale motions. For example, there is no unit of speed (such as "miles per hour") in ancient languages, no doubt largely due to the impossibility of measuring small units of time. The first thing needed to begin the study of motion (or any other rate of change) is to distinguish between uniform and non-uniform speeds—in mathematical terms, between a first and a second derivative. That distinction is a matter of pure conceptual analysis. The fourteenth century calculators not only did that, but distinguished further between uniform and non-uniform accelerations. Then they showed a deep understanding of uniform acceleration by proving the "Merton mean speed theorem": that a uniformly accelerated body travels the same distance as a body of uniform speed whose speed equals half the final speed of the accelerated body.[7] In the later language of calculus, that is to show that the integral of a constant function is a linear function.

It is true that the scholastics did not establish the main application of their analysis in physics, the fact that heavy bodies dropped near the earth's surface *are* uniformly accelerated. That is a difficult fact to discover, because the fall of such bodies is too fast to measure easily (without modern technology such as time-lapse photography). It was established with considerable experimental ingenuity by Galileo. Nevertheless the suggestion that falling bodies *might* be uniformly accelerated was made by a scholastic whose work was known to Galileo, Domingo de Soto (1494–1560), in his *Questions on the Eight Books of Aristotle's Physics* (1551).[8] Indeed, as Wallace's careful studies showed, the early Galileo was a late scholastic himself.[9] For example, his graphical proof of the mean speed theorem is very close to Oresme's.[10]

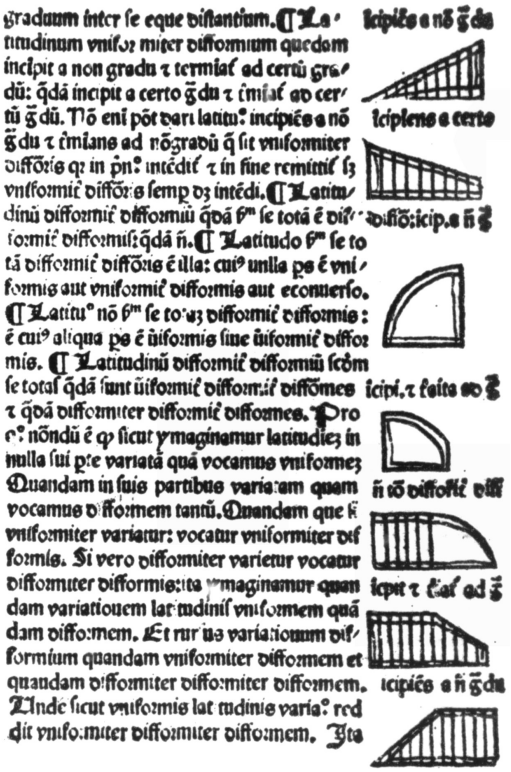
[7] Grant, *Source Book*, §§ 42–43.

[8] W. A. Wallace, *Domingo de Soto and the Early Galileo: Essays on Intellectual History* (Aldershot: Ashgate, 2004).

[9] W. A. Wallace, *Galileo's Early Notebooks: The Physical Questions* (Notre Dame, Ind: University of Notre Dame Press, 1977); W. A. Wallace, *Galileo and His Sources* (Princeton: Princeton University Press, 1984); E. A. Reitan, "Thomistic natural philosophy and the Scientific Revolution", *Modern Schoolman,* 73 (1996): 265–281.

[10] Hannam, *God's Philosophers*, 330–332.

Oresme also invented the concept of graphs, one of the few mathematical discoveries since ancient times that are familiar to every reader of newspapers, and one of the crucial tools for thinking about functions.



A page of graphs from a manuscript of Oresme's
Tractatus de latitudinibus formarum (1486)
(MPIWG Library, Berlin)

Analysis of infinities and the continuum is also suited to the conceptual methods of the scholastics;[11] Albert of Saxony (c. 1320–1390) pairs off infinite sets "in the imagination" in the same style as Cantor.[12]

[11] N. Kretzmann, *Infinity and Continuity in Ancient and Medieval Thought* (Ithaca, N. Y.: Cornell University Press, 1982).

[12] Albert of Saxony, *Commentary on De Caelo,* summarised in J. Sesiano, "On an algorithm for the approximation of surds from a Provençal treatise", in *Mathematics From Manuscript to Print 1300–1600*, ed. C. Hay (Oxford: Clarendon, 1988), 42–7.

1.2 Mathematical physics

The situation is partly but not wholly different for physics. The thesis of Duhem, that much of early modern physics was anticipated by the Merton School and associated scholastics in the fourteenth century, is well known and has been the object of much discussion. Despite some qualifications, it has largely stood the test of time.[13] But physics is not the subject in which the scholastics show to best advantage. While the medieval aversion to observation and experience in general is much exaggerated, and while the idea of mathematised science was understood, it is undeniable that *controlled* experiment and accurate measurement were largely absent from medieval science.[14] The medievals supported their physical theories with "experience", but they usually meant common experience, "what everyone knows". Without careful measurement and experiment, the conceptual analysis that is the strong point of the scholastic method could make only limited progress in physics, and it is Galileo's addition of those ingredients to the recipe of science that make his reputation for originality entirely deserved. Still, purely conceptual work, combined with everyday experience, can result in *some* good physics as well as good social science or law—statics, the subject of Duhem's original work,[15] can progress a good way purely on symmetry considerations, while the distinction between velocity and acceleration, necessary for any serious work on motion, is as we saw purely a matter of mathematical concepts. It is certainly possible to criticize the late scholastics for doing physics without proper experimentation and measurement. However, it is not customary to criticize Einstein for his lack of experiment. Analysis and theory are crucial to physics (and even more so to mathematics).

For the same reason but more so, the more down-to-earth empirical sciences were inappropriate for the scholastic method. Chemistry, pharmacology and metallurgy are examples: knowledge about the effects of chemicals and drugs and the strength of materials is so heavily empirical that looking into oneself

[13] P. Duhem, *Etudes sur Léonard de Vinci* (Paris: Hermann, 1906–1913); R. Ariew and P. Barker (eds.), *Duhem as Historian of Science*, special issue of *Synthese*, 83, 2 (1990); S. L. Jaki, *Uneasy Genius: The Life and Work of Pierre Duhem* (The Hague: Nijhoff, 1984), ch. 10; R. N. D. Martin, *Pierre Duhem* (La Salle, Ill: Open Court, 1991), chs. 8–9; J. E. Murdoch, "Pierre Duhem and the history of late medieval science and philosophy in the Latin west", in *Gli studi di filosofia medievale fra otto e novecento,* ed. R. Imbach & A. Maierù (Rome: Edizioni di storia e letteratura, 1991), 253–302; overview in E. Grant, *The Foundations of Modern Science in the Middle Ages* (Cambridge: Cambridge University Press, 1996), ch. 8.

[14] Many articles in E. Grant & J. E. Murdoch (eds.), *Mathematics and its Applications to Science and Natural Philosophy in the Middle Ages* (Cambridge: Cambridge University Press, 1987); A. C. Crombie, "Quantification in medieval physics", *Isis* 52 (1961): 143–60; also Colish, ch. 24.

[15] P. Duhem, *Les origines de la statique* (Paris: Hermann, 1905); trans. G. F. Leneaux, V. N. Vagliente and G. H. Wagener as *The Origins of Statics* (Dordrecht: Kluwer, 1991).

and analysing concepts will not make much progress, however good a memory one has. It is not an accident that these disciplines were undeveloped before very modern times. What knowledge there was in them was more a mass of engineering expertise than a scientifically grounded body of facts. In particular, they lacked a methodology for improving themselves.

1.3 Probability and risk

Probability, on the other hand, is perfect for conceptual analysis. Indeed, the continuing controversies in the philosophy of probability show how difficult the analysis is.

Probability is essentially of two kinds, at least on the surface. On the one hand, there is logical probability, dealing with the relation of evidence to conclusion in such areas as legal "proof beyond reasonable doubt" and the evidence for scientific theories. On the other, there is factual or stochastic probability, dealing with the long-run frequencies in the patternless outcomes of chance phenomena like the throwing of dice and coins.[16] Both kinds of probability became well understood, in a qualitative and conceptual way, in the late scholastic period prior to the foundation of the mathematical theory of probability by Pascal and Fermat's correspondence of 1654.

The central story of the developing understanding of logical probability lies in the law of evidence. Based on scattered remarks of ancient Roman law, the legal scholarship of the Glossators and Post-Glossators (12^{th}–14^{th} centuries) developed an elaborate grading of proofs—from suspicions and "indications" through half-proofs to "evident and manifest" proofs and "violent presumptions", up to the "proofs clearer than light" required for conviction in a criminal case.[17] The full theory was laid out with many distinctions in the commentaries of Baldus de Ubaldis (1327–1400). He writes, for example,

> Note that two imperfect kinds of proof, and two presumptions of different sorts, and one witness to truth, and two to reputation do not make full proof in a criminal case; for there is only the single witness to truth [not the two required by the Biblical two-witness rule].[18]

[16] Introductions to the distinction in J. Franklin, *What Science Knows: And How It Knows It* (New York: Encounter Books, 2009), ch. 10; I. Hacking, *The Emergence of Probability,* 2nd ed. (Cambridge: Cambridge University Press, 2006), ch. 2.

[17] J. Franklin, *The Science of Conjecture: Evidence and Probability Before Pascal* (Baltimore: Johns Hopkins University Press, 2001), chs. 2–3.

[18] Franklin, *Science of Conjecture*, 32.

That theory was familiar in legal circles in the 16th and 17th centuries, being elaborated in huge treatises on proofs and presumptions such as those of Jacobus Menochius (1532–1607) and Josephus Mascardus († 1588). These works are referred to by Leibniz and by 19th century English and American writers on the law of evidence, indicating the extraordinary power of legal tradition to preserve and propagate ideas.[19]

The ideas percolated into society more generally via canon law and the theory of casuistry (moral analysis of particular cases), developed because the confessional was thought of as a miniature court of canon law. It was this context that produced the 16th century scholastics' moral doctrine of probabilism, the theory that in case of doubt as to the morality of an action, one might follow a sufficiently probable course, even if the opposite opinion was more probable. "Probable" here refers to the balance of reasons and authorities in favour of an opinion. The possible consequences of this doctrine for laxity in morals became a matter of intense public debate through the celebrated attack on Jesuit probabilism in Pascal's *Provincial Letters* of 1656.[20]

Discussion of factual probability was found mostly in legal and moral works on "aleatory contracts"—contracts whose outcome depends on some matter of chance, such as insurance, life annuities, options contracts, speculative investments and gambling. It was understood that in such contracts a payment was made for a "hope", "peril" or "risk", that is, for a probability based on how often some outcome tended to occur, and that this distinguished such contracts from usury, the lending of money at interest.[21] Thus Domingo de Soto, answering the objection that insurance appears to involve a payment for nothing, compares it to a game of chance:

> For anything that can be estimated at a price, one can receive a fee: to render a thing safe [insure it], which is exposed to peril, can be estimated at a price … we say of a fair game: whether it will rain tomorrow or not, etc; so in the same way it is permitted to expose a thousand ducats, say, to peril with the hope of making fifty or sixty. There are some who regard it as stupid to allow the peril of someone's ship worth perhaps twenty or thirty thousand, in the hope of making a hundred or a thousand. To this we reply that it is not for us to dispute about prices: these can be just or unjust, but it is for the contracting parties to decide them. But there is no stupidity or folly in

[19] Franklin, *Science of Conjecture*, 43–46.

[20] Franklin, *Science of Conjecture*, ch. 4; I. Kantola, *Probability and Moral Uncertainty in Late Medieval and Early Modern Times* (Helsinki: Luther-Agricola-Society, 1994).

[21] Franklin, *Science of Conjecture*, ch. 10.

> accepting this kind of peril at the going price; in fact nothing is more obvious than that insurances can expect to gain. They may lose sometimes, but at other times they accumulate gain.[22]

Gambling, lotteries and other bets was one of the topics discussed under aleatory contracts. Antonio Escobar y Mendoza (1589–1669), the casuist most vigorously attacked in Pascal's *Provincial Letters*, argued that for games to be permitted, equality of the stakes was normally required but that a player might licitly stake less money if his potential winnings were greater.[23] These questions are close to the case of conscience which led Pascal and Fermat to their mathematical calculations, the just division of the stake in an interrupted game of chance.[24]

Section 2: The social sciences and psychology

It is a commonplace that the contemporary social sciences are riven by disputes about theory in a way that the natural sciences are not. Economics, anthropology, and legal and political theory are still full of vigorous debates about what concepts should be used to organise and ask questions about the empirical data—even debates about whether there are any empirical data free of theoretical perspectives. That is an indication that those fields are prime candidates for the conceptual analysis that was the strong suit of the late scholastics.

2.1 Legal theory

The law of evidence is only one example of the deep influence of late scholasticism on later legal theory. Modern law — especially Anglo-American law, which does not depend directly on the Roman texts — shows many evidences of its centuries of development under the scholastic intellectual *oikumene*. In intellectual style, the law is still very close to the scholastic method, with its respect for old authorities and its endlessly elaborating commentary and formal dispute on conceptual points and fine distinctions, comparison of texts, and logical argument for and against propositions[25] (and in many countries still, in its style of dress). Western law has also inherited from the scholastics and canon lawyers

[22] D. Soto, *De iustitia et iure*, lb. 6, q. 7 (Lyons, 1569), quoted in Franklin, *Science of Conjecture*, 286.

[23] A. Escobar y Mendoza, *Liber theologiae moralis* (Lyons, 1644), 400–401; Franklin, *Science of Conjecture*, 301.

[24] Observed by E. Coumet, "Le problème des partis avant Pascal", *Archives internationales d'histoire des sciences* 17 (1965): 244–272.

[25] Some discussion in S. A. Siegel, "The Aristotelian basis of English law 1450–1800", *New York University Law Review* 56 (1981): 18–59.

a special concern for the relation between ethical principles and the law as it stands, with principles of justice, fairness and equity being regarded as essential values that positive law cannot transgress.[26]

The process by which this came about has been closely studied for the law of contract, in Gordley's *Philosophical Origins of Modern Contract Doctrine*. The largely unexplained rules of ancient Roman law were given explanations in terms of Aristotelian concepts of the nature of contract, and the Spanish scholastics of the sixteenth century were responsible for a synthesis, Aristotelian in conception and Roman in detail, involving a casuistry of will, consent, fraud, mistake, duress and so on. Later legal theorists up to the present retained the scholastic language and distinctions, though ignoring as far as possible the underlying Aristotelian philosophy.[27]

A similar story is told in Brian Tierney's work on the origin of natural rights theories, the conception of pre-legal human rights that has had such success since the 1948 Universal Declaration of Human Rights. Scholastic debate on the conflicting jurisdictions of the middle ages, church and civil, led William of Ockham and later scholastic writers to a theory of individual rights existing prior to any human laws, and constituting a moral foundation that human laws were bound (morally) not to transgress. It was transmitted to later centuries by seventeenth-century writers such as Grotius.[28] Related conceptions dealing with the ethical protection of individuals became even more deeply embedded in Western law, notably the principle of equality before the law[29] and the presumption of innocence for the defendant in criminal cases. The formulation "everyone is presumed innocent, unless proved guilty" is found in the canon lawyer Johannes Monachus about 1300.[30] For both of these principles there are brief Roman law origins, but the development of them as moral concepts fundamental to the law is a scholastic achievement.

[26] Background for English law in D. R. Klinck, *Conscience, Equity and the Court of Chancery in Early Modern England* (Farnham: Ashgate, 2010).

[27] J. Gordley, *The Philosophical Origins of Modern Contract Doctrine* (Oxford: Clarendon, 1991); P. Grossi (ed), *La seconda scolastica nella formazione del diritto privato moderno* (Milan: Giuffrè, 1973).

[28] B. Tierney, *The Idea of Natural Rights: Studies on natural rights, natural law and church law, 1150–1625* (Atlanta: Scholars Press, 1997); K. Pennington, "Review essay: the history of rights in Western thought", *Emory Law Journal* 47 (1998): 237–252; C. J. Reid, "Canonistic contribution to the Western rights tradition: an historical inquiry", *Boston College Law Review* 33, 2 (1991): 37–92.

[29] J. M. Kelly, *A Short History of Western Legal Theory* (Oxford: Clarendon, 1993), 29–30, 146–148, 191–193.

[30] F. Quintard-Morénas, "The presumption of innocence in the French and Anglo-American legal traditions", *American Journal of Comparative Law* 58 (2010): 107–149; K. Pennington, "Innocent until proven guilty: the origins of a legal maxim", *The Jurist*, 63 (2003): 106–124.

The Spanish scholastics of the sixteenth century were the most influential thinkers on law, ethics and the intersection of the two. Especially prominent were their contributions to international law, which, not being under the control of any king, legislature or court, has a character more suited to the abstract discussion of the scholastics than the law of individual states. It was studied in the fourteenth century when it was recognised that Italian city states were *de facto* independent, whatever the pretensions of the Empire. The history of international law has had many decades to absorb the inclusion of the works of Francisco de Vitoria (c. 1492–1546) and Francisco Suárez (1548–1617), in English, in Scott's *Classics of International Law*, but credit for those scholastics' ideas is still often given to later thinkers like Grotius and Pufendorf.[31] A characteristic problem in the area, considered by Suarez and others, is the right and duty of humanitarian intervention on behalf of peoples oppressed by a tyrant; the issue remains as relevant as ever.[32]

Law is particularly important for the early modern development of ideas because of the large place it held in public life and intellectual training. Of the founders of modern thought, Copernicus, Bacon, Fermat, Huygens and Leibniz were professional lawyers, Montaigne a judge, Machiavelli, Pascal and Arnauld the sons of lawyers, and Petrarch, Rabelais, Luther, Calvin, Donne and Descartes former law students.[33]

2.2 Political theory

Political theory was conceived in legal and moral terms and the concepts of those disciplines formed the language in which political debates took place. Notions of constitutional government, the restraints of custom and tradition,

[31] A. Nussbaum, *A Concise History of the Law of Nations,* 2nd ed. (New York, 1954), ch. 2; "Bartolo on the conflict of laws", trans. J. A. C. Smith, *American Journal of Legal History* 14 (1970): 157–183, 247–275; J. Muldoon, *Canon Law, the Expansion of Europe, and World Order* (Aldershot: Ashgate, 1998); F. de Vitoria, *De Indis et De Iure Belli Relectiones*, ed. E. Nys (Washington: Carnegie Institute, 1917); F. Suarez, *Selections from Three Works* (Oxford: Clarendon, 1944); see J. B. Scott, *The Spanish Origin of International Law: Francisco de Vitoria and his Law of Nations* (Oxford: Clarendon, 1934 (and to the contrary, Nussbaum, *A Conise History of the Law of Nations*, appendix II); D. Kennedy, "Primitive legal scholarship", *Harvard International Law Journal* 27 (1986): 1–98; P. Stein, *Roman Law in European History* (New York: Cambridge University Press, 1999), 94–97; A. Anghie, *Imperialism, Sovereignty and the Making of International Law* (Cambridge: Cambridge University Press, 2004), ch. 1.

[32] T. Meron, "Common rights of mankind in Gentili, Grotius and Suárez", *American Journal of International Law* 1991; on a related topic, G. Cavallar, *The Rights of Strangers: Theories of International Hospitality, the Global Community, and Political Justice since Vitoria* (Aldershot: Ashgate, 2002).

[33] Franklin, *Science of Conjecture*, 348–352; W. Bouwsma, "Lawyers and early modern culture", *American Historical Review* 78 (1973): 303–327.

and the subtle relations between legitimacy of government and popular consent, are medieval achievements in both theory and practice.[34] The reasonableness of scholastic discussions of those matters is in some ways only now being attained again, after many unhappy detours through extremist theories of absolute monarchy, the divine right of kings, utopianism, theocracy, revolution and class war. The one-sidedness of such theories accounts for their memorability, and hence the corresponding difficulty of remembering more nuanced theories. It accounts also for their disastrous consequences in practice.

Simplified counterfactual situations are a staple of scholastic analysis in all fields. In political theory, they include the long-running scenario of a "state of nature" in which all are "born free and equal", which was considered by Suarez in his considerations on the native Americans.[35]

2.3 Economics

In economic history, the idea that the serious development of theory began with the seventeenth-century Mercantilists (perhaps with Aristotle deserving some passing mention) was exploded by Schumpeter and others, with their examination of the scholastics of, especially, the sixteenth century,[36] but it can

[34] A. Black, *Political Thought in Europe, 1250–1450* (New York: Cambridge University Press, 1992); J. M. Blythe, *Ideal Government and the Mixed Constitution in the Middle Ages* (Princeton: Princeton University Press, 1992); Q. Skinner, *The Foundations of Modern Political Thought* (Cambridge: Cambridge University Press, 1978), vol. II, ch. 5; B. Hamilton, *Political Thought in Sixteenth Century Spain: A study of the political ideals of Vitoria, de Soto, Suárez and Molina* (Oxford: Clarendon, 1963); D. E. Luscombe, ch. 40 of *Cambridge History of Later Medieval Philosophy*, ed. N. Kretzmann, A. Kenny & J. Pinborg (Cambridge: Cambridge University Press, 1982); J. H. Burns, "The scholastics", ch. 5, and H. A. Lloyd, "Constitutionalism", ch. 9 of *Cambridge History of Political Thought, 1450–1700*, ed. J. H. Burns (Cambridge: Cambridge University Press, 1991); F. de Vitoria, *Political Writings*, ed. A. Pagden, trans. J. Lawrance (New York: Cambridge University Press, 1991); K. Pennington, *The Prince and the Law, 1200–1600: Sovereignty and rights in the Western legal tradition* (Berkeley: University of California Press, 1993).

[35] J. P. Doyle, "Francisco Suárez on preaching the Gospel to people like the American Indians", *Fordham International Law Review* 15 (1992): 879–951.

[36] O. Langholm, *Economics in the Medieval Schools* (Leiden: Brill, 1992); O. Langholm, *The Legacy of Scholasticism in Economic Thought* (Cambridge: Cambridge University Press, 1998); B. J. Gordon, *Economic Analysis Before Adam Smith: Hesiod to Lessius* (London: Macmillan, 1975), chs 6–9; J. T. Noonan, *The Scholastic Analysis of Usury* (Cambridge, Mass: Harvard University Press, 1957); M. Grice-Hutchinson, *The School of Salamanca: Readings in Spanish monetary theory, 1544–1605* (Oxford: Clarendon, 1952); R. de Roover, "The scholastics, usury and foreign exchange", *Business History Review* 41 (1967): 257–71; J. A. Schumpeter, *History of Economic Analysis* (London: Allen & Unwin, 1955), ch. 2; J. Viner, "The economic doctrines of the scholastics", *History of Political Economy* 10 (1978): 46–113; L. G. Rivas, "Business ethics and the history of economics in Spain: 'The School of Salamanca': a bibliography, *Journal of Business Ethics* 22 (1999): 191–202; A. A. Chafuen, *Christians for Freedom: Late Scholastic Economics* (San

hardly be said to be common property even now. Concepts like demand, capital, labour, utility, scarcity and the cost of lost opportunity were developed at length by the scholastics, based on Aristotle's brief remarks. It is difficult to evaluate the contribution of the business community itself to these notions, for lack of evidence, but at present it seems that the explicit names and distinctions were due more to the scholastics' need for precision in ethical and legal discussions than to any strictly business requirements. In any case, the distinction between ethics and business was once not so rigidly drawn. Oresme's monetary theory is only one of the connections between the scholastics and more applied and mathematical investigations into business.[37]

2.4 Psychology

Psychology, especially of the introspective kind, was also well-adapted to the scholastic method, although in this case the main developments came earlier. The general medieval concentration on the inner life encouraged by Augustine, the self-examination of enforced confession and Aristotle's *De anima* is reflected in the extensive attention given to the mind and soul in scholastic works from the time of Albert the Great and Aquinas, and the large number of texts on psychological subjects in the sixteenth and seventeenth centuries.[38]

One of the longest-running themes in the history of psychology is "faculty psychology", as advanced by Avicenna and his Western scholastic followers from Aquinas on. Faculty psychology holds that human cognition is decomposable into largely distinct tasks like sensation, comparison of different sensory modalities, memory and so on, which are undertaken by different "faculties" located in different regions of the brain. It was the natural way of organising psychological data for many centuries,[39] and its (Latin) language is the way we still express our

Francisco: Ignatius Press, 1986); overview in M. Colish, *Medieval Foundations of the Western Intellectual Tradition, 400–1400* (New Haven: Yale University Press, 1997), ch. 25; W. Decock, "Lessius and the breakdown of the scholastic paradigm", *Journal of the History of Economic Thought* 31 (2009): 57–78; later connections in R. E. Prasch, "The origins of the a priori method in classical political economy", *Journal of Economic Issues* 30 (1996): 1105–1125.

[37] J. Kaye, *Economy and Nature in the Fourteenth Century: Money, Market Exchange and the Emergence of Scientific Thought* (New York: Cambridge University Press, 1998); R. W. Hadden, *On the Shoulders of Merchants: Exchange and the Mathematical Conception of Nature* (Albany: SUNY Press, 1994), ch. 4.

[38] H. Schüling, *Bibliographie der psychologischen Literatur des 16. Jahrhunderts* (Hildesheim: Olms, 1967); S. Kemp, *Medieval Psychology* (New York: Greenwood Press, 1990); J. Zupko, "What is the science of the soul?", *Synthese* 110 (1997): 297–334; S. K. Knebel, "Scotists vs. Thomists: what seventeenth-century scholastic psychology was about", *Modern Schoolman* 74 (1997): 219–26.

[39] A. Kenny, *Aquinas* (New York: Hill & Wang, 1980), ch 3; E. Harvey, *The Inward Wits: Psychological Theory in the Middle Ages and Renaissance* (London: Warburg Institute, 1975); E. P. Mahoney, "Sense,

"folk" psychological explanations of behaviour in terms of aspirations, sensations, imagination, actions, motives, emotions and so on.[40] As with the language of science, it is no accident that these words are Latin and the senses in which we use them are medieval more than classical. As a typical example, the *OED* traces the etymology of "imagination" thus: in classical Latin, it means the action of forming mental images, but in medieval Latin and European vernaculars, it is in the first instance the faculty in which mental images are formed: in Old French c. 1174, Catalan and Italian late 13th century, Spanish and Portuguese 14th century, English c. 1340.[41]

While the approach was disparaged in the 1950s heyday of behaviourism, the revival of faculty psychology under various names has been one vigorous strand in more recent cognitive psychology.[42]

2.5 Linguistics

Grammar was a foundation stone of medieval education, and the inherited texts were from the 12th century subjected to the same process as legal texts, of glossing and commentary in search of the philosophical principles underlying them. Many of the concerns of modern semiotics on the different ways in which words can have meaning are visible in medieval debates about signs. For example, Augustine's conception of a sign as something that is perceived and suggests something else to some mind raises questions about signs of the non-existent, signs not interpreted by any mind, and about the sameness of the "mental words" in the minds of speakers of different languages.[43]

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intellect and imagination in Albert, Thomas and Siger", ch. 30 of *The Cambridge History of Later Medieval Philosophy*; N. H. Steneck, "Albert on the psychology of sense perception", in *Albertus Magnus and the Sciences,* ed. J. A. Weisheipl (Toronto: Pontifical Institute of Mediaeval Studies, 1980), 263–290; refs to Avicenna's originals in D. L. Black, *Logic and Aristotle's Rhetoric and Poetics in Medieval Arabic Philosophy* (Leiden: Brill, 1990), 202, n. 66; also *Avicenna's Psychology*, trans. F. Rahman (London: Oxford University Press, 1952).

[40] S. P. Stich, *From Folk Psychology to Cognitive Science* (Cambridge, Mass: MIT Press, 1983); T. P. Greenwood (ed.), *The Future of Folk Psychology* (Cambridge: Cambridge University Press, 1991).

[41] "Imagination", *Oxford English Dictionary*.

[42] J. Fodor, *The Modularity of Mind: An Essay in Faculty Psychology* (Cambridge, Mass: MIT Pres, 1983); M. Minsky, *Society of Mind* (New York: Simon & Schuster, 1986).

[43] S. Meier-Oeser, "Medieval Semiotics", in *The Stanford Encyclopedia of Philosophy (Summer 2011 Edition)*, ed. Edward N. Zalta, URL = ⟨http://plato.stanford.edu/archives/sum2011/entries/semiotics-medieval/⟩; E. Vineis and A. Maierù, "Medieval linguistics", in *History of Linguistics*, ed. G. Lepschy, vol. II (London: Longman, 1994), ch. 2; G. L. Bursill-Hall, *Speculative Grammars of the Middle Ages* (The Hague: Mouton, 1971); U. Eco and C. Marmo (eds.), *On the Medieval Theory of Signs* (Amsterdam: J. Benjamins, 1989); L. Kaczmarek, "The age of the sign: new light on the role of the fourteenth century in the history of semiotics", *Dialogue* (Canada) 31 (1992): 509–515; C. Panaccio, "Ockham and Locke on

Vocabulary is one of great hidden successes of scholasticism. The present-day international language, in which this article is written, is a blend of Old English, Norman French and scholastic Latin; and it is the vast inheritance of scholastic vocabulary, mostly still carrying its medieval meaning, that bears the weight of academic discussion on all subjects.[44] Consider the current section in general, or the present sentence in particular, or examine adjacent portions of the text, for a variety of natural and artificial examples of scholastic abstract vocabulary.

2.6 Philosophy

While this article is focussed on the scholastics' contribution in areas other than their philosophical doctrines, the story would be incomplete without mentioning that they had a largely hidden influence on the conceptual apparatus of modern philosophy, just as they had in mathematics, law and the social sciences.

Since Gilson's studies a hundred years ago of Descartes' scholastic vocabulary, there has been much work on the dependence of the founders of modern philosophy on the conceptual apparatus of scholasticism.[45] The scholastics controlled the well-funded university posts, the academic presses and the curricula; their logic and philosophy were a central part of what every educated person had to learn.[46] The rationalists and empiricists who attacked the scholastics so forcefully provide perfect examples of the old topos of students and their teachers disagreeing heatedly on answers, but exhibiting a unity of questions, unspoken assumptions and concepts. The fiercest opponents at, so to speak, the species

mental language", in *The Medieval Heritage in Early Modern Metaphysics and Modal Theory, 1400–1700*, ed. R. L. Friedman and L. O. Nielsen (Kluwer: Dordrecht, 2003), 37–51.

[44] J. Franklin, "Mental furniture from the philosophers", *Et Cetera* 40 (1983): 177–191.

[45] E. Gilson, *Index scolastico-cartésien* (Paris: Alcan, 1913); É. Gilson, *Etudes sur le rôle de la pensée médiévale dans la formation du système cartésien* (Paris: Vrin, 1951); F. P. van der Pitte, "Some of Descartes' debts to Eustachius a Sancto Paulo", *Monist* 71 (1988): 487–497; R. Ariew, *Descartes and the Last Scholastics* (Ithaca: Cornell University Press, 1999); J. Secada, *Cartesian Metaphysics: The Scholastic Origins of Modern Philosophy* (Cambridge: Cambridge University Press, 2000); A. Tellkamp, *Das Verhältnis John Lockes zur Scholastik* (Münster: Aschendorff, 1927); W. H. Kenney, "John Locke and the Oxford Training in Logic and Metaphysics" (Dissertation, St Louis University, 1959); E. J. Ashworth, "'Do words signify ideas or things?' The scholastic sources of Locke's theory of language", *Journal of the History of Philosophy* 19 (1981): 299–326; D. Connell, *The Vision in God: Malebranche's Scholastic Sources* (Louvain: Nauwelaerts, 1967); P. Reif, "The textbook tradition in natural philosophy, 1600–1650", *Journal of the History of Ideas* 30 (1969): 17–32.

[46] R. Ariew and A. Gabbey, ch. 15 of *Cambridge History of Seventeenth Century Philosophy,* ed. D. Garber and M. Ayers (Cambridge: Cambridge University Press, 1998); M. H. Curtis, *Oxford and Cambridge in Transition* (Oxford: Clarendon, 1959), 111; W. T. Costello, *The Scholastic Curriculum at Early Seventeenth-Century Cambridge* (Cambridge, Mass: Harvard University Press, 1958), 49–50; H. F. Fletcher, *The Intellectual Development of John Milton*, vol II (Urbana, Ill: Univ. of Illinois Press, 1961), ch 7.

level are found to be united at the genus level. Descartes and Locke underwent particularly heavy exposure to scholasticism in their formative years, and the questions they ask, and the vocabulary of their answers, stray remarkably little from their teachers' practice. Gassendi very pointedly asks why the Cartesian ego, having doubted everything and put aside all prejudice and tradition, is still spouting scholastic terminology.[47]

Conclusion

There is less than meets the eye to the explosion of knowledge of which contemporary intellectual life boasts. Vast quantities of new empirical facts have indeed been observed and theories verified, but the conceptual superstructure into which they have been integrated is an old one. It is the one bequeathed to modern times by the later scholastics.

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[47] P. Gassendi, *Disquisitio Metaphysica*, med. 3, dub. 9, in *Opera Omnia* (Lyons, 1658, repr. Stuttgart-Bad Cannstatt, 1964), vol. III: 348.

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SUMMARIUM

Scientia per resolutionem conceptuum sive de scholasticorum seriorum ingenio

Scholastici qui saec. 14.–17. florebant praeter philosophiam multas partes scientiae excoluerunt. Methodus, qua usi sunt, "analysis conceptualis" seu ars resolvendi conceptus dici potest. Methodus ista maxime in scientiis speculatione potius quam experientia innitentibus fecunda est. Inter quos notanda est mathematica, in qua scholastici analysin motus continui (cuius elaboratione calculus subsequenter confectus est) et doctrinam de mensura risici seu periculi ac probabilitate excogitaverunt. Analytica tamen methodus praecipue in scientiis socialibus applicationem meruit. In iurisprudentia scholastici e. g. analysin moralem validitatis contractorum et de iure naturali doctrinam perfecerunt. In doctrina politica scholastici constitutionalismum et experimentum conceptuale "status naturalis" introduxerunt. Doctrinam oeconomicam scholastici notionibus augebant, quae usque ad hoc tempus fundamentales reputantur – ut notiones necessitatis (seu quaesitionis), capitalis, laboris, inopiae. Ultra hoc adde psychologiam potentiarum animae et semioticen. Posterior omnium huiusmodi doctrinarum evolutio et vocabulario, et conceptibus scholasticis magna ex parte semper innitebatur.

ABSTRACT

Science by Conceptual Analysis: The Genius of the Late Scholastics

The late scholastics, from the fourteenth to the seventeenth centuries, contributed to many fields of knowledge other than philosophy. They developed a method of conceptual analysis that was very productive in those disciplines in which theory is relatively more important than empirical results. That includes mathematics, where the scholastics developed the analysis of continuous motion, which fed into the calculus, and the theory of risk and probability. The method came to the fore especially in the social sciences. In legal theory they developed, for example, the ethical analyses of the conditions of validity of contracts, and natural rights theory. In political theory, they introduced constitutionalism and the thought experiment of a "state of nature". Their contributions to economics included concepts still regarded as basic, such as demand, capital, labour, and scarcity. Faculty psychology and semiotics are other areas of significance. In such disciplines, later developments rely crucially on scholastic concepts and vocabulary.