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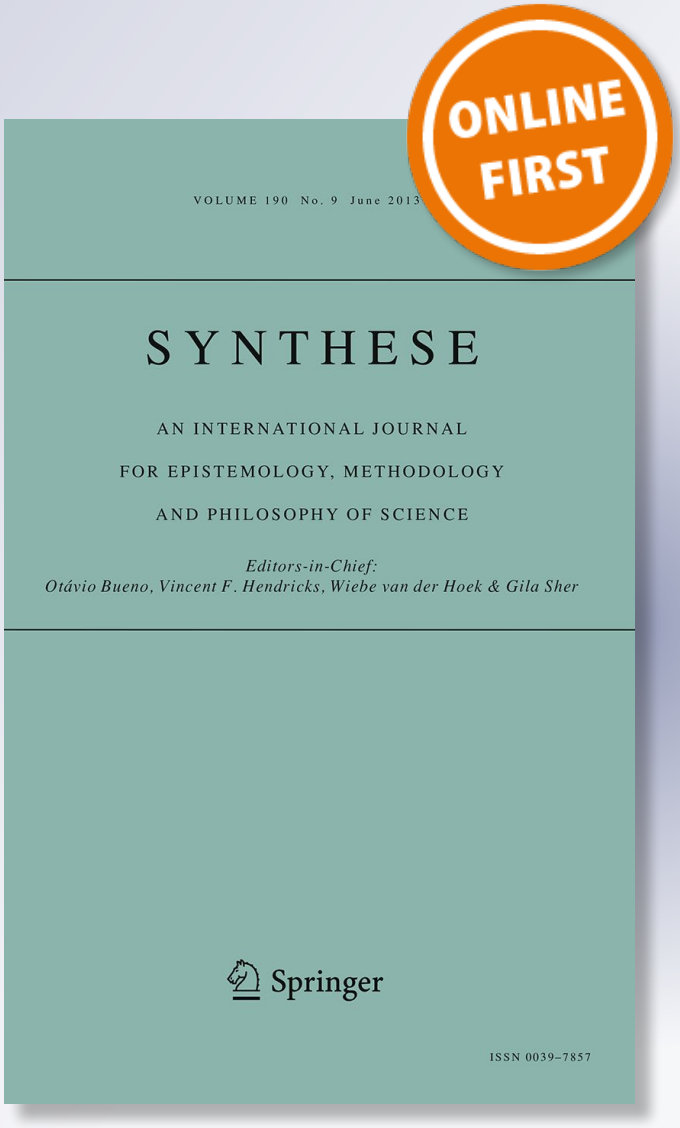

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S.I. : USE & ABUSE OF MATHS

Empress vs. Spider-Man: Margaret Cavendish on pure and applied mathematics

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Abstract The empress of Margaret Cavendish's The Blazing World dismisses pure mathematicians as a waste of her time, and declares of the applied mathematicians that "there [is] neither Truth nor Justice in their Profession". In Cavendish's theoretical work, she defends the Empress' judgments. In this paper, I discuss Cavendish's arguments against pure and applied mathematics. In Sect. 3, I develop an interpretation of some relevant parts of Cavendish's metaphysics and epistemology, focusing on her anti-abstractionism and what I call her 'assimilation' view of knowledge. In Sects. 4 and 5, I use this to develop Cavendish's critiques of pure and applied mathematics, respectively. These critiques center on the claims that mathematics purports to describe non-beings, that nature is infinitely and irreducibly complex, and, perhaps most originally, that mathematical thinking (like other formal methods in philosophy) deforms the subject of representation, not just the object.

Keywords Margaret Cavendish · Anti-mathematics · Mathematics · Natural philosophy · Spidermen

1 Introduction

When the heroine of Margaret Cavendish's *The Blazing World* was installed as Empress, she received a parade of motley characters, including ape-men chymists,

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bird-men astronomers and worm-men natural philosophers.[1] When she "at last had a mind to divert herself after her serious Discourses" (BW[2] 54), she sent for the spider-men and the lice-men, who were her mathematicians and her "geometricians". The spider-men showed her some numerical tables and attempted to square the circle. Meanwhile, the lice-men "endeavoured to measure all things to a hairs-breadth, and weigh them to an atom" (BW 55). Unsurprisingly, the Empress was not diverted.

But why did the Empress go further, dismissing the spider-men as a waste of her time and dissolving the society of lice-men, declaring that "there was neither truth nor justice in their profession" (BW 56)?[3] Cavendish does not always share the Empress's views, but in this case the Empress and the Duchess are of one mind. In her more theoretical writing, Cavendish offers a variety of loosely-related arguments that pure and applied mathematics do not help us to understand nature. In the first section, I'll identify five objections that emerge from the audience with the Empress. In the second section, I'll reconstruct Cavendish's account of how a finite human mind represents nature. In the third and fourth sections, I'll use this to understand Cavendish's comments about pure and applied mathematics, devoting a subsection to each of the Empress's five objections. I'll show that the two most important commitments driving Cavendish's arguments are (1) a very strong version of anti-abstractionism, driven by her metaphysics, and (2) her assimilation view of knowledge, on which knowing something involves becoming that thing.

[1] This paper owes much to discussions with a lively Cavendish reading group, organized by Marcy Lascano and Lewis Powell, and with the wonderful audience at the New Narratives in Philosophy conference at Duke University (April 14–17, 2016), organized by Andrew Janiak and Marcy Lascano. I am especially grateful to Marcy Lascano, Alan Nelson and Jon Shaheen for discussion and comments, and to two anonymous referees at *Synthese*.

[2] Abbreviations are: *Poems and Fancies* (PF), *Philosophical Letters* (PL), *Philosophical and Physical Opinions* (PPO), *Observations upon Experimental Philosophy* (OEP), *The Blazing World* (BW), *Grounds of Natural Philosophy* (G). OEP is ed. Eileen O'Neill. (2001). Cambridge: Cambridge University Press. Page numbers are from first editions, which are available online (e.g. at Early English Books Online), except OEP. I have modernized capitalization and spelling as O'Neill has done in OEP, described at OEP xlvi.

[3] Cavendish suggests that the various beast-men "each followed such a profession as was most proper for the nature of their species", but she does not say anything much more specific to tie the characters to their targets. Cavendish describes lice in a different and likely unrelated context in BW as "terrible Creatures" who feed on beggars and "instead of thanks, do reward them with pains, and torment them for giving them nourishment and food". Jon Shaheen pointed out to ME that the lice-men "measure all things to a hairs-breadth", and lice are, after all, often found in hair. In conversation, Sarah Hutton suggested the Royal Society as a target for the spidermen, pointing out that that in the *Novum Organum*, Francis Bacon compares "rationalists" or "dogmatists" to spiders, who "make cobwebs out of their own substance" and experimentalists to ants, who "only collect and use" (Book I, Aphorism 95). And spiders, of course, spin webs in geometrical patterns. Sarasohn writes that in this section Cavendish uses "parody to figuratively demolish an institution she viewed as dangerous, useless, and deluded into thinking that its experimental program could rival and confine the works of nature" (1). An anonymous referee suggests that while the spider-men represent mechanical philosophers, Cavendish's attacks on the lice-men are aimed at the scholastic curriculum, which counts mathematics as an art, and helpfully points out that Cavendish's anti-mathematics and anti-abstractionism echo some of the anti-scholastic rhetoric of her day. On Cavendish's attitude toward and visit to the Royal Society, see Sarasohn (pp. 31–34).

2 Spider-men, lice-men, and jackdaw-men

Cavendish's spider-men are pure mathematicians: they try to square the circle and they present the Empress with a numerical table, likely modeled on tables from scholastic instructional texts used to calculate, say, logarithms or sines. On the one hand, the Empress holds mathematicians in some esteem as "the chief tutors and instructors in many arts" (BW 55), and while she complains that their figures and proofs are obscure, she allows that she is not an expert judge. These sentiments are reflected in comments Cavendish makes in her theoretical work that acknowledge the value of mathematics and are self-effacing about her own mathematical abilities (e.g. PL 90). On the other hand, Cavendish points out in BW that the Empress has "a very ready wit", hinting that the obscurity she detects in the figures and proofs of the mathematicians is a limitation in mathematics itself. The Empress concludes:

> ...I can neither spare time from other affairs to busy my self in your profession; nor, if I could, do I think I should ever be able to understand your imaginary points, lines and figures, because they are non-beings (BW 55).

Though the lice-men are identified as 'geometricians', they are distinguished from the mathematicians, who after all study geometrical objects like lines and figures, by the fact that they try to measure natural things.[4] The applied mathematicians are dispatched quickly and less ambivalently than the spider-men:

> ...their weights would seldom agree, especially in the weighing of air, which they found a task impossible to be done; at which the Empress began to be displeased, and told them, that there was neither truth nor justice in their profession; and so dissolved their society (BW 56).

The Empress receives the spider- and lice-men in the same audience with the magpie-, parrot-, and jackdaw-men, who are orators and logicians. When an orator tries to make a speech, his "arguments and divisions" cause "a great confusion in his brain" (BW 56) so that he cannot proceed. The empress chides that the orators "follow too much the rules of art" and requests: "consider more the subject you speak of, then your artificial periods, connexions and parts of speech, and leave the rest to your natural eloquence" (BW 57).

Meanwhile, the logicians fling syllogisms at one another until the Empress interrupts:

> I have had enough...or your chopped logic, and will hear no more of your syllogisms; for it disorders my reason, and puts my brain on the rack; your formal argumentations are able to spoil all natural wit.

She continues:

[4] In the more general parlance of the time, "geometricians" refers to both pure and applied geometers, but measurement is clearly part of their task. See, e.g. the introduction to the English version of Burgersdijk's *Logic:* "Let the geometricians then be confined to their circles and measures, the arithmeticians to their numbers…"

> Art does not make reason, but reason makes art; and therefore as much as reason is above art, so much is a natural rational discourse to be preferred before an artificial: for art is, for the most part irregular, and disorders men's understandings more than it rectifies them (BW 58).

The logicians object that "knowledge of nature...would be imperfect without the art of logic". The Empress grants it, but continues:

> no particular knowledge can be perfect, by reason knowledge is dividable, as well as composable; nay, to speak properly, nature herself cannot boast of any perfection...because there are so many irregular motions in nature, and it is but a folly to think that art should be able to regulate them, since art itself is, for the most part, irregular" (BW 59).

In her philosophical writing, Cavendish routinely calls mathematics an art (e.g. OEP 48), characterizes mathematical demonstrations along with logic as artifice (PL 3), and criticizes geometry together with speech as artificial (PL 114). That suggests that the Empress's criticisms of the logicians and orators also apply to mathematicians as practitioners of formal arts.

So from the *Blazing World*, we can divine from a few reasons for the mathematicians' chilly reception. Of the pure mathematicians, the Empress complains that:

(1) they study and talk about non-beings or imaginary objects, viz. points, lines and figures; and
(2) the obscurity of mathematical proofs may signal a problem with mathematics itself.

And of the applied mathematicians:

(3) their task of measuring natural quantities is impossible and there is "neither truth nor justice" in it;
(4) the variety of nature's motions cannot be "regulated" by mathematics because it is an art, which is irregular; and
(5) artificial forms "disorder men's understandings", "spoil all natural wit", and "put [the] brain on the rack".

This is a diverse lot of criticisms, but they are all supposed broadly to support a epistemological claim or a methodological imperative: mathematics does not get us the best knowledge of nature or even knowledge of mathematical objects, and if you want to do natural philosophy, mathematics will, for the most part, lead you astray. It will be easier to understand these claims if we get a sense for what Cavendish thinks is the right way to do natural philosophy, which depends on how she thinks that the human mind represents nature. So I'll begin with a brief overview of the relevant aspects of Cavendish's system as I interpret it, with an eye to three related questions: how does Cavendish think that the human mind represents nature, what does Cavendish think that good representation of nature consists in, and how do we get it?

3 The mind in the world

According to Cavendish, there is nature, and there is God.[5] In nature there is only matter, and nature itself is "one material, self-moving, and self-knowing body" (OEP 137-8). Although Cavendish argues that nature is indivisible into "single parts", or parts that can exist independently of nature (OEP 31), nature does have "effective parts", or creatures, that are generated by the "corporeal figurative motions" of nature's matter (OEP 16, 27, 32).

You can picture a Cartesian plenum, in which parts are engendered by the relative motion of matter. But Cavendish's frequent explanations of natural phenomena in terms of the entire phrase "corporeal figurative motions" reflects a significant difference with Descartes. Inspired by Hobbes, Cavendish treats it as approaching a conceptual truth that only matter, which she identifies with substance (PL 308), exists. But in certain moods, she takes this to entail that modes, qualities, properties and accidents don't exist unless they are matter: not unless they are not material, but not unless they are matter itself. So, for example, she denies that motion is a mode of body, writing of Descartes,

> I do not assent to his opinion, when he defines motion to be only a mode of a thing, and not the thing or body itself; for, in my opinion, there can be no abstraction made of motion from body...

Cavendish isn't just arguing that motion cannot exist without body. First of all, she continues that there can be no *conceptual* abstraction of motion from matter:

> ...neither really, nor in the manner of our conception, for how can I conceive that which is not, nor cannot be in nature, that is, to conceive motion without body? Wherefore motion is but one thing with body, without any separation or abstraction soever" (OEP 97; see also PL 12, 97-8).

Second of all, she argues on the basis of this claim that motion cannot be transferred á la Descartes, since then bulk would be transferred, which is it not (e.g. OEP 74–75). Instead, the changes in a bit of matter's state of motion are caused by matter's own self-motion, and what looks like body-body causation occurs when one body serves as the occasion of the self-motion of another. The argument against Descartes relies on the claim that "motion [is] material and inseparable from matter".[6] Cavendish denies the modal distinction in the case of other qualities, too:

> Colour is as much a body, as place and magnitude, which are but one thing with body. Where when the body, or any corporeal part varies, whether solid or rare:

[5] Cavendish, like a number of her contemporaries, frequently refers to other worlds, e.g. G 234. These worlds differ from nature in more and less fundamental ways, and are something in between actual parts of nature and possible worlds, in that she seems to think that it is epistemically possible that they exist, but their primary function is to allow her to make claims about how our world might have been.

[6] There is a lot more to be said about this argument and about Cavendish's account of place and motion. If my reading here is right, then it shouldn't apply only to transferred motion, but should entail that whenever a body loses or gains motion (whatever that means for Cavendish), it loses or gains bulk. Cavendish does indeed imply at PL 445 that a thing's motion "hath a material being".

> place, magnitude, colour, and the like, must of necessity change or vary also" (OEP 81).

Besides denying the modal and conceptual distinction, Cavendish denies the form/matter distinction (OEP 252).[7] The intuition behind all this is that the true conceptual economy of materialism requires rejecting species, forms, and qualities, including figure and motion, as genuine explanatory principles. Anything that is nature is matter, including "motions, forms, thoughts, ideas, conceptions, sympathies, antipathies, accidents, qualities" (PL 12); in OEP Cavendish states that "he that introduces a new form, must also introduce new matter" (OEP 203).

Besides the creaturly or "effective" parts generated by corporeal figurative motions, nature is composed of what Cavendish calls "constitutive" or "essential" parts, which are three different kinds or "degrees" of matter: inanimate, sensitive, and rational (OEP 37). Sensitive and rational matter intrinsically and essentially have self-knowledge and self-motion, while inanimate matter has self-knowledge but not self-motion (OEP 49). The three types of matter differ in their degrees of agility, activity, purity and subtlety (e.g. OEP 25), and that is supposed to ground the differences between their functions. Sensitive matter is burdened with moving the inanimate parts of nature,[8] while rational matter is not; therefore, reason is freer (G 9, OEP 181) and as a result more agential. Cavendish frequently describes rational matter as an architect or planner overseeing sensitive matter, which is the laborer tasked with moving inanimate matter around (G 9, 21; OEP 24). Finally, every effective part of nature includes all three types of matter, or all three types of "constitutive" or "essential" parts (OEP 158).[9]

Human (and animal) life and mentality are explained in terms of the corporeal figurative motions of this matter; the question is, how? In particular, we'd like to know what role in grounding particular mental phenomena is played by the corporeal figurative motions, and what role is played by the intrinsic mentalistic capacities of the different kinds of matter.

The mental phenomenon that Cavendish treats in most detail is perception. At its most general, some bit of matter perceives when it somehow registers "foreign or exterior parts and actions" (OEP 13). In humans and in animals that we know about, this is done by patterning (OEP 15): the matter in my body patterns out, or makes a "picture" (G 65) or a "copy" (OEP 148) of the external object, so that my corporeal figurative motions come to resemble the external object in some respect. The respect in which the object is patterned depends on the perceiving matter: an eye perceives differently than a nose, and a giraffe perceives differently than a human. Cavendish offers a variety of ingenious arguments—many of them directed at Hobbes and Descartes—to show that the external object serves as the occasion for but not the cause of this patterning (e.g. PL 60, 63, 73, 78-9; G IX; OEP 15). In fact, seems that according to Cavendish, all it means for me to perceive an object is just that my

[7] But see OEP 253, where Cavendish writes that "whatsoever has neither form, figure, nor quality, is no body". Even there, though, Cavendish writes that the principle of form is innate and inherent self-motion, which is identical with matter.

[8] Cavendish is aware of the tension here with the view that all motion is self-motion; see OEP 27.

[9] For details of and arguments for Cavendish's matter theory, see, e.g., James (pp. 220–230), O'Neill (pp. iiv–vix) and Cunning (Ch. 2).

matter patterns itself after it. So in human beings, perceiving an external thing means becoming like it in some respect, and an idea had by patterning is the copy or picture of the external object in my matter. Cavendish grants that since (apparently) inanimate objects pattern, they also perceive:

> a looking glass, that patterns out the face of a man; and a man's eye, that patterns again the copy from the glass, cannot be said to have the same perception; by reason a glass, and an animal, are different sorts of creatures (OEP 141).

"[H]ow all these particular perceptions are made, no particular creature is able to know, by reason of their variety," but they are all different varieties of corporeal figurative motions (OEP 140).

Besides perception, humans engage in, among other things, "conception, imagination, fancy, memory, remembrance, understanding, judgment, knowledge, and all the passions" (PL 38-9); all these "thoughts" are just different kinds of corporeal figurative motions (PPO 151; PL 112; G 70–71). Rational matter is even responsible for consciousness of sense perception (e.g. OEP 152). A number of comments in the *Philosophical Letters* and the *Grounds* entail that thoughts are the figurative motions of rational matter only (PL 38, 112; G 23) while sensitive matter can only perceive and not conceive (G 58). At the same time, Cavendish repeatedly stresses that both rational matter and sensitive matter are involved in any corporeal figurative motions, and that the sense organs and the brain contain both sensitive and rational matter (PL 112, 187).

This ambivalence is just one symptom, I think, of the fact that Cavendish never specifies quite exactly *how* the intrinsic mentalistic or animistic capacities of matter make the possible "macroscopic" mental and animal phenomena that share their names. On the one hand, Cavendish is motivated to explain particular perceptions, knowledges, and other phenomena of human mental life as just so many corporeal figurative motions—that is, purely as the *effects* of matter in motion (e.g. PF 49, OEP 142, 156).

On the other hand, Cavendish thinks that knowledge and perception, as "general and fundamental actions of nature" (OEP 139), are *conditions* of motion, or at least of any kind of orderly motion like patterning. She writes (in one of many such passages):

> ...all the various changes of figures and parts, and of all the orderly productions, generations, transformations, dissolutions, and all other actions of nature; these cannot be performed without perception...for, how should parts agree, either in the generation, composition or dissolution of composed figures, if they had no knowledge or perception of each other? (OEP 167; see also 138–140)

Cavendish appeals to a a kind of acquaintance (OEP 35), agreement (G 19–20; OEP 160), or (less often) sympathy (G 21) among bits of matter, which they have in virtue of being parts of the same whole (OEP 159). The parts of a creature (or of nature), when they agree, move "to the property and nature of the whole creature...because the particular parts, by conjunction, make a whole" (G 19–20). While in principle this sympathy needn't be cashed out in mentalistic terms, Cavendish implies in a number of places that in fact it requires perception and knowledge, for "how should parts agree

in their actions, if they did not know each other; or if they had no sense nor reason?" (OEP 257, see also 139)

All of this in place, I'd like to argue that a significant motivating intuition for Cavendish is that representation is a kind of identity or assimilation of the subject and object, and that better knowledge is represented by more complete identity or assimilation.

We saw that Cavendish thinks that X perceives Y when X becomes like Y in some part, in some respect. In "Of Knowledge and Perception and General", Cavendish spends several curious pages explaining why, when X has a perception of Y, in the sense that it perceives it, that does not entail that X has a perception of Y, in the sense that it has the kind of perception that Y can have:

> ...a mineral or vegetable that perceives the figure of an animal, has no more the perception of an animal, than an animal which perceives or patterns out the figure of a mineral or vegetable, has the perceptions of those creatures... (OEP 142).

Why is Cavendish even worried about this?, we might wonder. It's one thing for me to perceive my cat, quite another for my cat to perceive something. But according to Cavendish, to perceive the cat is to pattern the cat, and to completely and perfectly pattern the cat is just to become completely like the cat. If I can become like the cat, then I can have the same kinds of that perceptions a cat has, since that depends on the constitution of the cat.

Cavendish argues that it is impossible for two creatures, even of the same species (OEP 139), to have "like perceptions" (OEP 141), because their interior natures are always different. But she goes on to suggest that two creatures becoming completely similar would entail the absurd consequence that they are identical:

> ...as *it is impossible that one figure should be another figure, or one part another part*; so likewise it is impossible, that the perception of one part should be the perception of another...those parts being different, they must be different also..." (OEP 142, my italics)

Cavendish seems to think that if one part of matter becomes like another part, it becomes that part. I think she accepts a version of identity of indiscernibles on the basis of a kind of anti-Leibnizian intuition that is grounded in her denial of the modal distinction: all qualitative differences in nature can be reduced to numerical ones. Perceiving something means becoming like it, but if a perceiver became *completely* like the perceived object, it would *become* the perceived object.

What is more, Cavendish argues that "the ground and principle of all particular knowledges and perceptions" (OEP 144) is intrinsic or "innate and fixt" self-knowledge, which is in "every part and particle of nature" (OEP 137). These self-knowledges can combine to form composite knowledge (OEP 143). Here, Cavendish seems driven by the intuition that for X to know Y is for X to become, assimilate to, or embody Y in some way, or the suspicion that a thing's knowledge and even perception can ever be *of* anything besides itself.[10]

[10] For more detailed studies of Cavendish's epistemology, see James (1999), Michaelian (2009) and Boyle (2015). Their interpretations don't always agree with mine. For example, Michaelian thinks that when

This is admittedly vague, and there is plenty that Cavendish says that conflicts with it. But it is reflected further in the fact that she seems totally to eschew the distinction between an idea and what it represents. This includes the familiar scholastic and Cartesian distinction between the formal and objective features of an idea, along with scholastic *intentio*. It leads Cavendish to admit, for example, that an architect has the house that he plans "materially made in the brain" (PL 422), and that ideas have colors. It also leads her to deny that we can represent the infinite because we are finite (OEP 200), or—in a kind of reverse-proto-Berkeleian move—that we cannot represent immaterials because we are material. Discussing "fancies, imaginations or chimeras" in the mind, she writes: "those fancies and imaginations are not nothings, but are as perfectly embodied as any other creatures...were they substanceless figures, [man] could not have them in his mind or thoughts" (PL 448).

Cavendish's denial of "intentionals" and her denial of forms and qualities are related, as she seems to acknowledge at PL 489:

> I [do not] know what ["the ancient and modern philosophers"] mean by making a difference between matter and form, power and act...nor do I understand what they mean by intentionals, accidentals, incorporeal beings, formal ratio, formal unity, and hundreds the like; enough to puzzle truth, when all is but the several actions of one cause, to wit, the one matter.

On a generalized Aristotelian picture, universals are formed by mental abstraction and they exist in the mind; at the same time, sense perception is caused by the transfer of forms and species. Cavendish has recourse to neither: without abstracted forms, there is nothing for sensing matter to "take on"; without mental content, there is nowhere for universals to live.[11]

4 Pure mathematics

4.1 Mathematics is a study of non-beings

The Empress accuses mathematicians of studying non-beings. Cavendish argues that because nature is just matter, "there is nothing that belongs to, or is a part of nature, which is not corporeal...therefore spiritual-beings, non-beings, mixt-beings, and what-

Footnote 10 continued
Cavendish says that all action of nature are perceptive, she means that "acting is always a matter of figuring, that acting always has this in common with perception" (41). But as I've argued, not all perception is patterning, for Cavendish, and her claim that all the actions of nature are perceptive means that motion and especially directed motion cannot occur unless one body somehow registers facts about the other body. Boyle is especially useful on the variety of ways Cavendish uses "perception" and "knowledge", and Michaelian on self-knowledge.

[11] Detlefsen (2007, p. 173) and Lascano (in correspondence) point out that Cavendish does posit classes or species of things, and relates them to order [e.g. "Nature is necessitated to divide her Creatures into Kinds and Sorts, to keep Order and Method" (G 166)]. This is true, and it is also true that Cavendish frequently appeals to explanations in terms of shared properties or forms. It is still true that, in other places (and sometimes in the same places) Cavendish provides arguments against explanations in terms of shared properties or forms, inspired by her reductionist materialism.

soever distinctions the learned do make, are no ways belonging to nature" (OEP 137; see also PL 242). Since we cannot have ideas of immaterials, we cannot have ideas of non-beings, including mathematical entities.

It's fair to ask why Cavendish thinks that mathematical objects like points, lines, figures and numbers are not material. The Empress gives a picturesque but less-than-satisfying reason: "their points and lines were so slender, small and thin, that they seemed next to imaginary" (BW 55). Moreover, Cavendish claims elsewhere that though mathematical entities are imaginary, they are nonetheless material (after all, our imaginations are made of matter):

> all points are not alike...there be points of pyramids, points of knives, points of pins, points of the flame of a candle, and numerous other sorts, which are all several points, and not one like another; for I do not mean a 'mathematical,' or imaginary point, such as is only made by the rational matter in the mind..." (OEP 94).

However, the points made by rational matter are still not "mathematical" points:

> although even amongst those imaginary points there is difference; for you cannot imagine, or think of the several pointed figures of several sorts or kinds of creatures, or parts; but you will have a difference in your mind (OEP 94).

True mathematical objects don't even exist in the mind, for a very straightforward reason: if they can't exist in matter, they can't exist in rational matter. Besides arguing that we cannot have ideas of mathematical objects, Cavendish also argues that non-beings cannot serve as principles or causes of any natural object or event (PL 242, 277). She applies this to mathematical entities in particular in her commentary on Pythagoras (OEP 257–259), which goes some way toward undercutting the idea that pure mathematical *entities* can be explanatory in any sense.

4.2 Mathematics is (intrinsically) difficult and obscure

The Empress's other critique of the pure mathematicians is that their proofs are difficult to understand, and that as a result she cannot "exactly tell" whether they are successful. Cavendish, like the Empress, allows that she is no expert, but she has a kind of ceteris paribus rule against methods of inquiry that, as she puts it frequently, "set man's brain on the rack" (PL 238). In particular, she takes "nice distinctions" (PL 238; OEP 8, 87), "perpetual quarreling" (OEP 214), and proliferation of "chimeras and fancies" like ideas and forms to be related marks of non-natural styles of inquiry. Cavendish does not even seem to allow that mathematics has a special relationship to certainty.

We'll see why Cavendish thinks that they are unnatural and why she thinks that it means that they shouldn't be used in the next section, on applied mathematics. Cavendish is above all concerned about how to study nature, and she thinks that the objects of pure mathematics are not parts of nature.

5 Applied mathematics

5.1 Nature cannot be measured, or forced into precise geometrical figures

The Empress's objection to the applied mathematicians is that precisely measuring the distances, weights and sizes of things in nature is impossible, and that there is "no truth" in it. Cavendish suggests a similar objection as herself, along with the related point that nature cannot be described by geometrical figures:

> mathematical rules, measures, and demonstrations, cannot rule, measure, nor demonstrate Nature... (PL 147)

> mathematicians...endeavor to inchant nature with circles, and bind her with lines so hard, as if she were so mad, that she would do some mischief, when left at liberty. Geometricians weigh nature to an atom, and measure her so exactly, as less than a hair's breadth; besides, they do press and squeeze her so hard and close, as they almost stifle her (PL 490).

Now, Cavendish clearly thinks that "figures" in some sense are real features of nature. But you'd be forgiven for thinking that her use of "figure" is, well, figurative, since often, the phrase "figurative motions" seems to have little to do with the shapes of things or motions and more like an underspecified stand-in for a the essence, nature or property of some part of matter. Cavendish does think that there are least approximate kinds of shapes in nature, and that the natures and behaviors of things can be explained in terms of shape-properties like lines, points and edges (e.g. PL 238, PPO 76). In fact, Cavendish does plenty of 'inchanting with circles' herself. In her early work especially (e.g. PPO 57–59), Cavendish explains a wide variety of natural phenomena in terms of contracting and dilating circles, which she associates especially with the phases of matter, although such explanations are emphasized less in later work.[12]

Cavendish distinguishes, however, between natural figures and 'mathematical figures.' There is some suggestion that natural, unlike geometrical figures, are not exact[13]:

> ...watery liquors, their interior figure being circular, may easily change, by contracting that circular figure into a triangle or square; that is, into ice or snow (for water, in my opinion, has a round or circular interior figure, snow a triangular, and ice a square; I do not mean an exact mathematical triangle or square, but such an one as is proper for their figure) (OEP 112).

[12] There are still such explanations in the late *Grounds* (e.g. G 186–9, 203, 211), but the *Grounds* is a revision of the much earlier *Philosophical* and *Physical Opinions*. In the OEP, Cavendish denies that spherical figures are any more perfect than other figures, or are the "principle out of which all other figures are made" (OEP 204).

[13] Although her use of 'exact' and 'perfect' do not always indicate geometrical exactness or regularity. When Cavendish denies an exact or perfect figure to nature as a whole, she means that nature cannot be circumscribed or limited (PL 520). When she suggests that finite parts are in a sense imperfect (PL 439–440), she usually means that they are dependent on the rest of nature, as in her arguments against atomism (PL 437). Perfection in creatures tends to mean adequacy to their forms, as in her discussions of animal development.

This isn't an admission that natural and mathematical figures differ only in their degree of exactness, so that natural figures could be regarded as approximations to mathematical figures. Elsewhere, Cavendish suggests a deeper contrast between natural and mathematical figures:

> ...a circular line may be drawn many several ways, into different and several sorts of figures, without breaking the circle...as into a square, or triangle, or oval, or cylinder, or like several sorts of flowers, and never dissolve the circular line...But some may say, that, when a circle is drawn into several works, it is not a circle: as for example, when a circle is squared, it is not a circle, but a square. I answer: it is a circle squared, but not a circle broken...for, the interior nature is not dissolved, although the exterior figure is altered: it is a natural circle, although it should be put into a mathematical square....I say, that all such sorts of figures that are (like circular lines) of one piece, may change and rechange their exterior figures, or shapes, without any alterations of their interior properties (G 178-9).

It may look like Cavendish is making the relatively mundane point that in a composite object, the exterior shapes may change while the interior shapes remain the same, so that the internal parts of a squared circle are still circle-y. But a very similar passage at PPO 91 adds that

> ...all those figures that naturally are made of one piece, *without distinct parts*...may change, and rechange their shapes, and yet keep their own interior nature entire.

Cavendish seems to think that the squared circle retains its circularity even considered as a simple figure.[14] Part of this is that Cavendish thinks of a circle as a kind of maximally relaxed polygon that can be "drawn into" other figures without being dissolved (G XIV).[15] But she makes the more general point that since matter is never destroyed, and matter and figure are identical, natural figures are never annihilated:

> It is true, particular natural figures may be infinitely changed, dissolved, transformed; but they can never be dissolved from being matter, or parts of nature; and if not, they cannot perish; *no, not the figures of finite parts*: for as matter cannot perish, so neither can figure, because matter and figure are but one thing; and though one part be transforms into millions of figures, yet *all those figures*

[14] Cunning argues that Cavendish has an imagistic account of ideas, and that "Cavendish is committed to the view that our very best mathematical reasoning is a matter of reasoning through imagistic figures" (23). He then constructs an anti-mathematical argument for Cavendish along the lines of Locke, Berkeley and Hume, so that mathematical reasoning involves using particular imagistic ideas with a more general application. I am less sure that Cavendish thinks that ideas are imagistic in the first place, but Cunning's account is welcome, since Cavendish does not provide a very explicit story about how it is that we have general ideas in the face of her strong anti-abstractionism. Cunning also points out that, given this imagistic account of ideas, if Cavendish does allow that there are legitimate mathematical demonstrations, she "would need to explain…the way in which our ideas of the truths of logic and mathematics incorporate a sense of the necessity of those truths" given that we do not encounter those necessities in our experience (27).

[15] Katherine Brading helpfully suggested that the understanding of figure that Cavendish exhibits in these passages is a topological rather than a geometrical one.

> *do not perish in their changes and alterations, but continue still in nature, as being parts of nature*, and therefore material (OEP 261, my italics).

So Cavendish thinks that there are figures in nature, but she treats the manifest figures of objects in many cases as non-fundamental, and it is not clear that she explains them straightforwardly in terms of the manifest figures of their parts. Instead, when she refers to the "natural figure" of a thing, she is often referring to their fundamental nature without specifying how it relates to their geometry in any obvious sense. Even if the fundamental features of nature were geometrical figures, as Cavendish less commonly suggests, we are not in a position to know them; for example, in her criticisms of microscopy:

> how should the fluid particles of air and light be able to produce a constant and settled effect, being so changeable themselves, what instances soever of geometrical figures be drawn hither to evince it? If man knew nature's geometry, he might perhaps do something; but his artificial figures will never find out the architecture of nature, which is beyond his perception or capacity (OEP 76–77).

But it is far from clear that "nature's geometry" is geometrical in any sense that we would recognize.

As nature cannot be described by precise figures, it cannot be measured—neither nature as a whole, because it is infinite (e.g. PL 6; OEP 130), nor its parts. Of experimental philosophers who try to measure heat and cold, Cavendish writes:

> But do what they can, their artificial measures or weights neither will, nor can be so exact as the natural are, to wit, so as not to make them err in more or less...no man can measure what he doth not know; and who knows all the different sorts of heats and colds? Nay if man did endeavour to measure only one sort of heat or cold: As for example, the degrees of the heat or coldness of the air, how it is possible that he should do it, by reason of the continual change of the motions of the heat or cold of the air, which are so inconstant...the heat and cold, may vary so, as many times we shall never find the same measure again (OEP 101).

The constantly changing and infinitely divisible motions of nature is cited in a number of places as two reasons that it has no "perfect measure" or "constant figure" (e.g. OEP 124, 131).

So too is nature's irreducible variety. Cavendish often expresses the sentiment that nature and her figures, motions, actions and effects are infinitely various and that they cannot be reduced to genera any more specific than self-motion. For example, in OEP she argues that no "particular corporeal figurative motion can be said the prime or fundamental" and since motions yield figures, "the globular figure is not the prime or fundamental of all other figures" (OEP 55); that "figurative motions are too different, and too diversely various, to be tied to one way of acting in all productions" (OEP 67, see also 68); that "the various productions of nature...cannot be reduced to one principal kind, but are more numerous than man's particular and finite reason can conceive" (OEP 68, see also 70 and PL 437); that it is "a very wild and extravagant conceit, to measure the infinite actions of nature according to the rule of one particular

sort of motions" (OEP 72). The exact nature of this variety is not completely clear, but this seems to be part of Cavendish's point.

A part of nature is differentiated from the rest and has all the qualities that it can be said to have in virtue of its corporeal figurative motions. But Cavendish thinks that corporeal figurative motions cannot be reduced to classes. If mathematics is useful to the extent that it picks out generalities and relates them quantitatively, corporeal figurative motions resist mathematization in this sense.

What about canonically quantitive properties of matter: extension or magnitude, location and speed? Doesn't Cavendish think that these are fundamental features of matter that are also homogenous in some sense and as such measurable or countable?

Cavendish classifies place and magnitude as *effects* of corporeal figurative motions at OEP 124, but she also claims that both place and magnitude are, like motion, strictly identical with matter. In fact, her doctrine of place entails that a body cannot change place, just as it cannot change motion without changing its matter: she takes a body's place to be wherever it is, which she compares to Descartes's internal place, rejecting Cartesian external place (OEP 124-125). Neither place nor magnitude can be abstracted from matter; they literally are matter, according to Cavendish. Cavendish rarely discusses speed, but in one spot, she claims that bodies routinely change their speeds discontinuously, moving from very slow to very fast in an instant, making it hard to see how she could go about mathematizing it. Generalizing from this, she concludes that "the truth is, no man is able to measure the infinite degrees of natural motions....nature...doth consist of infinite particulars...and who can number from finite to infinite?" (OEP 102)

There is also some evidence that Cavendish is skeptical that any units can be identified that are natural or adequate to describing nature, although finding it requires some intrepid interpretation:

> Of Inequalities.
>
> IF *infinites* have *infinite* degrees,
> And none alike to make Equalities.
> As if a *Haire* be cut with curious Arts,
> *Innumerable* but unequal parts,
> And that not any part alike shall be,
> How shall we joyn, to make them well agree?
> If every one is like it self alone,
> Three cannot be, unlesse three equal *One*.
>
> If one, and one make two; and two, and two make four yet there must be two equal ones to make two, and two equal two's to make four. And as two and one make three, yet there must be two equal ones joyned to a single one, to make three, or three equal single ones to joyn in three.
>
> The like is in weight, and Measure, Motion and Strength.[16]

[16] PPO 3. Compare to Hobbes, *De Corpore* VII 7: "NUMBER is. One and One, or One One and One, and so forwards; namely One and One make the Number Two, and One One and One, the Number Three; and so are all other Numbers made; which is all one as if we should say, Number is Unities".

I *think* that this poem is identifying a dilemma: in the first part, Cavendish argues that the parts of nature are unequal and cannot join in the regular way that would be required for addition to describe it. In the second part, she points out that the success of addition means that the parts must be equal (in the sense of comparable). In the next poem, she resolves the dilemma by suggesting that parts can indeed form unities by the harmony of nature, but as we will see in few paragraphs, the ordering actions of nature are beyond our ability to understand and systematize them.

Cavendish identifies the temptation to homogenize and universalize is an important source of human error:

> there's not anything that has, and doth still delude most men's understandings more, than that they do not enough consider the variety of nature's actions;...preferring art and experiments, before reason...makes them stick so close to some particular opinions, and particular sorts of motions or parts; as if there were no more motions, parts, or creatures in nature, than what they see and find out by their artificial experiments. Thus the variety of nature, is a stumbling block to most men...and how should it be otherwise, since nature's actions are infinite, and man's understanding finite? (OEP 99)

She charges that "most of the ancients"

> do make general principles of particular effects; and abstract quality, motion, accidents, figure, place, magnitude, etc. from matter, which causes so many confusions and differences in their opinions; nor can it be otherwise, because of the irregularities and divisions of nature's corporeal actions: and most of our moderns do either follow altogether the opinions of the ancient philosophers, putting them only into a new dress, or patch them up with some of their own, and so make a gallimaufry in natural philosophy (PL 275).[17]

Our attempts to generalize in this way, Cavendish thinks, represents our attempt to know the whole of nature. This is bound to fail because we are finite parts of nature, and "no particular part can know its whole, nor one finite part, that which is infinite" (OEP 138). This source of error is incorrigible:

> it is impossible but that parts or particular creatures must be subject to errors, because no part can have a perfect or general knowledge, as being but a part, and not a whole; for knowledge is in parts, as parts are in matter" (PL 510; see also OEP 41, 48).

[17] Cavendish does allow that rational matter has a more "general perception" than sensitive matter; it can "judge better of objects than the sensitive, as being more knowing; and knows more, because it has a more general perception, because it is more subtle and active" (OEP 143–144, see also OEP 39, 180). But when Cavendish writes that something is "general" she does not mean that it has a general or universal application, but that it comprehends a greater part of a whole: "[the rational] can more easily make a united perception, than the sensitive; which is the reason the rational parts can make a whole perception of a whole object, whereas the sensitive makes but perceptions in part, of one and the same object" (PL 141). The perception of reason is also more "general" in time, since the rational retains the past actions of the sensitive parts (OEP 145).

This is a consequence of Cavendish's assimilation view of knowledge: since a part cannot become the whole, it cannot have perfect knowledge of the whole. Note also that the Empress of the Blazing World observes that that the lice-men never agree in a measurement: not only are they finite, but as Section 3 showed, each of them is characterized by at least slightly different internal figurative motions. So insofar as we pattern nature, we each pattern it slightly differently, leading Cavendish to skepticism about mathematics as a kind of shared intellectual language.

Cavendish's resistance to universalization is, of course, related to her denial of the modal distinction, of qualities, species and "intentionals". Universal terms are formed from singulars by separating, or abstracting, a form or a property from a particular, and Cavendish's philosophy is centered on resisting abstraction. It was commonly accepted among Cavendish's influences, including Hobbes and medieval Aristotelianism, that mathematics in particular a product of abstraction from sense experience, in particular, of the abstraction of quantity from matter. Cavendish's denial that abstraction is a legitimate natural philosophical method extends even to denying that quantity or magnitude, motion and figure can be treated in isolation from the matter in which they inhere:

> ...whosoever will study nature...must not make abstractions of motion and figure from matter, nor of matter form motion and figure, for they are inseparable, as being one thing; viz. corporeal figurative motions; and whosoever conceives any of them as abstract will, in my opinion, very much err (PL 65).

> I wonder [Aristotle] makes qualities to be no substances, or bodies, but "accidents," which is something between body, and no body...they are no more but effects of nature, and cannot be above their cause, which is matter" (OEP 271).

What about mathematical *laws*—do they have any role in explaining nature, according to Cavendish? Cavendish was familiar with Descartes's *Principles of Philosophy*, in which Descartes articulates a fundamental quantitive law of motion: that the quantity of motion in any interaction is conserved. As Section 3 discussed, Cavendish criticizes this law, replacing it with a mechanism—patterning—but giving no indication of the laws that might connect the patterned body and the patterner or even whether the relationship is deterministic. She allows that there are, for example, figuring motions in the brain that are spontaneous in the sense that they are not occasioned by an external object. But it is not clear whether they are totally spontaneous or are occasioned by other corporeal figurative motions, like ones that are internal to the brain or body. One claim *can* be read as an explicit denial of determinism: Cavendish claims that "one and the same cause may produce several and different effects" (OEP 141). But it is not clear that she is referring to the total and not a partial cause here.

Cavendish does invoke the "such exact rules...undissolvable laws...fixt decrees [and] order" of nature in her "Condemning Treatise of Atoms". But there is no indication that by 'laws' or 'rules' here she means principles of universal application. Discussing Descartes in *Philosophical Letters*, she writes:

> But if you desire my opinion how many laws nature hath, and what they are; I say nature hath but one law, which is a wise law, viz. to keep infinite matter in order, and to keep so much peace, as not to disturb the foundation of her government:

> for though nature's actions are various, and so many times opposite, which would seem to make wars between several parts, yet those active parts, being united into one infinite body, cannot break nature's general peace (PL 146).

So nature does not contain in it any exact or regular figures, measures, invariants or laws, but Cavendish's appeal to the peace, order and regularity of nature suggests that nature may have some kind of discernible structure. After all, Cavendish does allow that in virtue of being part of a "regularly composed" whole, parts may "judge more probably of the whole" (OEP 138, see also 153). What sort of regularity does nature admit of, and how does that bode for the success of mathematics?

5.2 Regularity

Nature is regular in some sense; this much is clear, especially in Cavendish's arguments against atomism, which she thinks fail to account for nature's orderly operations. But Cavendish herself is clearly vexed by the question of nature's relationship to regularity. Even in the later OEP, she includes this question in the Argumental Discourse, a point-counterpoint exercise that she admits treats topics on which she sees good arguments on both sides of a question (OEP 45). In earlier work like the PPO and parts of the PL, Cavendish seems to think that there is regularity and no irregularity in nature:

> such actions which are different, cross and opposite, not moving always after their usual and accustomed way, I name Irregular, for want of a better expression; but properly there is no such thing as Irregularity in Nature, nor no weariness, rest, sleep, sickness, death or destruction, no more then there is place, space, time, modes, accidents, and the like, any thing besides body or matter (PL 539).

But elsewhere, even in the letters, she writes that nature strikes a "poise" or "balance" between irregularity and regularity, like any opposing or contrary qualities (PL 135, 255; G 12, 60), even though "no particular creature was able to know the exactness of the proportion that is between them, because they are infinite" (OEP 36, see also 105). Still elsewhere, Cavendish says that both regularity and irregularity are relative "to our conceptions, because those motions which move not after the ordinary, common or usual way or manner, we call irregular" (PL 360).

Cavendish associates irregularity with finitude, parthood and variety, suggesting that nature considered as infinite is perfectly regular, whereas considered as divided, it is irregular. She defines irregularity "nothing but an opposition or strife between parts" (OEP 144) and suggests that if they were not real features of nature, then there would be no variety:

> nature is peaceable, being always one and the same, and having nothing in itself to be crossed or opposed by; whenas the actions of nature, or natural matter, are continually striving against each other, as being various and different (PL 280; see also 238).

> what we call irregularities in nature, are really nothing but a variety of nature's motions (OEP 71).

> ...all [nature's] actions seem to be poised, or balanced, by opposition; as for example, as nature hath dividing, so also composing actions: Also, as nature hath regular, so irregular actions" (G 13).

There would be, at the same time, no unity if there were not regularity among the parts:

> there is perpetual war and discord amongst the parts of nature, although not in the nature and substance of infinite matter, which is of a simple kind, and knows no contraries in itself, but lives in peace...war is made by the division of nature's parts, and variety of natural actions, so peace is caused by the unity and simplicity of the nature and essence of only matter (PL 280).

Parthood and variety on the one hand, and unity and harmony on the other, are not mere matters of perspective (as finitude and infinity will not be mere matters of perspective for Spinoza), but the distinction does concern nature under two different aspects. She makes an analogous distinction in the case of a single creature, associating irregular actions in a creature with "effects that do not properly belong to the nature" of the creature as a whole (PL 183–183), which explains why she associates irregularity with negative phenomena like false beliefs (PL 149), madness and birth defects (G 42), indigestion (PL 358) and disease (G 48).[18]

Finally, this picture is obliquely supported by the fact that Cavendish sometimes identifies 'rational' with 'regular' (e.g. OEP 16, G 22). She does not deny that it is possible for rational matter and motions to be irregular; however, as we saw above, she does argue that reason has a more general knowledge of a creature as a whole. So we can see reason as being sensitive to and regulating a whole in a way that sensitive perception is not, and so more strongly associated with regularity than sensitive perception.

In early work, nature's order very occasionally seems to be cast in mathematical terms. For example, Cavendish writes that rational matter "moves in number and measure...as musical instruments do" (PPO 178; see also the Epistle to the Reader) and frequently references the "harmony" of nature. But this language quickly drops out of Cavendish's work and is replaced by references to nature's wisdom and ends:

> Nature being a wise and provident lady, governs her parts very wisely, methodically, and orderly (OEP 105).

[18] In an interesting and more detailed study on the order and disorder of nature, Detlefsen (2007) argues that it is as wrong, albeit tempting, to read Cavendish as claiming that in order to explain order among nature's parts, nature as a whole must guide, "from the top-down, all the parts in their causal interactions" to explain why those interactions are orderly (170). What I say here is not an endorsement of this reading; it does not imply that nature has some causal power or knowledge, over and above the causal power and knowledge of its parts, that is required to maintain order. The power and knowledge of nature as a whole may be nothing more than the power and knowledge of the sum of its parts, but it may still be necessary to appeal to power and knowledge of the whole to explain order. Moreover, the reading I am offering here agrees with Detlefsen that "there are true disorders independent of the human perspective" (177). But I am less sure that there are true disorders when nature is considered as whole, given (the many) passages like PL 280, which suggest that for Cavendish, as for Spinoza, nature can be considered as natura naturata or natura naturans.

> Nature's infinite natural wisdom, which is the cause of her orderly government in all particular productions, changes and dissolutions; so that all creatures in their particular kinds, do move and work as nature pleases, orders and directs (OEP 109).

> But nature is wiser than we or any creature is able to conceive: and surely she works not to no purpose, or in vain; but there appears as much wisdom in the fabric and structure of her works, as there is variety in them. (OEP 60, see also 72, 85; G 7).

I am not sure how literally we should take Cavendish when she says that nature has ends, although the fact that she makes knowledge, perception and even agency (in the case of rational matter) fundamental to nature suggests that maybe we should. Whether nature's designs are ultimately cashed out in terms of final or efficient causation, however, nature's order is far beyond our ability to describe it in terms of mathematical laws.[19]

Finally, Cavendish relates irregularity with art, in a passage that draws together a number of related threads:

> nature, being a corporeal substance, has infinite parts, as well as an infinite body; and art, which is only the playing action of nature, and a particular creature, can easier divide and separate parts, then unite and make parts; for art cannot match, unite, and join parts so as nature doth; for nature is not only dividable and composeable, being a corporeal substance, but she is also full of curiosity and variety...and there is a great difference between forced actions, and natural actions; for the one sort is regular, the other irregular. But you may say, irregularities are as natural as regularities. I grant it; but nature leaves the irregular part most commonly to her daughter or creature art, that is, she makes irregularities for variety's sake, but she herself orders the regular part, that is, she is more careful of her regular actions; and thus nature taking delight in variety suffers irregularities, for otherwise, if there were only regularities, there could not be so much variety (PL 345–346).

To close, we'll take a look at why Cavendish thinks that mathematics is an art and as such cannot provide us with knowledge of nature.

5.3 Art

Everything is a part of nature, but something counts as artificial, according to Cavendish, if is produced by "the particular nature of [a] creature", rather than by "general nature" in a "general manner" (OEP 198). She gives sexual reproduction as an example of the latter. Since creatures are parts of nature and act on other parts of

[19] A number of scholars have explored aspects of Cavendish's reliance on nature's wisdom and addressed the role of teleology in Cavendish's system. See Detlefsen, Lascano (9-11), Boyle, Walters (83-85), Cunning (70-96), Broad (50-51). Cunning contrasts also highlights some of Cavendish's arguments against alternative explanations of order; for example, Pythagoras's numbers or laws of nature (90-91).

nature, properly speaking, art produces "hermaphroditical effects, that is, such as are partly natural, and partly artificial" (OEP 197).

Here is a sampling of the slurs that Cavendish throws at art: "nature's foolish changeling child" (PL 210), "nature's mimic or fool" (PL 283), "the insnarled motions of nature" (PL 281), "nature's sporting or playing actions" (OEP 105), and "nature's winking or juggling motions...by which she deceives her creatures' expectations, and by that means keeps them from knowing and understanding her subtle and wise government" (OEP 87). It is a prominent theme in Cavendish's work that art is delusive; for example, she writes that art "doth oftener obscure and disturb nature's ordinary actions, than prove any truth in nature" (PL 281). How does art lead to error? Cavendish argues that "art...is but a particular creature" and as such "cannot inform us of the truth of the infinite parts of nature" (OEP 48). But this can't be the only reason, because our "natural sense and reason" is also finite.

Cavendish's most extended discussions of art's deception is in the context of her critiques of experimental philosophy and especially microscopy. The reasoning is complicated and interesting, but the upshot is that magnifying lenses often "present falsely the picture of an exterior object" (OEP 51). The main reason sees to be that the perception is mediated: when I examine a mite through a lens, instead of patterning a mite, my eye is patterning a figure in the lens.

You might wonder: why isn't using a microscope like fixing nearsightedness: in both cases, the pattern that results in my sense organs corresponds more exactly to the figure of the original object? While this objection makes sense for a Hobbesian or Cartesian view of vision, where it is caused by the impact of light on the eye, according to Cavendish, it arises from patterning, and presumably patterning, like sexual reproduction, is a "general action" of nature.

Nature's general actions, we saw earlier, are infinitely complex and wise; her wise works are "more subtle and mysterious, than that they can be known by art" (OEP 198). To apply human art to perception is to pretend that a finite effect of nature can overpower nature:

> ...art must attend reason as the chief mistress of information, which in time may make her a more prudent and profitable servant than she is; for in this age she is become rather vain than profitable, striving to act beyond her power... (OEP 201–201)

> ...we have no power at all over natural causes and effects; but only one particular effect may have some power over another, which are natural actions; but neither can natural causes nor effects be overpowered by man so, as if man was a degree above nature, but they must be as nature is pleased to order them" (OEP 49) .

Nature's patterning is already aimed at reproducing form (unlike for, say, a mechanistic account of perception); the eye is designed, to speak loosely, to pattern the characteristic of an external object in a way that is appropriate to it. That is why

> the best optic is a perfect natural eye, and a regular sensitive perception; and the best judge, is reason; and the best study, is rational contemplation joined with the observations of regular sense, but not deluding arts; for art is not only gross in comparison to nature, but, for the most part, deformed and defective...natural

> reason is above artificial sense...wherefore, those arts are the best and surest informers, that alter nature least (OEP 53).

Cavendish explicitly associates experimental philosophy with applied mathematics:

> Neither will artificial characters and geometrical figures be able to make their opinions and experiments more probable...much less will dioptrical glasses give any true information of them, but rather they delude the sight; for art is not only intricate and obscure, but a false informer (OEP 87).

In the case of lenses, we act beyond our power by trying to redesign nature's patterning mechanism. It is less clear how "man conceits himself to be above nature" (OEP 95) in the case of mathematics, but I take it that Cavendish thinks that we should trust nature in inquiry as well, and that methods like mathematics, that seem to involve "over-nice distinctions", excessive effort, and seemingly ineliminable disagreement, are not part of nature's toolbox. This is true of the other formal arts as well: the art of logic, for example, is like "thick dark clouds, that darken truth" (PL 478). Concern with syllogistic form, linguistic niceties and mathematical rules doesn't just reflect a concern with form over real rational and natural insight: those formal strictures, in virtue of being created by humans, "deform" reason.

Instead, we should rely on natural and regular sense and reason, having faith that nature will provide us with "knowledges" and sense perceptions that are "proper to the nature of their figure" (OEP 29, 54; see also G 8, 18). Cavendish ties together these threads with characteristic literary flair in the *Letters*:

> ...immaterial substance, non-beings, and many the like...can neither do any good nor hurt to nature, but only spoil philosophical knowledge, and as nature is ignorant of immaterials and non-beings, so art is ignorant of nature; for mathematical rules, measures, and demonstrations, cannot rule, measure nor demonstrate nature, no more, then chymical divisions, dissolutions and extractions (or rather distractions, nay, I may say destructions) can divide, dissolve, extract, compose, and unite, as Nature doth...the best and readiest way to find out nature, or rather some truth of nature, is sense and reason, which are parts of active substance and therefore the truest informers of nature (PL 347–348).

6 Conclusion

Cavendish's criticisms of mathematics arise from two different sets of commitments: one set concerns the object of mathematical representation, and one set concerns the subject of mathematical representations.

Nature intrinsically resists mathematization, Cavendish thinks, because she expresses herself in infinite variety, which Cavendish does not think can be measured or grouped into classes. Cavendish makes no exception for canonically quantitative properties like extension, motion, time or shape. On top of this, Cavendish holds a very strong version of anti-abstractionism: she thinks that all qualities are literally identical with matter, denying any kind of modal distinction, and she does not think that conceptual distinctions can be made where there are no distinctions in nature.

These positions are driven by a most radical materialism, which prescribes (at least officially) the denial of the explanatory power of any forms.

Cavendish adopts an epistemology on which—with some exceptions—knowing something means becoming it, at least in part. As a result, you can't know anything that you cannot become: if you're material, you cannot have ideas of immaterials; if you're finite, you can't have ideas of the infinite. Since nature is infinite and it is not obviously characterized by invariants or common notions that might be in fact patternable by a finite mind, the human mind cannot have complete knowledge of nature. The best we can do is keep our brains off the rack, or our hands off our natural or regular sense and reason, for the reason that nature is wiser than we are. Forcing nature into mathematical patterns is an attempt to best nature (as are, for example, the application of logic or over-dependence on the rules of grammar).

These two very general features of Cavendish's system generate her critique of mathematics, and the question of the epistemic status of mathematics is a special case of a more general problem for her system. On the one hand, given the assimilation view of knowledge, to know nature would be to become like it. Since we are merely parts of nature, that means changing or deforming our minds to reflect what is greater than us. On the other hand, there is no way for us to become like nature, and our active attempts to do so amount to hubristic artifice. One very natural response would be to seek the general features of nature like her laws or common notions, but as her critique of mathematics shows, Cavendish eschews this path. She is left with an acute version of a deep question: if our minds are but the parts and the effects of nature, how can we possibly know nature itself?

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