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QUALITATIVE CHANGE

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At the boundaries of metaphysics and natural philosophy lies a fascinating medieval dispute over the way qualitative change takes place. Although modern philosophy has had little to say about this issue, anyone who needs properties or dispositions to do serious explanatory work should attend to how such qualitative features of reality intensify and diminish. For now, the most sophisticated such accounts are to be found in the later Middle Ages.

Motivating the Problem

A qualitative change is a change to quality, as opposed to a change to quantity or substance. The difference arises ultimately out of Aristotle's division of being in the *Categories*, which was widely understood to license a fundamental distinction between these different kinds of being. For present purposes, we can set aside the many controversies over the precise nature of the distinction between quality, quantity, and substance, and content ourselves with a few paradigmatic examples. When a thing becomes larger or heavier, or moves faster, it undergoes a change in *quantity*. When the thing itself—a dog, a tree, some water—goes out of existence, and is succeeded by something else, then there is a change in *substance*. When the thing endures, but becomes hotter, moister, or greener, it undergoes a change in *quality*. For scholastic Aristotelians, such qualities are in fact the fundamental causal agents in the natural world, completely overshadowing the peripheral role played by quantitative (geometric or kinetic) explanations. In keeping with this prominent physical role, for most scholastic authors, qualities also have a robust metaphysical status as *accidental forms* that are really distinct from the subjects (typically, the substances) in which they inhere.¹

In thinking about why the debate over qualitative change matters, we might start by imagining a theory of the world that makes no use of forms whatsoever: a view on which the only facts about the world worth keeping track of are facts about the location of particles in space over time. In such a context, problems of qualitative change can scarcely arise, because it is unproblematic to think of a particle's being located a little more in one direction or another, or moving a little more quickly or slowly. These are—at least on their face—strictly quantitative changes. Now suppose someone becomes dissatisfied with such a purely quantitative approach, and feels that it fails to give an adequate explanation of what is happening in the world. There are, of course, many reasons, which any Aristotelian can recite, for thinking that a wholly reductive account in terms of particles in motion must be supplemented by some sort of story about the forms of things. Let us not be distracted by those familiar reasons, but instead notice that the proponent of forms might at this point go in two rather different directions. One direction would treat forms as essentially epiphenomenal, by

which I mean that the forms would be a conceptual framework laid on top of some more reductive, mechanistic story. Explanatory appeals to form would be *necessary*, on this approach, but only insofar as we wanted to be able to come to grips with the underlying reductive story in a way that is reasonably simple and intelligible. The forms, so understood, would give us tractable *labels* for talking about the messy reductive level, but the real action would still take place at that lower level. The forms would not play any true causal role, and so might be dispensed with entirely in contexts where we were able to work directly at the complex level of particles in motion.

Contrast this with a picture on which forms enter directly and indispensably into our best scientific account of how the world is. Such a world will presumably include particles in motion, but will also include explanatory principles of a different sort, forms, which are not mere labels for other sorts of processes, but are themselves irreducible aspects of natural phenomena. One could not leave these forms out of the story, even in principle, without radically distorting the way nature works. Or, better, nature simply could not work without forms.

The problem of qualitative change might arise on either of these perspectives, but would do so in quite different ways. On the “epiphenomenalist” approach, the tendency of things to take on forms more and less intensely over time would be a necessary fact to account for, if our labeling is to track reality at all. Socrates is sometimes whiter and sometimes darker. This happens, indisputably, and we want to be able to put it in these terms, rather than have to dump our formal vocabulary and speak directly in terms of his surface particles absorbing and reemitting more and less light (as we would now tell the story). So conceived, the problem of the intension and remission of forms becomes a linguistic puzzle: what does it *mean* when we say that Socrates becomes whiter? Are we saying that he loses one shade of whiteness and gains another? Or are we saying that there is a change to the whiteness that he possesses? Inasmuch as this epiphenomenalist approach as I am imagining it really believes in forms, the question is not empty. But inasmuch as this approach holds that the real causal, scientific story occurs at a deeper level—a level so thoroughly quantitative that these issues do not arise—the question lacks a certain urgency. To put it another way, the question seems purely *philosophical*. What conception of form best accounts for how we want to think and talk about the situation? Our puzzle in fact looks strikingly similar to modern puzzles over vagueness. Just as we want a satisfactory account of how to talk about properties that have no precise cut-off points—say, when a thing ceases to be white and begins to be pale tan—so we want a satisfactory account of how to talk about any sort of qualitative change of properties. Does every such qualitative change mark the elimination of one property and the introduction of another, or can the same property endure through qualitative change? For the proponent of forms—or we might just call them properties—such questions ought to be seriously puzzling indeed.

Matters become much more serious, however, if we think that forms enter into our best scientific picture of the world. If we think that we cannot—on any level—explain Socrates’s becoming white without appeal to one or more forms of whiteness, then our problem is not a narrowly philosophical one, but a broadly scientific one. We would then face not just the question of how to analyze the way we naturally prefer to talk about change, but the question of how incremental changes can even happen in cases where the units of change do not appear to admit of increments. It is in this more serious guise that the problem appeared in the medieval context, inasmuch as these authors took the second of the aforementioned views—they were no epiphenomenalists. Questions over qualitative change thus become one of the foundational problems of scholastic natural philosophy, standing between a sustained Aristotelian metaphysics of form and a quantitative physics in the modern style. Because scholastic philosophers were able to form cogent accounts of how qualitative change might occur, amenable to quantitative precision, they were able to take some steps along the road to modern science. But because the issues always remained metaphysically obscure, and resistant to measurement, scholastic Aristotelianism was never able to provide a conducive environment for developing physics in a mathematical framework.²

Simple Views

As we look back at this material, we might ask ourselves whether the problems here are so serious that we ought to renounce forms altogether. In effect, this is how Galileo and other seventeenth-century proponents of the new science reacted to these issues.³ But we should hesitate before leaping to embrace this “modern” response. For, as I have suggested already, what goes for scholastic forms may well go for modern properties too. And whether or not we are Aristotelians, we ought to hesitate before giving up on the notion that things can undergo an incremental change to their properties. After all, there is no denying that things gradually do change their color. So we too should feel some pressure to find a plausible way to account for incremental qualitative change.

What, then, are the options? Looking over the range of historical solutions, there are two fundamental questions that serve to divide up the range of available solutions. First, there is the question of whether incremental qualitative change is to be explained in terms of a single enduring form or a series of numerically distinctive successive forms. Opting for succession, most prominently, were Godfrey of Fontaines and Walter Burley. For those who endorse a single enduring form, a second fundamental question arises: is the incremental change at issue intrinsic to the form itself or extrinsic? Those opting for an extrinsic solution included Thomas Aquinas and Giles of Rome. Those opting for an intrinsic solution included Henry of Ghent, John Duns Scotus, Thomas Wylton, and William Ockham.

As we will see, it is this last family of views that becomes most prominent in later scholastic discussions. But it took the debate a while to reach that point, because the thesis that qualitative change consists in intrinsic change to an enduring quality requires supposing that this quality somehow exhibits a complexity that allows it to endure through change. Yet, this flies in the face of a central assumption about the nature of forms: that forms are simple. One governing dictum here is the Aristotelian analogy: “forms are like numbers” (*Met.* VIII.3, 1043b32). The picture suggested is that—and this is another Aristotelian dictum—forms do not admit of more and less (*ibid.*: 1044a10). Just as a quantity either is or is not five, so a body either does or does not have a specific determinate shade of blue. You may have a little more than five things, or a little less—perhaps you can even have 4.999 things. But *being five* does not itself come in degrees, and the same holds for a determinate shade of blue, or for any quality. It is important to see that there are powerful reasons for wanting to insist on this all-or-nothing principle, beyond simply wanting to adhere to a few authoritative passages. For how *could* we think of forms as having parts? What sorts of parts might they have? What would unify those parts? Would the parts themselves have parts? Will it ever end? Reasonably enough, there was a strong prejudice in favor of the view that forms are the simple constituents of an Aristotelian metaphysics.

Yet if forms are simple, it would seem that they lack the sort of structure that admits of gradual change. How can a form vary, unless it is complex? Give parts to a form, and we can then allow those parts to change. If, in contrast, a form is simple, then any variation would seem to entail its becoming a different form. Hence, the proponents of the simplicity of form seem forced to explain qualitative change either in terms of the wholesale replacement of one quality by another, or in terms of a change to something other than the quality itself.

Views of this last kind are particularly prominent in the thirteenth century. One common thirteenth-century view—found in different ways in both Aquinas and Giles of Rome—holds that the very same unchanged quality can inhere more or less strongly in a given subject, and that differences within the subject determine the intensity with which the quality is possessed. Aquinas thinks that, at least for a wide class of qualities, this is the only possible solution, because “one instance of whiteness, considered in itself, is no more a whiteness than another” (*On the Cardinal Virtues*, 3c, in 2010). This is a tidy solution, in a certain way, but puts a great deal of weight on

what is involved in an accident's inhering in a subject. Inasmuch as no one had any very clear story to tell about that, this solution hardly counts as explaining much of anything. And it hardly helps when Aquinas speaks of a subject's *participating* more or less in a form, or when Giles talks of a form possessing greater or lesser *existence* in a subject. Given that both of these authors are inclined toward a highly deflationary conception of accidental forms, according to which a form's existencing is nothing more than a substance's existencing in a certain way, it is no surprise that they seek to explain qualitative change by focusing on the subject rather than on the form. Even so, their accounts seem simply to shift the locus of mystery from one place to another.⁴

A much more straightforward way to safeguard the simplicity of form, commonly ascribed to Godfrey of Fontaines, and later defended in considerable detail by Walter Burley, gives up on trying to explain how the same simple quality can make its subject more or less qualified. Instead, when Socrates becomes progressively more white, he takes on a series of ever-so-slightly different qualities, each one being whiteness of a slightly different determinate shade. This succession view has considerable appeal, because it avoids much of the metaphysical subtlety other views had required. There is no need to look for some kind of change within the subject, and no need to postulate that a quality can undergo intrinsic change, becoming more or less intense. What looks like change to a quality—Socrates's color—in fact is the replacement of one form with another along a latitude of similar qualities. To say that Socrates's color changes is not to say that one and the same color becomes more or less intensely white, but that Socrates loses his current color and acquires another. As an analogue to this line of thought, we might think of how some modern philosophers, when confronted with a substance's change over time, simply deny that a substance *can* change over time, and argue instead that what looks to be a single enduring substance is really a series of distinct, momentary stages, each one quickly replaced by another. Burley's conception of accidental form is just like this. The exterior of your house may seem to have a single accidental form—its color—day after day, but in fact as its color fades in the sun over the years, it is running through a series of forms.⁵

This looks, *prima facie*, like a promising solution to the problem of intension and remission. For while it seems on its face bizarre to think, as is today fashionable, that persisting *substances* are in fact a series of momentary substance stages, there is no such apparent bizarreness to the idea that seemingly persisting *accidents* are in fact sequences of temporary accident stages. After all, it is part of the very point of accidental forms that they are the sort of things that come and go while their subject remains. Burley's succession view simply postulates that such accidents come and go more often than one might have supposed. Given the sorts of examples we have considered—things changing their color—it cannot even be said that Burley's approach looks counterintuitive. For it would seem that we simply have no intuitions about whether a thing that slightly changes its color should be said to take on a *new* quality (a new accidental form), or should be said to undergo a modification in the character of the quality (form) it possesses. Given the difficulty of making sense of how an accidental form can undergo modification, it thus seems very natural to embrace succession, and say that all qualitative change, however slight, involves the loss of one accident and the gain of another.

Addition Views

On careful scrutiny, however, the succession view faces some very powerful objections. One such objection, pressed by Ockham, charges that, assuming qualitative change is continuous, the succession view is committed to an infinity of forms, coming and going, within any given time, in any case of qualitative change. Granted, no more than one of these forms would inhere in its subject at a given time, but still any qualitative change to an object—whether of heat, color, etc.—would require this sort of bloated ontology of entities, coming into and going out of existence.

This is a result that Burley frankly acknowledges as an implication of his account, remarking that “this is not absurd, but necessary.” Indeed, he argues that whenever we find successive entities (such as events) that endure through constant change, we should understand them to be composed of infinitely many instantaneous parts.⁶

Another kind of objection, which Wylton makes against Burley, is that the smallest of causes would be capable of producing the most dramatic of effects. Wylton’s example is that a single drop of water might extinguish the entire heat of the heavens. For it seems as if a single drop of cool water lowers the temperature of the heavens, even if very slightly. But if it cools the heavens, then the heavens no longer have the form they once had. Thus, absurdly, the entire heat of the heavens would be destroyed by a single drop of water. Burley’s response to this objection tries to downgrade the extent of the problem here. He denies that a single drop of water would change the temperature of the whole heavens, from east to west. And in that local area where there is a slight temperature drop, it is not as if the heavens would no longer be hot at all. But ultimately, Burley has to concede that a small agent can produce surprisingly large effects. In general, on the succession view, qualities are surprising fragile. Just as the slightest force may cause an antique vase to crumble, so too any change at all to the qualities of a thing destroys the form that was there and brings a new form onto the scene.⁷

Such fragility may not seem all that problematic in cases of color and temperature, but in the case of habits or dispositions, this looks to be extremely problematic. Habits are, after all, supposed to be characterized precisely by their stability. On the succession view, however, habits turn out to be every bit as fragile as sensible qualities. This leads to what is perhaps the most serious objection to the succession view, an objection first advanced by Scotus, who focuses specifically on the moral virtues. A virtue is supposed to be a quality that is acquired slowly, over a protracted period of time, as one’s virtuous activity steadily strengthens the virtue. On the succession view, however, nothing like this can be the case. On the contrary, acts of virtue literally destroy the virtue that gave rise to them, and cause that virtue to be replaced by a numerically distinct virtue. Burley has no choice other than to hug this monster, and insist that the stability of habits refers to the persistence of the broader kind of habit, even as individual instances change. A charitable person, then, will possess no single enduring habit of charity, but will stably possess one or another habit of a charitable kind, each of which will give rise to activities that, in turn, inculcate a new habit. This looks like a seriously counterintuitive result.⁸

If these arguments leave the succession view looking implausible, and if we do not want to shift the problem over to some sort of change within the subject of inherence, then it seems we need to find a way to allow the forms themselves to change intrinsically, becoming more or less intense without losing their identity. This strategy was attempted by Henry of Ghent, and then given its most influential formulation by Scotus. According to Scotus, we can distinguish between the accidental form itself, which has a certain fixed and unchanging “quiddity,” and the various “grades” or “modes” that the form can acquire or lose. This allows Scotus to agree with Aquinas that whiteness is never anything other than whiteness, unchangeably so. And Scotus can further account for why we think that a virtue like charity can stably increase over time, rather than constantly giving way to a distinct virtue. The price, of course, as usual with Scotus, is a highly speculative metaphysics that raises as many questions as it answers. The appeal to modes is supposed to be an improvement on the succession theory’s proliferation of distinct forms (and in this way, the account might seem to anticipate the seventeenth-century’s wholesale shift from accidents to modes). But, of course, there is still proliferation and distinctness here. Scotus thinks of these modes as “formal parts” of the accidental form, parts that somehow come together to make one thing. The more such formal parts there are, the more intense the accident is. But what unifies all these modes, and how many or few of them might there be, and could they exist apart from the form itself? The obscurity of all these questions is itself a considerable cost of the theory.⁹

A story along these general lines would be widely accepted by subsequent generations, but there is, of course, considerable debate over the details. On Thomas Wylton's view, which had a direct influence on Burley's formulation of the succession theory, the grades of a form are understood on the model of material rather than formal parts. So just as a material body can remain what it is even while gaining or losing material parts, so a form can remain what it is—whiteness, for instance, or charity—even while gaining or losing grades of intensity. William Ockham would later put pressure on Scotus's view along different lines, treating each of these grades as itself a real and distinct entity, separable in principle from every other grade, with each grade of charity itself being "altogether of the same character as the previous charity." Each of the parts of charity is thus itself fully an instance of charity.¹⁰

Within the already byzantine scheme of scholastic metaphysics, these debates are quite extraordinary, inasmuch as they open up the familiar framework of Aristotelian hylomorphism to a whole new level of composition. While one might have supposed that the basic principles of material objects are form and matter, it turns out that forms—at least accidental forms—are not simple at all, but themselves admit of further composition into their essence and their "formal" or "material" parts. These debates parallel questions that arise over whether substantial forms are simple or complex. Those discussions, however, are driven not by the prospect of incremental change, which was not supposed to occur at the level of substance, but by the need to account for the complexity of material substances. Hence, the debate over qualitative change remains its own distinct sphere of investigation, where the questions that arise are so desperately obscure that it is not even clear how the investigation is to be conducted. Still, one can see why the debate seems worth having, when one sees the inescapable need for some account of how qualitative change is possible.

Part of what makes all this so interesting is that these views open the door to the beginnings of a more quantitative natural philosophy. Medieval natural science was largely conducted in imprecise, non-quantitative terms, in part because no one had a reason to suppose that quantitative precision could be fruitful, and in part because it was unclear how to measure, and so give meaningful numerical values to, the sorts of qualities that were fundamental to the theory. But once these qualities are conceived of as themselves complex, and built up out of an aggregation of modes, then in principle those modes can be measured. Once that happens, qualitative theories can be formulated in quantitative terms. Indeed, the additive theory effectively seeks to treat qualitative change on the model of quantitative change, so that the story of how a substance changes its color or its disposition is structurally the same as the story of how it changes its shape or size—namely, in terms of adding and losing parts. Accordingly, fourteenth-century movements to put natural philosophy on a more quantitative basis—at Merton College, for instance, and at Paris, most prominently in the work of Nicole Oresme—gave prominent attention to these sorts of additive theories of qualitative change. In medicine too, the addition framework was seen as a bedrock conceptual tool in the effort to calibrate a patient's physiological state. In the words of the great sixteenth-century Italian physician Giambattista da Monte, "medicine is the science of all things in their latitude, from the first grade to the ultimate."¹¹

Going beyond this historical context, the problem of qualitative change should have enduring relevance to philosophers today, given that what goes for qualities would seem to go just as much for properties or for any modern analogue of modes or forms. More generally, the problem arises for any ontology that embraces the qualitative features of things and refuses to give a wholly reductive analysis of those things in terms of explicitly quantifiable magnitudes. To be sure, the Aristotelians were confronted with an especially virulent version of this problem, inasmuch as they wanted such qualities to play an ineliminable causal role in natural philosophy. But the problem is very real for anyone who believes in such familiar properties as whiteness or heat, or in behavioral dispositions such as virtues and vices. Modern philosophers have hardly paid attention to this issue at all. But the difficulties it raises are so fundamental that one might well consider

whether accidents and properties and habits and dispositions are perhaps more trouble than they are worth. If we have to treat them as constantly replaced in succession, or as having an intricate part-like structure, perhaps we would be better off getting rid of them entirely, by reducing them to some sort of wholly quantitative, micro-level account. Of course, we now know at least roughly how such a story would have to go. Heat becomes particles in motion, color becomes light waves, the virtues become neural networks. If such thoroughgoing reductionism sounds unappealing, then we need some answer to the problem of qualitative change.

Notes

- 1 For an overview of the Aristotelian metaphysics of substance and form, see Thomas Ward's contribution to this volume. For more details regarding later scholastic debates over the status of quantities and qualities and their relationship to substance, see Pasnau (2011).
- 2 Two of the fundamental modern scholarly discussions of the scholastic conception of qualitative change—Maier (1968) and Sylla (1972)—give particular attention to the way these issues lie at the foundation of scholastic natural science.
- 3 For a typical post-scholastic treatment of the degrees of quality, see Locke (1975), IV.2.11–13, who rehearses the sort of reductive quantitative story that might be told for color, but then observes that we have no way of determining what the precise relationship is between the quantitative reductive story and the observable qualitative story.
- 4 For Aquinas on qualitative change, see, e.g., *Summa Theologiae* 1a2ae 52.1c in (1947–1948). For Giles, see 1521, *Sent.* I.17.2.1. For a detailed survey of the debate as it runs from Aquinas to Scotus, see Solère (2012), which discusses in careful detail the range of views that explain qualitative change in terms of something external to the quality itself. On the inherence relationship between accidental forms and their subjects, see Pasnau (2011: ch. 11). On the sort of deflationary view of accidents that is common among thirteenth-century scholastics, see Pasnau (2011: ch. 10). For a clear indication of how Aquinas's deflationism informs his conception of qualitative change, see *Questions on the Virtues in General* (2010), 11c.
- 5 For a summary of Walter Burley's succession view, see Jung (2013). There has been considerable scholarly disagreement over how to understand Godfrey of Fontaines's earlier account, but recent opinion seems to have settled on the same verdict that Godfrey's contemporaries had reached: that he is a key forerunner of the succession view. See Celeyrette and Solère (2002) and Dumont (2009).
- 6 For Ockham's objection from an infinity of successive forms, see *Ordinatio* I.17.5 (in 1967–1989). For Burley, see his *Tractatus Secundus* (1496) ch. 6, f. 14va (a modern edition is underway by Elzbieta Jung). Neither of these works has been translated, but for a detailed discussion of this issue, see Adams (1987: 706–708). For the notion of a successive entity (in contrast to a permanent entity) to which Burley alludes here, see Pasnau (2011:ch. 18).
- 7 For Wylton's objection, see the second of his quodlibetal questions on intension and remission, an edition of which is forthcoming from Stephen Dumont. In work not yet published, Dumont establishes the connection between Wylton and Burley, and reports on Burley's response to Wylton, which appears in Burley's early and still unedited *Expositio super Physicam* V.62. I am indebted to Dumont for sharing this material with me. Indeed, the origins of this chapter lie in comments that I had the occasion to write for the Toronto Colloquium in Medieval Philosophy, where Dumont presented some of this material.
- 8 For Scotus's argument against the successive replacement of virtues by distinct virtues, see e.g. *Reportatio I-A*, dist. 17 pt. 2 q. 1 n. 80 (in 2004–2008). Ockham recites this argument approvingly at *Ordinatio* I.17.5 (in 1967–1989). For Burley's response, see his *Tractatus Secundus* (1496) ch. 6, f. 15r.
- 9 For Scotus's overall account, see Cross (1998: ch. 10), who also discusses in some detail Henry of Ghent's earlier and rather different view, which Scotus himself criticizes. Scotus develops his position in his various discussions of *Sentences*, book I, distinction 17—in his *Lectura*, *Ordinatio*, and *Parisian Lectures*. Only the last of these is presently available in translation, in (2004–2008).
- 10 For Ockham's insistence on the parts of a quality being themselves real and distinct from the other parts, see *Ordinatio* I.17.6 (in 1967–1989). That these parts are neither material nor formal, but rather of the same character (*ratio*) as all the other parts (see *ibid.*: q. 7). These discussions are not yet translated into English, but for a more detailed discussion, see Adams (1987: ch. 17).
- 11 Giambattista da Monte is quoted in Maclean (2002: 139), which discusses the broader context of the remark. For the Merton School, and its use of the addition theory to quantify a qualitative Aristotelian physics, see Sylla (1972) and also Murdoch (1969). For Oresme, see Kirschner (2000).

References

- Adams, M. (1987) *William Ockham*, 2 vols. Notre Dame, IN: University of Notre Dame Press.
- Aquinas, Thomas (1947–1948). *Summa Theologiae*, trans. L. Shapcote. New York: Benzinger.
- . (2010). *Disputed Questions on the Virtues*, trans. J. Hause. Indianapolis, IN: Hackett.
- Aristotle (1984) *The Complete Works of Aristotle*, 2 vols, ed. J. Barnes. Princeton, NJ: Princeton University Press.
- Burley, Walter (1496) *Tractatus de Intensione et Remissione Formarum*. Venice.
- Celeyrette, J. and J.-L. Solère (2002) “Godefroid de Fontaines et la théorie de la succession dans l’intensification des formes.” In *Chemins de la pensée médiévale: études offertes à Zénon Kaluza*, ed. P. Bakker. Turnout: Brepols, pp. 79–112.
- Cross, R. (1998) *The Physics of Duns Scotus: The Scientific Context of a Theological Vision*. Oxford: Clarendon Press.
- Dumont, S. (2009) “Godfrey of Fontaines and the Succession Theory of Forms at Paris in the Early Fourteenth Century.” In *Philosophical Debates at Paris in the Early Fourteenth Century*, ed. S. Brown, T. DeWender, and T. Kobusch. Leiden: Brill, pp. 39–125.
- Jung, E. (2013) “Physical Forms and Matter.” In *A Companion to Walter Burley: Late Medieval Logician and Metaphysician*, ed. A. Conti. Leiden: Brill, pp. 247–265.
- Kirschner, S. (2000) “Oresme on Intension and Remission of Qualities in His Commentary on Aristotle’s Physics.” *Vivarium* 38: 255–274.
- Locke, John (1975) *An Essay Concerning Human Understanding*, ed. P. Nidditch. Oxford: Clarendon.
- Maclean, I. (2002) *Logic, Signs, and Nature in the Renaissance: The Case of Learned Medicine*. Cambridge, MA: Cambridge University Press.
- Maier, A. (1968) *Zwei Grundprobleme der Scholastischen Naturphilosophie: das Problem der intensiven Grösse, die Impetustheorie*, 3rd ed. Rome: Edizioni di Storia e Letteratura.
- Murdoch, J. (1969). “*Mathesis in Philosophiam Scholasticam Introducta*: The Rise and Development of the Application of Mathematics in Fourteenth-Century Philosophy and Theology.” In *Arts libéraux et philosophie au moyen âge*. Montreal: Institut d’Études Médiévales, pp. 215–254.
- Ockham, William (1967–1989) *Opera Philosophica et Theologica*. St. Bonaventure, NY: Franciscan Institute.
- Pasnau, R. (2011) *Metaphysical Themes 1274–1671*. Oxford: Clarendon.
- Rome, Giles (1521) *In Primum Librum Sententiarum*. Venice. Reprinted (1968). Frankfurt: Minerva.
- Scotus, John Duns (2004–2008) *Reportatio I-A*, 2 vols, ed. A. Wolter and O. Bychkov. St. Bonaventure University Press.
- Solère, J.-L. (2012) “Les variations qualitatives dans les theories post-thomistes.” *Revue Thomiste* 112: 157–204.
- Sylla, E. (1972) “Medieval Concepts of the Latitude of Forms.” *Archives d’histoire doctrinale et littéraire du moyen âge* 47: 223–283.