

inductive definitions. As initiated in Feferman (1996), I am optimistic that it can be used to elaborate Gödel's program for new axioms in set theory and in particular to draw a sharper line between which such axioms ought to be accepted on intrinsic grounds and those to be argued for on extrinsic grounds.

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#### CHAPTER 5

### *A Second Philosophy of logic*

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What's hidden in my hand is either an ordinary dime or a foreign coin of a type I've never seen. (I drew it blindfolded from a bin filled with just these two types of objects.) It's not a dime. (I can tell by the feel of it.) Then, obviously, it *must* be a foreign coin! But what makes this so?

It's common to take this query as standing in for more general questions about logic – what makes logical inference reliable? what is the ground of logical truth? – and common, also, to regard these questions as properly philosophical, to be answered by appeal to distinctively philosophical theories of abstracta, possible worlds, concepts, meanings, and the like. What I'd like to do here is step back from this hard-won wisdom and try to address the simple question afresh, without presumptions about what constitutes 'logic' or even 'philosophy'. The thought is to treat inquiries about reliability of the coin inference and others like it as perfectly ordinary questions, in search of perfectly ordinary answers, and to see where this innocent approach may lead.

To clarify what I have in mind here, let me introduce an unassuming inquirer called the Second Philosopher, interested in all aspects of the world and our place in it.<sup>1</sup> She begins her investigations with everyday perceptions, gradually develops more sophisticated approaches to observation and experimentation that expand her understanding and sometimes serve to correct her initial beliefs; eventually she begins to form and test hypotheses, and to engage in mature theory-formation and confirmation; along the way, she finds the need for, and pursues, first arithmetic and geometry, then analysis and even pure mathematics;<sup>2</sup> and in all this, she often pauses to reflect on the methods she's using, to assess their

<sup>1</sup> The Second Philosopher is introduced in (Maddy 2007), and her views on logic detailed in Part III of that book. The discussion here reworks and condenses the presentation there (see also (Maddy to appear)).

<sup>2</sup> For more on the Second Philosopher's approach to mathematics, see (Maddy 2011).

effectiveness and improve them as she goes. When I propose to treat the question of the reliability of the coin inference as an ordinary question, I have in mind to examine it from the Second Philosopher's point of view. She holds no prior convictions about the nature of the question; she sees it simply as another of her straightforward questions about the world and her investigations of it.

The first thing she's likely to notice is that neither the reliability of the coin inference nor the truth of the corresponding if-then statement<sup>3</sup> depends on any details of the physical composition of the item in her hand or the particular properties that characterize dimes as opposed to other coins. She quickly discerns that what's relevant is entirely independent of all but the most general structural features of the situation: an object with one or the other of two properties that lacks one must have the other. In her characteristic way, she goes on to systematize this observation – for any object  $a$  and any properties,  $P$  and  $Q$ , if  $Qa$ -or- $Pa$  and not- $Qa$ , then  $Pa$  – and from there to develop a broader theory of forms that yield such highly general forms of truth and reliable inference. In this way, she's led to consider any situation that consists of objects that enjoy or fail to enjoy various properties, that stand and don't stand in various relations; she explores conjunctions and disjunctions of these, and their failures as well; she appreciates that one situation involving these objects and their inter-relations can depend on another; and eventually, following Frege, she happens on the notion that a property or relation can hold for at least one object, or even universally – suppose she dubs this sort of thing a 'formal structure'.<sup>4</sup>

Given her understanding of the real-world situations she's out to describe in these very general, formal terms, she sees no reason to suppose that every object has precise boundaries – is this particular loose hair part of the cat or not? – or that every property (or relation) must determinately hold or fail to hold of each object (or objects) – is this growing tadpole now a frog or not? She appreciates that borderline cases are common and fully determinate properties (or relations) rare. Thinking along these lines, she's led to something like a Kleene or Lukasiewicz three-valued system: for a given object (or objects), a property (or relation) might hold, fail, or be indeterminate; not-(...) obtains if (...) fails and is otherwise indeterminate; (...) and-() obtains if both (...) and () obtain, fails if one of them fails, and is otherwise indeterminate; and so on through the obvious

<sup>3</sup> I won't distinguish between these, except in the vicinity of footnote 5.

<sup>4</sup> In (Maddy 2007) and (Maddy to appear), this is called KF-structure, named for Kant and Frege.

clauses for (...) or-(), (there is an  $x$ , ... $x$ ...) and (for all  $x$ , ... $x$ ...). A formal structure of this sort validates many of the familiar inference patterns – for example, the introduction and elimination rules for 'not', 'and', 'or', 'for all', and 'there exists'; the DeMorgan equivalences; and the distributive laws – but the gaps produce failures of the laws of excluded middle and non-contradiction (if  $p$  is indeterminate, so are  $p$ -or-not- $p$  and not-( $p$ -and-not- $p$ ).<sup>5</sup> The subtleties of the Second Philosopher's dependency relation undercut many of the familiar equivalences: not-(the rose is red)-or- $2 + 2 = 4$ , but  $2 + 2$  doesn't equal 4 *because* the rose is red. Fortunately, modus ponens survives: when both ( $q$  depends on  $p$ ) and  $p$  obtain,  $q$  can't fail or be indeterminate. Suppose the Second Philosopher now codifies these features of her formal structures into a collection of inference patterns; coining a new term, she calls this 'rudimentary logic' (though without any preconceptions about the term 'logic'). She takes herself to have shown that this rudimentary logic is satisfied in any situation with formal structure.

This is a considerable advance, but it remains abstract: what's been shown is that rudimentary logic is reliable, assuming the presence of formal structure. Common sense clearly suggests that our actual world does contain objects with properties, standing in relations, with dependencies, but the Second Philosopher has learned from experience that common sense is fallible and she routinely subjects its deliverances to careful scrutiny. What she finds in this case is, for example, that the region of space occupied by what we take to be an ordinary physical object like the coin does differ markedly from its surroundings: it contains a more dense and tightly organized collection of molecules; the atoms in those molecules are of different elements; the contents of that collection are bound together by various forces that tend to keep it moving as a group; other forces make the region relatively impenetrable; and so on. Similarly, she confirms that objects have properties, stand in relations, and that situations involving them exhibit dependencies.

Now it must be admitted that there are those who would disagree, who would question the existence of ordinary objects, beginning with Eddington and his famous two tables:

One of them is familiar to me from my earliest years. . . . It has extension; it is comparatively permanent; it is coloured; above all it is *substantial*. By

<sup>5</sup> Here, briefly, the distinction between logical truths and valid inferences matters, because the gaps undermine all of the former. Inferences often survive because gaps are ruled out when the premises are taken to obtain.

substantial I do not mean merely that it does not collapse when I lean upon it; I mean that it is constituted of 'substance'. (Eddington 1928: ix)

Table No. 2 is my scientific table. . . . It . . . is mostly emptiness. Sparsely scattered in that emptiness are numerous electric charges rushing about with great speed; but their combined bulk amounts to less than a billionth of the bulk of the table itself. Notwithstanding its strange construction it turns out to be an entirely efficient table. It supports my writing paper as satisfactorily as table No. 1; for when I lay the paper on it the little electric particles with their headlong speed keep on hitting the underside, so that the paper is maintained in shuttlecock fashion at a nearly steady level. If I lean upon this table I shall not go through; or, to be strictly accurate, the chance of my scientific elbow going through my scientific table is so excessively small that it can be neglected in practical life. (Eddington 1928: x)

So far, the Second Philosopher need have no quarrel; Eddington can be understood as putting poetically what she would put more prosaically: science has taught us some surprising things about the table, its properties and behaviors.

But this isn't what Eddington believes:

Modern physics has by delicate test and remorseless logic assured me that my second scientific table is the only one which is really there. (Eddington 1928: xii)

The Second Philosopher naturally wonders why this should be so, why the so-called 'scientific table' isn't just a more accurate and complete description of the ordinary table.<sup>6</sup> In fact, it turns out that 'substance' in Eddington's description of table No. 1 is a loaded term:

It [is] the intrinsic nature of substance to occupy space to the exclusion of other substance. (Eddington 1928: xii)

There is a vast difference between my scientific table with its substance (if any) thinly scattered in specks in a region mostly empty and the table of everyday conception which we regard as the type of solid reality . . . It makes all the difference in the world whether the paper before me is poised as it were on a swarm of flies . . . or whether it is supported because there is substance below it. (Eddington 1928: xi–xii)

Here Eddington appears to think that being composed of something like continuous matter is essential to table No. 1, that one couldn't come to

<sup>6</sup> Some writers reject the ordinary table on the grounds that its boundaries would be inexact. As we've seen, the Second Philosopher is happy to accept this sort of 'worldly vagueness'.

realize that its supporting the paper or resisting my elbow arise very differently than I might have at first imagined – that one couldn't come to realize this, that is, without also coming to realize that there is no such thing as table No. 1. But why should this be so? Why should our initial conceptualization be binding in this way? For that matter, is it even clear that our initial conceptualization includes any account at all of how and why the table supports paper or resists elbows? The Second Philosopher sees no reason to retract her belief in ordinary macro-objects.<sup>7</sup>

So let's grant the Second Philosopher her claim that formal structure as she understands it does turn up in our actual world. This means not only that rudimentary logic applies in such cases, but that it does so regardless of the physical details of the objects' composition, the precise nature of the properties and relations, any particular facts of spatiotemporal location, and so on. This observation might serve as the first step on a path toward the familiar idea, noted earlier, that questions like these are peculiarly philosophical: the thought would be that if the correctness of rudimentary logic doesn't depend on any of the physical details of the situation, if it holds for any objects, any properties and relations, etc., then it must be quite different in character from our ordinary information about the world; indeed, if none of the physical details matter, if these truths hold no matter what the particular contingencies happen to be, then perhaps they're true necessarily, in any possible world at all – and if that's right, then nothing particular to our ordinary, contingent world can be what's making them true. By a series of steps like these, one might make one's way to the idea that logical truths reflect the facts, not about our world, but about a platonic world of propositions, or a crystalline structure that our world enjoys necessarily, or an abstract realm of meanings or concepts, or some such distinctively philosophical subject matter. Many such

<sup>7</sup> Eddington's two tables may call to mind Sellars' challenge to reconcile 'the scientific image' with 'the manifest image'. In fact, the manifest image includes much more than Eddington's table No. 1 – 'it is the framework in terms of which, to use an existentialist turn of phrase, man first encountered himself' (Sellars 1962: 6) – but Sellars does come close to our concerns when he denies that 'manifest objects are identical with systems of imperceptible particles' (Sellars 1962: 26). He illustrates with the case of the pink ice cube: 'the manifest ice cube presents itself to us as something which is pink through and through, as a pink continuum, all the regions of which, however small, are pink' (Sellars 1962: 26), and of course the scientific ice cube isn't at all like this. Here Sellars seems to think, with Eddington, that science isn't in a position to tell us surprising things about what it is for the ice cube to be (look) pink; he seems to agree with Eddington that some apparent features of the manifest ice cube can't be sacrificed without losing the manifest ice cube itself. Indeed the essential features they cling to are similar: a kind of substantial continuity or homogeneity. The Second Philosopher remains unmoved.

options spring up in the wake of this line of thought, but ordinary facts, ordinary information about our ordinary world has been left behind, and ordinary inquiry along with it – we've entered the realm of philosophy proper.

But suppose our Second Philosopher doesn't set foot on this path. Suppose she simply notices that nothing about the chemical makeup of the coin is relevant, that nothing about where the coin is located is relevant, – that only the formal structure matters to the reliability of the rudimentary logic she's isolated. From here she simply continues her inquiries, turning to other pursuits in geology, astronomy, linguistics, and so on. At some point in all this, she encounters cathode rays and black body radiation, begins to theorize about discrete packets of energy, uses the quantum hypothesis to explain the photo-electric effect, and eventually goes on to the full development of quantum mechanics. And now she's in for some surprises: the objects of the micro-world seem to move from one place to another without following continuous trajectories; a situation with two similar particles *A* and *B* apparently isn't different from a situation with *A* and *B* switched; an object has some position and some momentum, but it can't have a particular position and a particular momentum at the same time; there are dependencies between situations that violate all ordinary thinking about dependencies.<sup>8</sup> Do the 'objects', 'properties', 'relations', and 'dependencies' of the quantum-mechanical micro-world enjoy the formal structure that underlies rudimentary logic? The Second Philosopher might well wonder, and sure enough, her doubts are soon realized. In a case analogous to, but simpler than position and momentum, she finds an electron *a* with vertical spin up or vertical spin down, and horizontal spin right or horizontal spin left – (*Ua* or *Da*) and (*Ra* or *La*) – but for which the four obvious conjunctions – (*Ua* and *Ra*) or (*Ua* and *La*) or (*Da* and *Ra*) or (*Da* and *La*) – all fail. This distributive law of rudimentary logic doesn't obtain!

We're now forced to recognize that those very general features the Second Philosopher isolated in her formal structures actually have some bite. Though it wasn't made explicit, an object in a formal structure was assumed to be an individual, fundamentally distinct from all others; having a property – like location, for example – was assumed to involve having a particular (though perhaps imprecise) property – a particular location, not just some location or other. These features were so obvious as to go unremarked until the anomalies of quantum mechanics came along to

<sup>8</sup> For more on these quantum anomalies, with references, see (Maddy 2007, §III.4).

demonstrate so vividly that they can in fact fail.<sup>9</sup> Those of us who ventured down that path the Second Philosopher didn't take were tempted to think that her formal structure is to be found in every possible world, but it turns out it isn't present even in every quarter of our own contingent world!<sup>10</sup> Rudimentary logic isn't necessary after all; its correctness is contingent on the very general, but still not universal, features isolated in the Second Philosopher's formal structure.

We've focused so far on the metaphysics – what makes these inferences reliable, these truths true? – but there's also the epistemology – how do we come to know these things? If we followed the philosopher's path and succeeded in dismissing the vicissitudes of contingent world as irrelevant well before the subsequent shocks dealt the Second Philosopher by quantum mechanics, then we might continue our reasoning along these lines: if logic is necessary, true in all possible worlds, if the details of our contingent world are beside the point, then how could coming to know its truths require us to attend to our experience of this world?<sup>11</sup> Again a range of options flourish here, from straightforward theories of a priori knowledge

<sup>9</sup> In yet another twist in the tradition of Eddington and Sellars, Ladyman and Ross (2007) begin from this observation – that the micro-world doesn't seem to consist of individual objects – then go on to classify the ordinary table, along with the botanist's giant redwoods and the physical chemist's molecules, as human constructs imposed for 'epistemological book-keeping' (p. 240) on an entirely objectless world. I suspect that this disagreement with the Second Philosopher traces at least in part to differing pictures of how 'naturalistic' metaphysics is to be done. The Second Philosopher's 'metaphysics naturalized' simply pursues ordinary science and ends up agreeing with the folk, the botanist and the chemist that there are tables, trees and atoms, that trees are roughly constituted by biological items like cells, cells by chemical items like molecules, molecules by atoms, and so on. She doesn't yet know, and may never know, how to extend this program into the objectless micro-world, but she has good reason to continue trying, and even if she fails, she doesn't see that this alone should undermine our belief in the objects of our ordinary world. In contrast, the 'naturalized metaphysics' of Ladyman and Ross is the work of 'naturalistic philosophical under-labourers' (p. 242), designed to show 'how two or more specific scientific hypotheses, at least one of which is drawn from fundamental physics, jointly explain more than the sum of what is explained by the two hypotheses taken separately' (Ladyman and Ross 2007: 37) – and it's this project that delivers the surprising result that ordinary objects are constructed by us. From their perspective, the Second Philosopher 'metaphysics naturalized' is just more science: the botanist and the physical chemist make no contribution to ontology; metaphysics only begins when their hypotheses are unified with fundamental physics. From the Second Philosopher's perspective, there's no reason to suppose that ordinary objects are human projections or to insist that assessments of what there is must involve unification with fundamental physics. Indeed, from her perspective, given our current state of understanding (see below), quantum mechanics is perhaps the last place we should look for ontological guidance!

<sup>10</sup> This incidentally removes another sort of skeptical challenge to the Second Philosopher's belief in ordinary macro-objects, namely, the charge that an inquiry starting with objects with properties, etc., will inevitably uncover objects with properties.

<sup>11</sup> An inference from necessary to a priori is less automatic in our post-Kripkean age, when many philosophers recognize a posteriori necessities, but logical truth seems a poor candidate for this sort of thing. In any case, what I'm tracing here are tempting paths, not conclusive arguments.

to complex accounts of how logic serves to constitute inquiry and thus can't itself be confirmed. But let's return to the Second Philosopher's more naïve inquiries, still well clear of the philosopher's path, and ask how she answers the simple question: how do we come to know that rudimentary logical inference is reliable?

In general, the Second Philosopher's epistemological investigations take the form of asking how human beings – as described in biology, physiology, psychology, linguistics, and so on – come to have reliable beliefs about the world – as described in physics, chemistry, botany, astronomy, and so on.<sup>12</sup> Work in psychology, cognitive science, and the like is primary here, but the Second Philosopher's focus is somewhat broader; not only does she study how people come to form beliefs about the world, she also takes it upon herself to match these beliefs up with what her other inquiries have told her about how the world actually is, and to assess which types of belief-forming processes, in which circumstances, are reliable. Though her epistemology is naturalized – that is, it takes place roughly within science – it's also normative.

In the case of rudimentary logic, the Second Philosopher's focus is on formal structure: her other studies of the world have revealed the existence of many objects, with properties, standing in relations, with dependencies, and she now asks how we come to be aware of these worldly features. Here she recapitulates the work of an impressive research community in contemporary cognitive science.<sup>13</sup> The modern study of our perception of individual objects reaches back at least to the 1930s, when Piaget used experiments based on manual search behavior<sup>14</sup> to argue that a child reaches the adult conception of a permanent, external object by a series of stages ending at about age 2. Conflicting but inconclusive indications from visual tracking suggested that even younger children might have the object concept, but it wasn't until the 1980s that a new experimental paradigm emerged for testing this possibility: habituation and preferential looking. In such an experiment, the infants are shown the same event over and over until they lose interest, as indicated by their decreased looking time (habituation); they're then shown one or another of two test displays, one that makes sense on the adult understanding of an object, the other

<sup>12</sup> This is reminiscent of many of Quine's descriptions of his 'epistemology naturalized', but Quine also tends to fall back on more traditional philosophical formulations, asking how we manage to infer our theory of the external world from sensory data (see Maddy 2007, §1.6; for more).

<sup>13</sup> I can only give the smallest sampling of this work here. For more, with references, see (Maddy 2007, §III.5).

<sup>14</sup> E.g., does the child lift a cloth to find a desirable object she's seen hidden there?

inconsistent with the adult understanding; if an infant is thinking like the adult, the inconsistent display should draw a longer gaze (preferential looking).

So, for example, suppose a metal screen is attached to a long hinge that extends from left to right on a stage; the screen can lie flat toward the viewer on the stage surface, and it can pivot through 180° arc to lie flat away from the viewer. The infant is habituated to seeing the screen move through this range of motion. Then the screen is positioned toward the infant, a box is placed behind it, and the screen is rotated backwards. The consistent display shows the screen stopping when it comes to rest on the now-hidden box; the inconsistent display shows it moving as before and coming to rest on the stage surface away from the viewer. If the infant thinks the box continues to exist even when it's hidden by the screen, and that the space it occupies can't be penetrated by the screen, then the inconsistent display should draw the longest gaze. (Notice that the inconsistent display is exactly the one the infant has been habituated to, so its very inconsistency would be sufficiently novel to overcome the habituation.) In this early use of the new paradigm, this is exactly what was observed in infants around five months of age.

Obviously this is only the beginning of the story. For example, does the infant understand the box as an individual object, as a unit, or just as an obstacle to the screen? Experiments of similar design soon indicated that infants as young as four months perceive a unit when presented with a bounded and connected batch of stuff that moves together. Now imagine a display with two panels separated by a small space. An object appears from stage left, travels behind one screen, after which an object emerges from behind the second screen, and vanishes stage right. One group of four-month-olds is habituated to seeing an object appear in the gap between the screens, as if it moved continuously throughout; another group is habituated to seeing an object disappear behind the first screen and an object emerge from behind the second screen without anything appearing in the gap. The test displays are then without panels, showing either one or two objects. The result was that the infants habituated with the apparently continuous motion looked longer at the two-object test display than the infants habituated with the scene where no object was seen in the gap. It seems an object is regarded as an individual if its motion is continuous.

Of course there's much more to this work than can be summarized here, but the current leading hypothesis is that these very young infants conceptualize individual units in these terms: they don't think that such a unit

can be in two places at once or that separate units can occupy the same space, and they expect them to travel in continuous trajectories. In the words of Elizabeth Spelke, a pioneer in this field, the infant's objects are 'complete, connected, solid bodies that persist over occlusion and maintain their identity through time' (Spelke 2000: 1233):

Putting together the findings from studies of perception of object boundaries and studies of perception of object identity, young infants appear to organize visual arrays into bodies that move cohesively (preserving their internal connectedness and their external boundaries), that move together with other objects if and only if the objects come into contact, and that move on paths that are connected over space and time. Cohesion, contact, and continuity are highly reliable properties of inanimate, material objects: objects are more likely to move on paths that are connected than they are to move at constant speeds, for example; and they are more likely to maintain their connectedness over motion than they are to maintain a rigid shape. Infants' perception appears to accord with the most reliable constraints on objects. (Spelke et al. 1995: 319–320)

Partly because so much of this research depends on experiments conducted with habituation/preferential-looking and closely related designs, partly for other reasons,<sup>15</sup> these conclusions can't be taken as irrevocably established, but then the fallibility of ongoing science is an occupational hazard for the Second Philosopher. Let's take the early emergence of a modest human ability to detect (some of) the world's individual objects as a tentative datum.

As for properties and relations, the infants' sensitivity to these plays a role in the habituation/preferential-looking studies mentioned earlier: habituating to green objects then preferentially looking at red ones must involve noticing those colors, likewise the spatial relations of objects and the screens. What's surprising is that object properties aren't initially used to individuate them. Ten-month-old infants watched as a toy duck emerged from the left side of a single screen, followed by a ball emerging from the right side of the screen; one of the two test displays then showed the duck and the ball, the other just the duck – and no significant difference between their reactions was found! The same experiment run

<sup>15</sup> E.g., Hatfield (2003) argues that the findings of Spelke and her collaborators only establish that young infants perceive 'bounded trackable volumes' not 'individual material objects'. Of course, Spelke (e.g., in Spelke et al. (1995), cited by Hatfield) does allow that the infant's object concept continues to develop in early childhood, so there is room here for clarification of levels or degrees of object perception. A question like this would prompt the Second Philosopher to get down to sorting things out, but I'm not so idealized an inquirer and leave these further investigations to others.

on slightly older one-year-olds delivered what an adult would have expected: the test display with the duck alone drew greater attention.

On reflection these results aren't so bewildering. While infants begin with simple but highly reliable spatiotemporal constraints on object identity (as Spelke notes), property distinctions require more judicious application: a red ball can turn blue and still be the same object; a human can change clothes and still be the same person. Some experience and learning must be needed for the child to realize that ducks don't generally turn into balls, and considerably more to reach the full adult concept:

We are inclined to judge that a car persists when its transmission is replaced, but would be less inclined to judge that a dog persists if its central nervous system were replaced. . . . Because we know that dogs but not cars have behavioral and mental capacities supported by certain internal structures, we consider certain transformations of dogs to be more radical than other, superficially similar transformations of cars. (Spelke et al. 1995: 302–303)

With this in mind, it's less surprising that the beginnings of the child's identification of objects by their properties comes a couple of months later than their identification by the more straightforward spatiotemporal means, and perhaps even that this new development apparently coincides with the acquisition of their first words – property nouns like 'ball' and 'duck'!

So as not to belabor this fascinating developmental work, let me just note that similar studies have shown that young infants detect conjunctions and disjunctions of object properties, the failure of properties or relations, simple billiard-ball style causal dependencies, and so on. It's also notable that many of these abilities found in young infants are also present, for example, in primates and birds. This suggests an evolutionary origin, and clearly the advantages conferred by the ability to track objects spatiotemporally, to perceive their properties and relations, to notice dependencies, would have been as useful on the savanna as they are in modern life.

All this leaves the Second Philosopher with two well-supported hypotheses: the ability to detect (at least some of) the formal structure present in the world comes to humans at a very early age, perhaps largely due to our evolutionary inheritance; whether by genetic endowment, normal maturation, or early experience, the primitive cognitive mechanisms underlying this ability are as they are primarily because humans (and their ancestors) interact almost exclusively with aspects of the world that display this formal structure. From here it's a short step to the suggestion that the presence of these primitive cognitive mechanisms, all tuned to formal

structure, is what makes the simpler inferences of rudimentary logic strike us as so obvious. Assuming that the Second Philosopher has this right – that the formal structure is often present, that we are configured to detect it, and that this accounts for our rudimentary logical beliefs – then a sufficiently externalist epistemologist might count this as a case of a priori knowledge. An epistemologist of more internalist leanings might hold that the sort of a posteriori inquiry undertaken here would be required to support actual knowledge of rudimentary logic. The Second Philosopher isn't confident that this disagreement has a determinate solution, isn't confident that the debate is backed by anything more substantial than the various handy uses of 'know', so she's content to offer a fuller version of the story sketched here, and to leave the decision about 'knowledge' to others.

Notice, incidentally, that if this is right, if the Second Philosopher's formal structure is so deeply involved in our most fundamental cognitive mechanisms, this explains why it's so difficult for us to come up with a viable interpretation of quantum mechanics, where formal structure goes awry. But this observation raises another question: if formal structure and hence rudimentary logic are missing in the micro-world, and if these are so fundamental to our thought and reasoning, how do we manage to carry out our study of quantum mechanics? Some suggest that we should adopt a special logic for quantum mechanics,<sup>16</sup> but the question posed here is how we manage to do quantum mechanics now, apparently using our ordinary logic. I think the answer is fairly simple: what we actually have in quantum mechanics isn't a theory of particles with properties, in relations, with dependencies, but a mathematical model, an abstract Hilbert space with state vectors.<sup>17</sup> This bit of mathematics displays all the necessary formal structure – it consists of objects with properties, in relations, with (logical) dependencies – so our familiar logic is entirely reliable there.<sup>18</sup> The deep problem for the interpretation of quantum

<sup>16</sup> See the discussion of deviant logics below.

<sup>17</sup> As noted above (footnote 9), Ladyman and Ross (2007) argue on grounds similar to the Second Philosopher's that the micro-world doesn't consist of objects. Given her account of how our cognition and our logic work, the Second Philosopher would predict that these authors should encounter some difficulty when it comes to describing the subject matter of quantum mechanics, and in fact, what they say on that score is consistent with the line taken here: 'it is possible that dividing a domain up into objects is the only way we can think about it' (Ladyman and Ross (2007: 155); 'we can only represent [the non-objectual structures of the micro-world] in terms of mathematical relationships' (Ladyman and Ross 2007: 299).

<sup>18</sup> In fact, the mathematical world is in some ways more amenable to our logical ways (see footnote 19 below).

mechanics is to explain how and why the mathematical model works so well, to figure out what worldly features it's tracking, but in the mathematics itself, our natural ways of thinking and reasoning are on impeccable footing.

Now for all its advertised virtues – reliability in a wide variety of worldly settings, harmony with our most fundamental cognitive mechanisms – rudimentary logic is in fact a rather unwieldy instrument in actual use. We've seen, for example, that the presence of indeterminacies eliminates the law of excluded middle, the principle of non-contradiction, and indeed all logical truths. An inference rule as central as *reductio ad absurdum* can be seen to fail: that (*q*-and-not-*q*) follows from *p* only tells us that *p* is either false or indeterminate. And the substantive requirements on dependency relations undercut most of our usual manipulations with the conditional. Though he's speaking of a full Kleene system, with a truth-functional conditional, I think Feferman's assessment applies to rudimentary logic as well: 'nothing like sustained ordinary reasoning can be carried on' (Feferman 1984: 95).

Under the circumstances, a stronger, more flexible logic is obviously to be desired. The Second Philosopher has seen this sort of thing many times: she has a theoretical description of a given range of situations, but that description is awkward or unworkable in various ways. To take one example, she can give a complete molecular description of water flowing in a pipe, but alas all practical calculation is impossible. In hope of making progress, she introduces a deliberate falsification – treating the water as a continuous substance – that allows her to use the stronger and more flexible mathematics of continuum mechanics. She has reason to think this might work, because there should be a size-scale with volumes large enough to include enough molecules to have relatively stable temperature, energy, density, etc., but not so large as to include wide local variations in properties like these. This line of thought suggests that her deliberate falsification might be both powerful enough to deliver concrete solutions and benign enough to do so without introducing distortions that would undercut its effectiveness for real engineering decisions. She tests it out, and happily it does work! This is what we call an 'idealization', indeed a successful idealization for many purposes. (It would obviously be unacceptably distorting if we were interested in explaining the water's behavior under electrolysis.) In similar ways, we ignore friction when its effects are small enough to be swamped by the phenomenon we're out to describe; we treat slightly irregular objects as perfectly geometrical when this does no harm; and so on.

With the technique of idealization in mind, the Second Philosopher looks for ways to simplify and streamline her theoretical account of formal structure, that is, her rudimentary logic, in ways that make it more flexible, more workable, and to do so without seriously undermining its reliability. To this end, she makes two key idealizations, introduces two falsifying assumptions – that there is no indeterminacy, that any particular combination of objects and properties or relations either holds or fails; and that dependencies behave as material conditionals<sup>19</sup> – and at a stroke, she transforms her crude rudimentary theory into our modern classical logic. There can be no doubt that full classical logic is an extraordinarily sophisticated and powerful instrument; the only open question is whether or not the required idealizations are benign. And as in the other examples, this judgment can be expected to vary from case to case.

This is where some of the so-called ‘deviant logics’ come in. Proponents of one or another of the various logics of vagueness, for example, may insist that indeterminacy is a real phenomenon,<sup>20</sup> may condemn ‘the lamentable tendency . . . to pretend that language is precise’ (J. A. Burgess 1990: 434). On the first point, the Second Philosopher agrees – indeterminacy is real – but she views the classical logician’s pretending otherwise as no different in principle than the engineer’s pretending that water is a continuous fluid; what determines the acceptability of either pretense isn’t the obvious fact that it is a pretense, but whether or not it is beneficial and benign in the situation at hand. Most logics of vagueness begin from a picture not unlike the Second Philosopher’s, in which, for example a property can hold of an object, fail to hold, or be indeterminate for that object; there’s also the problem of higher-order indeterminacy, that is, of borderline cases between holding and being indeterminate, between being indeterminate and failing. So far, I think it’s fair to say that there is no smooth and perspicuous logic of vagueness, no such logic that escapes Feferman’s critique. It is, of course, true that classical logic can lead us astray in contexts with indeterminacy – this is the point of the sorites paradox – but at least for now the Second Philosopher’s advice is simply to apply

<sup>19</sup> Though these idealizations involve falsification in her description of the physical world, they are satisfied in the world of classical mathematics: excluded middle holds and the dependencies are logical. For more on the ontology of mathematics, see (Maddy 2011).

<sup>20</sup> There is serious disagreement between various writers over the source of the indeterminacy: is it purely linguistic or does the world itself include borderline cases and fuzzy objects? Here the Second Philosopher sides with the latter, but this shouldn’t affect the brief discussion here, despite the formulation in the quotation in the next clause above.

classical logic with care,<sup>21</sup> as one should any idealization, rather than switch to a less viable logic.<sup>22</sup>

Advocates of various conditional logics protest the Second Philosopher’s other bold idealization: replacement of real dependencies with the simple material conditional. There are many proposals for a more substantial conditional, far too many to consider here (even if my slender expertise allowed it), but perhaps the conditional of relevance logic can be used as one representative example. The motivation here speaks directly to the falsification in question: the antecedent of a conditional should be ‘relevant’ to the consequent.<sup>23</sup> To return to our earlier example, the redness of this rose isn’t relevant to the fact that  $2 + 2 = 4$ , despite the truth of the corresponding material conditional (if the rose is red, then  $2 + 2 = 4$ ). Of course, as before, the Second Philosopher fully appreciates that the material conditional is a falsification, that the rose inference is an anomaly, but the pertinent questions are whether or not the falsification is beneficial and benign, and whether or not the relevance logician has something better to offer. Again I think that for now, we do best to employ our classical logic with care.

So we see that some deviant logics depart from the Second Philosopher’s classical logic by rejecting her idealizations,<sup>24</sup> and that our assessment then depends on the extent to which the falsifications introduced are beneficial and benign, and on the systematic merits of the proposed alternative. But not all deviant logics fit this profile; some concern not just the idealizations of classical logic, but the fundamentals of rudimentary logic itself. Examples include intuitionistic logic – which rejects double negation elimination – quantum

<sup>21</sup> Sorensen (2012) credits this approach to H. G. Wells: ‘Every species is vague, every term goes cloudy at its edges, and so in my way of thinking, relentless logic is only another name for a stupidity – for a sort of intellectual pigheadedness. If you push a philosophical or metaphysical enquiry through a series of valid syllogisms – never committing any generally recognized fallacy – you nevertheless leave behind you at each step a certain rubbing and marginal loss of objective truth and you get deflections that are difficult to trace, at each phase in the process’ (Wells 1908: 11).

<sup>22</sup> Williamson (1994) also advocates retaining classical logic, but his reason is quite different: because there is no real vagueness, because apparent borderline cases really just illustrate our ignorance of where the true borderline lies. This strikes many, including me, as obviously false.

<sup>23</sup> Relevance logicians are particularly unhappy with what they call ‘explosion’, the classical oddity that anything follows from a contradiction. For related reasons, full relevance logic rejects even some rudimentary logical inferences not involving the conditional, like disjunctive syllogism, but I leave this aside here. (For a bit more, see Maddy 2007: 292, footnote 24.)

<sup>24</sup> Some other deviant logics respond to idealizations of language rather than the worldly features of rudimentary logic: e.g., free logicians counsel us to reject the falsifying assumption that all naming expressions refer. Here, too, our assessment depends on the effectiveness of the idealization and the viability of the alternative. In practical terms, leaving aside the various technical studies in the theory of free logics, I’m not sure using a free logic is readily distinguishable from being careful about the use of existential quantifier introduction in the context of classical logic. In any case, our concern here is with worldly idealizations, not linguistic ones.



logic – which rejects the distributive laws – and dialetheism – which holds that there are true contradictions. Given the connection of rudimentary logic with the Second Philosopher’s formal structure, the challenge for each of these is to understand what the world is like without this formal structure, what the world is like that this alternative would be its logic.<sup>25</sup> Of the three, intuitionistic logic comes equipped with the most developed metaphysical picture, but it’s suited to describing the world of constructive mathematics, not the physical world.<sup>26</sup> Quantum logic at first set out to characterize the non-formal-structure of the micro-world, but in practice it has not succeeded in doing so;<sup>27</sup> the problem of interpreting quantum mechanics remains open. And dialetheism faces perhaps the highest odds: as far as I know, its defenders have focused for the most part on the narrower goal of locating a compelling example of a true contradiction in the world, perhaps so far without conspicuous success.<sup>28</sup> The Second Philosopher tentatively concludes that rudimentary logic currently has no viable rivals as the logic of the world, and that classical logic likewise stands above its rivals as an appropriate idealization of rudimentary logic for everyday use.

In sum, then, the Second Philosopher’s answer, an ordinary answer to the question of why that coin must be foreign, is that the coin and its properties display formal structure and the inference in question is reliable in all such situations. This answer doesn’t deliver on the usual philosophical expectations: the reliability of the inference is contingent, our knowledge of it is only minimally a priori at best. The account itself results from plain empirical inquiry, which may lead some to insist that it isn’t philosophy at all. Perhaps not. Then again, if the original question – why is this inference reliable? – counts as philosophical – and it’s not clear how else to classify it – then the answer, too, would seem to have some claim to that honorific. But the Second Philosopher doesn’t care much about labels. After all, even ‘Second Philosophy’ and ‘Second Philosopher’ aren’t her terms but mine, used to describe her and her behavior. In any case, philosophy or not, I hope the Second Philosopher’s investigations do tell us something about the nature of that inference about the coin.<sup>29</sup>

<sup>25</sup> Our interest here is in the logic of the world, not the logic that best models something else, as, e.g., paraconsistent logic (a variety of relevance logic) might serve to model belief systems (see Maddy 2007: 293–296).

<sup>26</sup> See the discussion of Creator Worlds in (Maddy 2007: 231–233, 296) and (Maddy to appear, §II).

<sup>27</sup> See (Maddy 2007: 276–279, 296). <sup>28</sup> See (Maddy 2007: 296–297).

<sup>29</sup> My thanks to Patricia Marino for helpful comments on an earlier draft and to Penelope Rush for editorial improvements.

## CHAPTER 6

### *Logical nihilism*

*Curtis Franks*

#### 1. Introduction

The idea that there may be more than one correct logic has recently attracted considerable interest. This cannot be explained by the mere fact that several distinct logical systems have their scientific uses, for no one denies that the “logic” of classical mathematics differs from the “logics” of rational decision, of resource conscious database theory, and of effective problem solving. Those known as “logical monists” maintain that the panoply of logical systems applicable in their various domains says nothing against their basic tenet that a single relation of logical consequence is either violated by or manifest in each such system. “Logical pluralists” do not counter this by pointing again at the numerous logical systems, for they agree that for all their interest many of these indeed fail to trace any relation of logical consequence. They claim, instead, that no one logical consequence relation is privileged over all others, that several such relations abound.

Interesting as this debate may be, I intend to draw into question the point on which monists and pluralists appear to agree and on which their entire discussion pivots: the idea that one thing a logical investigation might do is adhere to a relation of consequence that is “out there in the world,” legislating norms of rational inference, or persisting some other wise independently of our logical investigations themselves. My opinion is that fixing our sights on such a relation saddles logic with a burden that it cannot comfortably bear, and that logic, in the vigor and profundity that it displays nowadays, does and ought to command our interest precisely because of its disregard for norms of correctness.

I shall not argue for the thesis that there are no correct logics. Although I do find attempts from our history to paint a convincing picture of a relation of logical consequence that attains among propositions (or sentences, or whatever) dubious, I should not know how to cast general doubt