The Design Metaphor

with Doren Recker, "How to Confuse Organisms with Mousetraps"; Helen De Cruz and Johan De Smedt, "Paley's iPod"

HOW TO CONFUSE ORGANISMS WITH MOUSETRAPS: MACHINE METAPHORS AND INTELLIGENT DESIGN

by Doren Recker

Abstract. Why do design arguments—particularly those emphasizing machine metaphors such as "Organisms and/or their parts are machines"—continue to be so convincing to so many people after they have been repeatedly refuted? In this essay I review various interpretations and refutations of design arguments and make a distinction between *rationally* refuting such arguments (Refuting$_R$) and rendering them *psychologically* unconvincing (Refuting$_P$). Expanding on this distinction, I provide support from recent work on the cognitive power of metaphors and developmental psychological work indicating a basic human propensity toward attributing *agency* to natural events, to show that design arguments "make sense" *unless* one is cued to look more closely. As with visual illusions, such as the Müller-Lyer arrow illusion, there is nothing wrong with a believer's cognitive apparatus any more than with their visual apparatus when they judge the lines in the illusion to be of unequal length. It takes training or a dissonance between design beliefs and other beliefs or experiences to play the role that a ruler does in the visual case. Unless people are cued to "look again" at what initially makes perfect sense, they are not inclined to apply more sophisticated evaluative procedures.

Keywords: agency and teleological bias; cognitive psychology; cognitive status of metaphors; design arguments; developmental psychology; dual process reasoning; intelligent design; machine metaphors

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One of the oldest arguments for God's existence (and wisdom, power, and usually benevolence) is the argument from design. Thomas Aquinas's "fifth way" is a good example.

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> We see that things which lack knowledge, such as natural bodies, act for an end, and this is evident from their acting always, or nearly always, in the same way, so as to obtain the best result. Hence it is plain that they achieve their end not by chance, but by design. . . . Therefore, some intelligent being exists by whom all natural things are ordered to their end. (Aquinas [1265–73] 1952, 13)

The argument, as in ancient times, is tied to teleology, adjusting means to ends, and good results. After the seventeenth century, natural bodies and nature itself were increasingly understood via mechanical models. There was a split at this point between mechanists and nonmechanists and, among mechanists, between those who rejected final causes in science and those who advocated teleological explanations.[1]

By the eighteenth century teleology and mechanism were both firmly ensconced within natural theology. David Hume has Cleanthes express a canonical version of this sort of position.

> You will find it [the world] to be nothing but one great machine, subdivided into an infinite number of lesser machines. . . . All these various machines, and even their most minute parts, are adjusted to each other with an accuracy, which ravishes into admiration all men, who have ever contemplated them. The curious adapting of means to ends . . . resembles exactly, though it much exceeds, the productions of human contrivance. . . . Since . . . the effects resemble each other, we are led to infer, by all the rules of analogy, that the causes also resemble; and that the Author of nature is somewhat similar to the mind of man. . . . (Hume [1779] 1947, 143)

Grounded in a machine metaphor and driven by induction based on analogy, this version is what Philo devotes most of his energy to attacking in the remainder of the *Dialogue.*

A few decades later, the most famous defense of design was developed by William Paley. Here the dependence of an organism's functioning on the tight interrelationship among its parts was enlisted over and over to counter explanations based on chance or undirected natural law. After surveying the many components of a watch and showing that each was *contrived* to contribute to the successful fulfilling of the watch's function, Paley immediately compares this to the relation between organisms and their parts: "Every indication of contrivance, every manifestation of design, which existed in the watch, exists in the works of nature. . . . There is precisely the same proof that the eye was made for vision, as there is that the telescope was made for assisting it" (Paley [1802] 1809, 20). Paley diagnoses virtually every part of a variety of organisms in the same way and with the same conclusion.

There are several outstanding issues concerning Paleyan design. First, there is disagreement concerning what *sort* of argument it represents, and whether or not it is the same as that attacked by Hume.[2] Second, there is controversy concerning whether it was Hume or Charles Darwin who (allegedly) sounded its death knell. And third, we can ask about the *status* of this sort of design argument. Most philosophers and scientists agree that it has been refuted (though by whom and in what way is less clear) and that it should play no role in explanations of natural phenomena. But it has always been, and continues to be, very convincing to many people. Why? What is its attraction? These questions assume more importance as intelligent design (ID) continues to be widely advocated, posing a serious threat to science education.[3]

In this essay I first address the issues of what sort of an argument Paleyian design represents and who (if anyone) has refuted it. I then investigate the cognitive status of the "organisms (and/or their parts) are machines" metaphor. Finally, I discuss evidence from developmental psychology that further supports the cognitive status of this metaphor (and teleological thinking, generally). The main concern is to better understand why Paleyian design seems so compelling to so many in spite of having been refuted rationally and scientifically.

Paleyian Design

What sort of argument is Paley's support for direct design? At first glance, it seems a straightforward argument from analogy. Insofar as machines display a tight interrelationship among their parts, all serving particular ends, human planning and ingenuity are responsible. Because we find similar detailed functional complexity among organisms and their parts, we can infer that these arrangements also require conscious planning. Paley hammers the similarities between parts of organisms and machines and insists that both require direct design. "Arrangement, disposition of parts, subserviency of means to an end . . . imply the presence of intelligence and mind" (Paley [1802] 1809, 16).

There also are reasons to take Paley's argument as being abductive, or an inference to the best explanation. The obvious functional complexity in organisms requires an explanation. One possibility is that, like the machines they resemble, organisms and their parts are consciously designed. Another is that "random physical forces acted on the lumps of matter and turned them into living things" (Sober 2000, 3; Mackie 1982, 137). While Paley clearly uses an analogy between organisms and machines to help make his case, he also may be arguing that the design hypothesis is a better explanation of the data than any appeal to random physical forces (Sober 2000, 31–33).

Elliot Sober claims that with or without the analogy Paley's argument "stands on its own" as an abductive argument (2000, 35). And scientists no longer tend to accept analogical or metaphorical arguments as evidential, so it may be more charitable to construe Paley's argument as abductive. Paley does continually contrast the merits of his favored explanation of functional complexity with a version of the alternative hypothesis—absence of art, or "chance" (Paley [1802] 1809, 52–53, and *passim*). He also considers and rejects other alternatives, such as an unknown "principle of order" (blind law—pp. 12–13).

A third possibility is that Paley actually *equates* organisms (or their parts) and machines, at least insofar as they are constructed on mechanical principles (Gillespie 1990, 214). While not ruling out the abductive reading, this interpretation makes the "like effects –> like causes" intuition much stronger than mere analogy, and perhaps not susceptible to the usual attacks on analogical arguments (stressing *dis*analogies). If at least certain aspects of organisms *are* machines, their origin is to be found "in the same intention as that of any other machine: in the will and purpose of the builder" (Gillespie 1990, 214). This suggests that Paley's inference was not simply to the best explanation but to the *only* explanation. Machines, after all, are consciously made. If parts of organisms are machines, then. . . .

Paley does not simply identify organisms and machines. He readily admits that there are nonmechanical aspects of the former and that our "tracing of mechanism" (reverse engineering) continues only "to a certain point, and then we are stopped." This is either because the mechanism becomes too "subtile" to be seen, or we come across something "besides the known laws of mechanism" (Paley [1802] 1809, 22). But he insists that insofar as we *can* trace mechanism and engage in reverse engineering, "the reasoning is as clear and certain in the one case [organic parts] as in the other [machines]" (p. 22). The detailed functional complexity displayed by the eye famously provides his leading case, but he also includes myriad other examples. The conclusion is the same. "There is a mechanism in animals . . . this mechanism is as properly such, as it is in machinery made by art; . . . this mechanism is intelligible and certain; [and] . . . it is not the less so, because it often begins or terminates with something which is not mechanical" (p. 63). Parts of organisms that can be successfully reverse-engineered *are* machines.

Whatever type of organism Paley presented, was it Hume or Darwin who refuted him (if anyone has)? This depends on which of the above arguments we understand as Paleyian design and what refuting it would amount to. Those who support Hume tend to interpret Paley's argument as analogical (Hume certainly understood Cleanthes's argument in this way) and consider his many examples of disanalogies between machines and natural phenomena to be conclusive. Those who favor Darwin tend to interpret Paley's argument as an inference to the best explanation and argue that, not having a legitimate alternative explanation to offer for detailed functional complexity, Hume could not destroy the force of the design inference. Darwin's theory, though, offered just such a viable alternative explanation (Sober 2000, 36ff.; Dawkins 1986, 5). Not many consider the third (identity) alternative, and those who do are not contrasting Hume and Paley (Gillespie 1990; Recker 2004). Still, it is important to consider whether Paley came to take the machine metaphor for an identity statement. As we shall see, many continue to do so.

Has any of these interpretations of Paley's argument been refuted? Sober distinguishes between a sociological and a logical notion of refutation. Two different questions need to be asked: "When (if ever) did educated opinion turn against the design argument?" and "When (if ever) was the argument shown to be fatally flawed?" (Sober 2000, 30) Rationally or scientifically refuting Paleyian design is not the same as convincing people that it is flawed. Let us label rationally or scientifically refuting a claim *Refuting*$_R$ (the flip-side being *Justifying*$_R$), and rendering it psychologically unconvincing *Refuting*$_P$ (the flip-side being *Justifying*$_P$). In terms of Refuting$_R$, both the analogical and abductive versions of Paleyian design have been overwhelmingly refuted. This is accepted by virtually all scientists, historians, and philosophers (and many others) and has been for some time. The third interpretation, *equating* organisms and machines, would be seen as a logical confusion not requiring refutation.

Concerning analogy, although organisms (or their parts) and machines share important similarities, there are important differences. We know that the designers exist—and often what their likely motives and capabilities are—in the machine case, but not in the organism case (Himma 2005, 6–8; Shanks 2004, 165–76). There also are numerous aspects of organisms that are not shared by machines (Shanks 2004, 67–69). The literature abounds with other examples. Concerning inference to the best explanation, there is even more support for the explanatory superiority of Darwinian evolution over any sort of direct design (see Ruse 2003, ch. 15; Shanks 2004, chs. 2, 5–6; Miller 2000; Pennock 2000).

What about Refuting$_P$? Many people do not accept Darwinian evolution and favor design arguments. And although geographical variation points to some sociological or educational factor, this cannot be the entire story. Continued belief in direct design is too widespread and crosses educational and socioeconomic boundaries. Something about direct design is inherently persuasive to a lot of people and resists all sorts of Refuting$_R$ strategies. Whatever this is also plays a large role in the popular success of the ID movement.

Interestingly, recent claims made by ID supporters seem to be based on the equation, rather than mere metaphor or analogy, between organisms and machines (the third interpretation of Paleyian design considered above). "Life is based on *machines*—machines made of molecules!" writes Michael Behe (1996, 4–5). As the title of his work, *Darwin's Black Box*, implies, much of the text is devoted to "opening the black box" that confronted Darwin (and Paley) and tracing mechanism further into the subtle details of the cell. The relation between machines and organism-parts is taken to be much stronger than analogical or metaphorical. "Modern biochemistry has shown that the cell is operated by machines—literally, molecular machines (Behe 1996, 51). William Dembski makes a similar claim: "Intelligent design's positive contribution to science is to reverse engineer objects shown to be designed. Indeed the design theorist is a reverse engineer" (1999, 108). Dembski's and Behe's criteria for detecting intelligent design are based on the same tight interconnection between parts serving an overall function that impressed Paley. All three claim that finding such detailed functional complexity *demonstrates* direct design.

ID proponents also criticize Darwinians who admit that many aspects of organisms *appear* to be consciously designed while denying that this is in fact so. Richard Dawkins calls biological entities displaying the appearance of conscious design "designoids" to distinguish them from human artifacts. "Designoid objects *look* designed, so much so that some people . . . think they *are* designed. . . . They have in fact been shaped by a magnificently non-random process which creates an almost perfect illusion of design" (Dawkins 1996, 6–7). He explicitly acknowledges his indebtedness to Paley: "I suppose people like me might be labeled neo-Paleyists" (Dawkins 1983, 404). Dawkins is not alone among Darwinists who appreciate the strength of the "Organisms (and/or their parts) are machines" metaphor (cf. Alberts 1998, 291). ID proponents are quick to call such statements "admissions" and argue that resisting the inference to direct design in biological cases represents an arbitrary commitment to naturalism (Behe 1996, 192–93).

Similarly, the Discovery Institute's ID film *Unlocking the Mystery of Life* (Meyer and Allen 2004, shown on many PBS stations a few years back) is chock full of references to "molecular machines." Its splashy graphics illustrate microbiological processes looking ever so much like electronic gizmos. It is almost impossible to watch the graphics without identifying the biological processes depicted with machines. But the same sort of graphics are used to illustrate such processes in *non*-ID biological contexts. All biology texts overflow with machine metaphors and analogies as well as illustrations visually reinforcing the organism-machine connection.

This is partly why so many people find design arguments stressing machine metaphors so persuasive. The language of biological science, reinforced by a visual support system, is replete with them. Machine metaphors are among our most pervasive cultural icons, and everyone seems comfortable with their use. Thinking about nucleotides binding by illustrating them as a zipper or explicating cellular transport in terms of a factory system greatly aid in the understanding of these complex phenomena—and often this is all that people remember about them.

I argue in the next section that this is a main reason for machine-driven design arguments to continue to be persuasive, and helps explain some of the difficulty in Refuting$_P$ them (however much effort is expended on

Refuting$_R$ them). After that, I reinforce these claims for the cognitive role of metaphors by assessing recent evidence in developmental psychology for teleology functioning as a default mode in ordinary reasoning.

The Cognitive Role of Metaphors

Michael Ruse and Niall Shanks both discuss the role of metaphor within both design arguments and current biology. Shanks credits the rise of machine metaphors in science (and everyday life) to Renaissance technological developments that transformed everyday experience (Shanks 2004, 25–28). Once machines occupied a large proportion of people's lives, and their power and (sometimes) their inner workings became more familiar, it seemed natural to draw on them to help make sense of new data coming from science. "We find it very natural to conceptualize that which is strange, alien, and puzzling by the use of metaphors and analogies that are drawn from more familiar domains of human experience and activity" (p. 25). If this forged connection between conceptual domains is fruitful (and/or becomes commonplace), it is not difficult for it to become reified into an identity relation. "Somewhere in this process our intellectual ancestors made a transition from seeing nature *as if it* was a machine, with many and complex components, to seeing *it literally as* a machine" (p. 28). Once organisms and/or their parts are seen as machines, the move from analogy toward identity, and the necessity of a divine machine-*maker*, are almost a matter of course (pp. 28–29).

We have now reached Paleyian design. "Undergirding Paley's grand scheme of argument is his intellectual inheritance of the conception of nature-as-machine, composed in part of organisms-as-machines" (p. 39). This same influence of, and reliance on, a reified machine metaphor undergirds ID positions. A nonliteral reliance on the same connection grounds positions like Dawkins's. The crucial difference is whether the machine-metaphor advocate sees the connection as comparative (*as-if* a machine) or as an identity (*is* a machine) (pp. 165–66). As we shall see, this may not be a matter of choice.

Ruse underscores the natural connection between machines and organisms and the fact that the connecting metaphor, whether reified or not, highlights actual detailed functional complexity in biology, in both Paleyian design and Darwinism.

> Organized complexity is artifactual. That was the whole point of natural theology—the argument to design. . . . Whether or not organisms really are designed, thanks to natural selection they . . . seem as if designed. For the natural theologian, the heart is literally designed by God—metaphorically, we compare it to a pump made by humans. For the Darwinian, the heart is made through natural selection, but we continue, metaphorically, to understand it as a pump made by humans. (Ruse 2003, 265)

This "understanding" persists, and it should not be surprising that for those who either don't understand or don't accept the Darwinian reading, literal design still "looks right" and perhaps is the only way to make sense of the obvious detailed functional complexity involved. That is, for many, Darwinians have not Justified$_P$ the causal efficacy of natural selection, whether or not it is considered to be Justified$_R$ by most philosophers and scientists.

What is going on *cognitively* when concepts are linked metaphorically? This has received a great deal of attention from philosophers, linguists, and cognitive scientists.[4] There is widespread agreement that there is some sort of "mapping" between domains of concepts, that this mapping is asymmetrical (with one concept, the source, serving as a template for understanding the other, the target), and that it is the relational structures of the two conceptual domains that are being compared rather than surface similarities between the objects represented by the concepts (Gentner 1983; Gentner and Markman 1997; Kittay 1987). For example, with "Organisms (and/or their parts) are machines," "machines" functions as the source, and the salient features of machines provide a perspective for focusing on similar aspects of the "target"—organisms and/or their parts. The relation is asymmetrical, because the salient features of the source guide our thinking and not vice versa. Relations are compared, rather than surface similarities of the named objects, because what guides our thinking are entire inference structures associated with the source concept domain (its semantic field or implicative complex) (Kittay 1987, 31; Lakoff and Johnson 1980, 61–94).

The implicative complex of the concept domain of machines, for example, includes being composed of parts, being understood in terms of component parts, needing an energy source, parts being replaceable, parts functioning together to serve an overall purpose, and so forth. We also behave toward machines in similar ways: take them apart in order to understand them, fix them with replacement parts, assume all of the same type are basically identical. When this whole implicative complex is used as a template for organizing our thinking and behavior toward organisms and their parts, we anticipate similar subconcepts playing analogous roles in the target domain. For example, successful reduction is expected, analysis of energy input and output becomes biologically important, we manufacture artificial organs as replacement parts, we look for general laws for dog behavior, we understand monkey parts in terms of their functioning together to serve monkey interests, and so on. Attention and expectation are focused on just those aspects of organisms that share subconcepts and roles with machines, while other aspects are suppressed. Again, it is not the overall surface similarities between source and target that provide metaphorical mappings (aardvarks don't *look* very much like computers or washing machines) but rather the salient aspects of the source taken as a structured whole (the relations among the various subconcepts).

What is the cognitive basis for such abilities? Recent attempts to answer this question agree that, in one sense or another, the key lies in taking an embodied approach to cognition. That is, metaphorical mappings are somehow rooted in basic perceptual, emotional, and kinesthetic experiences (and/or in the underlying neurophysiological apparatus). Thirty years ago, George Lakoff and Mark Johnson argued that many sorts of metaphors are based on prelinguistic bodily experiences. "Orientational metaphors," for example ("Happy is Up/Sad is Down," "Consciousness is Up/Unconscious is Down"), have their foundation in common experiences such as slouching when we're sad or not feeling well, rising up when we're excited or when we awake, and so on (Lakoff and Johnson 1980, 14–16). These basic metaphorical connections between bodily spatial orientations and moods and mental states provide a common implicative structure involving numerous subconcepts and their roles ("I'm feeling *down* today," "Let's see if we can *elevate* your mood," "Wake *up*!" "She *slipped* into a coma"). Universal bodily experiences (as the source domain) give rise via cross-domain connections to other concepts such as emotions and consciousness (as the target domain), thereby helping make sense of the more abstract target in terms of the more familiar source.

Nearly twenty years later, the same authors elaborated on the bodily basis of metaphor and provided additional experiential and theoretical evidence. "The same neural and cognitive mechanisms that allow us to perceive and move around also create our conceptual systems and modes of reasoning" (Lakoff and Johnson 1999, 4). Included in the new evidence were neural models that develop architectures for visual perception that also could be used to model "higher" cognitive skills (pp. 39–42, 570–83). Srini Narayanan (1999) developed a computer model that utilized metaphoric mapping from "concrete and embodied domains" (such as vision) onto "abstract domains" (narratives about politics). This model was expanded into a "neural theory of language," in which abstract neural models were joined with actual physical evidence from neurophysiology to support the view that the same neuronal structures support sensorimotor and cognitive activities (Feldman and Narayanan 2004). There is now a fair amount of neurophysiological work indicating that visual pattern recognition, motor activity, and higher cognitive faculties jointly use parts of the same neuronal architecture or are directly connected neurophysiologically (Ramachandran and Hubbard 2001; Rizzolatti and Craighero 2004; Pulvermüller et al. 2005).

In 2005, Lakoff could use this sort of data to support the bodily underpinnings of metaphor (and language, generally). "The sensory-motor system not only provides structure to conceptual content, but also characterizes the semantic content of concepts in terms of the way we function with our bodies in the world" (Gallese and Lakoff 2005, 456). Although there is disagreement concerning how far this can be taken, and whether it undermines more traditional computational approaches to language and cognition, there is a growing consensus among many researchers that it needs to be taken seriously.

So what? Once analogical and metaphorical connections are taken to be bodily based, pervasive, and central to our cognitive structure (rather than as mere tropes), we can begin to appreciate the role they play in establishing and supporting belief. This loops back to our concerns with Justifying_{P}.

As with visual perception, it is usually the *result* of the mapping that we are aware of rather than the process responsible for it. Usually we don't even realize a metaphor is being used. "I'm *down* today" is neither consciously meant to be, nor usually taken to be, metaphorical. We do not generally plan what words will spill from our mouths unless the context cues rehearsal and/or warns us to be particularly careful. Phenomenologically, both pattern recognition and speaking seem effortless and immediate, despite the fantastically complex subsurface activities employed.

As Howard Margolis has pointed out, both cognition and visual pattern recognition have the same basic form, and we react to respective miscueings in similar ways (Margolis 1987, 9–19). Knowing that the Müller-Lyer illusion (see Figure 1) is an illusion—the two lines are the same length—does not enable us to see it differently, any more than knowing that organisms are not machines prevents us from inferring properties of the former from the latter. Although we can sometimes correct or qualify such cases, this is not easy, and simply being aware of the problem is not enough. In both perceptual and conceptual cases, the appropriate cues unconsciously generate a particular range of responses. And, in both sorts of cases, the underlying cognitive activities are generally reliable (though somehow miscued on occasion).

In the 1970s, P. C. Wason and J. St. B. T. Evans interpreted systematic mistakes involving conditional reasoning as indicating that there were dual processes of reasoning in human cognition, one more intuitive (with only the results being perceived) and the other more sequential and conscious (which looked more like reasoning as usually understood). Reasons provided by subjects after making a (faulty) decision were typically ad hoc rationalizations rather than reliable descriptions of the reasoning process

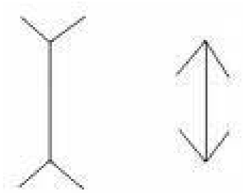

Fig. 1. The Müller-Lyer illusion.

involved (Wason and Evans 1975, 147–52; Haidt 2001). Dual processes of reasoning of this sort have been confirmed by numerous researchers from a variety of fields (Sloman 1996; Evans 2003; Haidt 2001).

The distinction between these two reasoning processes corresponds to Justifying_P/Justifying_R. The former is generally "good enough," is very contextual, and allows us to make sense of a situation intuitively and perform an appropriate judgment or behavior. It does this by using the similarity-based associative mappings from object to object and domain to domain found in metaphorical reasoning. The latter is much more precise and less content-sensitive, and it spurs us to apply appropriate quantitative or technical methods to enhance the accuracy of a judgment or behavior. Traditionally, "reason" has been restricted to the second type, but lately more and more emphasis has been placed on the former (popularized in Gladwell 2005). Associative or intuitive reasoning also seems to be the default mode (Haidt 2001, 819–20; Bargh and Williams 2006). It *can* be superseded by training or the cueing of the need for more rigorous procedures, but if these are unavailable, or if the intensity of affective bias is strong, it often will not be.

This goes some way toward explaining the persistence of Paleyian design long after it has been both logically and scientifically defeated. Metaphorical and other intuitive, associative reasoning is not bad reasoning. It is how we usually think, and it is generally reliable. The same is true of visual pattern recognition. We usually perceive things correctly enough to get about successfully in our world. In the Müller-Lyer illusion this reliable process is miscued. There is nothing wrong with our vision when we misjudge the length of the arrows. Here, rule-based reason (careful measurement) helps us judge correctly in spite of the persistent miscuing.

Similarly, intuitive reasoning has a pattern recognition–like component, which also delivers results that usually are reliable. Such results can conflict with the more explicit, better argued and/or measured results of rule-based reasoning. For the latter to trump the former, however, either it must not conflict too drastically with strong intuitions resulting from the former, or training and new strong intuitions must be developed on the rule-based side. For those who have a strong experiential or emotional commitment to the domain structure supporting Paleyian design and/or have not been trained sufficiently concerning the evidential support for Darwinian evolution, this will not be the case.

Like those who have no reason to measure the arrows in the Müller-Lyer illusion, the default mode of reasoning will hold. The results of their reasoning will not appear weak or strange to them, and they will not experience the cognitive dissonance necessary to move to a more rule-based approach. Their judgments seem to fit their experience and also make sense of it, as all successful metaphors and analogies do.

The (very) successful "Organisms (and/or their parts) are machines" metaphor can easily be taken to be an *identity* and offers an explanation for detailed functional complexity in biology that really does make sense of the data, in lieu of more careful rule-based reasoning to the contrary.

Natural Theists?

Jean Piaget revealed a strong tendency among children to provide animistic and "artificialistic" explanations for natural events (Piaget [1929] 1960; 1930). The first attributes life properties and goals to inanimate objects and processes, while the latter attributes their origins (and often their behaviors) to being made or caused by agents ([1929] 1960, 253–55; 1930, 70–74). The following exchange took place with a six-year-old subject.

"Why does the sun move along?"

"*To keep us warm.*"

"Is the sun alive?"

"*Yes, because it moves along.*"

"And the moon, how does it move along?"

"*It's God that does it*" (1930, 75).

Many more such examples are analyzed, responses varying by age (five stages distinguished by Piaget [1930, 61–62 and ff.], with these basic tendencies continuing until around age ten.

Piaget argues that such responses are innate and not based on, say, religious training ([1929] 1960, 353–54). "It does not seem possible to explain the generality and tenacity of child artificialism solely by the pressure of education" (pp. 354–55). Subsequent work, though, disagrees with his attribution of a special precausal cognition to young children, which they later outgrow and replace with rule-based reasoning.

Preschoolers have been found to distinguish artifacts from natural kinds (against Piaget's strong artificialism) and to realize that only animals are capable of self-motion (against his strong animism), and even infants can reason causally (against his precausal "stages") (Gelman and Kremer 1991; Boyer 2001b; Kelemen 2004). Lest baby and bathwater are both lost, however, there is growing evidence that there *is* a strong early tendency toward teleological and intentional thinking (purpose- and/or agency-centered) in very young children (Csibra and Gergely 1998; Kelemen 1999b; Johnson 2003). This also appears to be an "intuitive cognitive bias" rather than something taught by parents.

One view, "Promiscuous Teleology," holds that a propensity to reason teleologically is not, as Piaget thought, restricted to an immature style of reasoning but rather denotes "a fundamental human propensity—one that remains as a default strategy throughout development" (Kelemen 1999a, 466). This reconnects us with the themes of the previous section.

As with the "Organisms (and/or their parts) are machines" metaphor, one of the main reasons for teleology-based thinking is the ubiquity of artifacts and machines in modern human culture. By nine to eighteen months of age, children understand both that agents act according to goals and that they use objects to achieve these goals. By thirteen to eighteen months of age, they display "a good working knowledge of the ways that familiar and unfamiliar artifacts can be used to fulfill goals" (Kelemen 1999a, 466). This experiential reinforcement helps to establish machine *explanations* as a default mode.

> Experiences that suggest objects exist in the world to fulfill the purposes of agents, might subsequently contribute to the tendency to over-generate purpose-based teleological explanations when faced with explanatory gaps. . . . In the absence of other explanations, children might draw on their privileged knowledge of intentions and artifacts to conclude that, like artifacts, natural objects exist in the world because some agent put them there for a purpose. (Kelemen 1999a, 466)

On this view, agency detecting is basic, and Piaget's artificialism is a natural construct from this base in an environment where machine use is prevalent. This provides a developmental cognitive foundation for Shanks's earlier claim that machine metaphors became more common and convincing as machines played a larger role in people's lives, providing a rich source domain for metaphorical mapping.

Anthropomorphism, too, makes good cognitive sense and is also tied to agency-based reasoning. Populating the animate and inanimate world with conscious beings and seeing all sorts of causal relations as agency based are cognitively grounded in the sorts of teleologically and agent-oriented cognitive tendencies we have been discussing—and remember, these tendencies do not end in childhood. From seeing faces in the clouds and cursing at our cars and computers to mistaking tree stumps along a dark path for strangers, we are prone to detect and respond to (possible) animate and (especially) human signals, and we tend to do this whenever the incoming information is ambiguous (Guthrie 1980, 186–88; 1993, 40–45; Boyer 2001a, 142–44). Most adults may not believe that they are "communicating" with their car when they plead with it or curse at it (or actually beat it after "warning" it, as actor John Cleese did in an episode of the British comedy *Fawlty Towers*), but the fact that such behavior is universal indicates some very basic cognitive machinery behind it.

When this tendency is added to an environment chock full of machines, the agent-artifact connection readily maps as source domain onto (less well understood) aspects of organic and inorganic nature. Put simply, "Organisms (and/or their parts) are machines" enjoys a great deal of cognitive support. Moving from machinelike natural properties to humanlike creators as their source is reasonably taken as the *natural* way to understand detailed functional complexity in organisms, and it has considerable Justification$_P$ behind it. Granted, most of this is unconscious and associative, but that's how most of the processes we have discussed work. The results "make sense" and "look right" via such intuitive processes. So, it is not difficult to understand why Justifying$_R$ fails to automatically trump Justifying$_P$. Taking Paleyian design seriously is not a silly mistake, any more than judging Müller-Lyer arrows to be unequal in length is a silly mistake. But both *are* mistakes from a Justifying$_R$ perspective. What, if anything, can be done about this?

Conclusion

The major interpretations of Paleyian design have been Refuted$_R$ to the satisfaction of nearly everyone adequately informed about scientific practice in general and Darwinian evolution in particular. We have reviewed reasons for appreciating the cognitive status of analogical and metaphorical thinking in order to illustrate why Paleyian design could be so resistant to Refuting$_R$. It seems to be solidly ensconced within deep intuitive connections between machines as a source domain and anything depicting detailed functional complexity. As long as machine-metaphorical explanations "make sense" and fit experience adequately, there is no reason to look more closely. We also reviewed evidence from developmental psychology indicating that agency- and teleology-based reasoning, central to completing the machine-organism mapping, may well be cognitively basic, further entrenching Paleyian design.

It is therefore not simply a matter of convincing others by the light of reason that they should be "putting away childish things" (Dawkins 1995). Teleological explanations make sense, which is why they are appealed to metaphorically by Darwinian biologists as well. There are also religious prejudices and sociopolitical aspirations involved in the resilience of teleological thinking, but they are not the only (or most basic) explanation for its prevalence.

Because of the strong, intuitive bias in favor of various aspects of this entrenched position, simple exposure (such as brief treatment in a class) to proper procedures of Justifying$_R$ or to the correct explanation for biological functional complexity is not likely to suffice. Even among college students introduced to evolutionary concepts (and who accept that Darwinian evolution is the best explanation for detailed functional complexity), there is a strong tendency to understand evolution as Lamarckian rather than Darwinian (Almquist and Cronin 1988; Greene 1990). Again, this can be attributed to a teleological default mode of reasoning, used when cued "if no other model is available" (Greene 1990, 876). In this case another model *was* available, but it was systematically misunderstood in the default direction.

Relatedly, while most theology has become quite abstract and apparently nonanthropomorphic (attributing very nonhuman qualities to the relevant deity or deities), there seems to be a much more "folksy" and anthropomorphic default position when people think about interacting with the deity/ies, or interpret religious stories. For example, although God is omniscient and omnipresent, the need is still strongly felt to express personal prayer, as if it would otherwise not be heard (Barrett and Keil 1996). Although careful and well-articulated religious narratives would criticize overly anthropomorphized positions, simply pointing out the theological inconsistencies and repeating the orthodox position is also insufficient to overcome deeply entrenched intuitive anthropomorphism.

We should not take intuitive thinking lightly, or attack the reasoning abilities of those using it. Although it can be shown that the Müller-Lyer arrows are equal in length, it is not stupid to think otherwise before this demonstration is performed. There is no reason for it to look wrong before then. Likewise, it can be shown that what we know in all branches of biology is overwhelmingly supportive of Darwinian evolution, but it is not stupid to think otherwise before this demonstration is provided—and this takes time and effort, not fifteen minutes in a debate or a few examples in a biology class.

It has been thoroughly demonstrated in books, articles and (some, not enough) classrooms that Darwinian evolution is good science and by far the best explanation for diverse biological data. But it has not been demonstrated for most individuals in the United States, who did not read the books or articles and received at best a smattering of evolutionary theory in their required classes.[5] It is within individual minds trying to make sense of individual experiences that dissonance is felt and new alternatives are considered. If there is no motivation to look more closely at something that seems to be adequate, there will be no reason to abandon the default mode of reasoning. Even a great deal of familiarity with Darwinian explanations will not automatically lead to Justifying_R trumping Justifying_P. The overriding beliefs of one's community can make entrenchment very deep.

Educators (and scientists and philosophers of science) need to pay more attention to the sorts of results from cognitive science discussed above. There also needs to be a more continuous and in-depth exposure to methodological and philosophical aspects of science than is currently in place. For nonscientists, this may be more important than learning scientific results. It is certainly *as* important. Exposure to Darwinian evolution needs to be more continuous and in-depth. It is understanding that the basic patterns of data found in biogeography, comparative anatomy, development, molecular biology, and genetics *all* map nicely onto the basic Darwinian models, that these models have been incredibly fruitful in generating detailed research programs throughout the life sciences, and so on, that ultimately plays the role here of using a ruler to determine the lengths of the arrows in the Müller-Lyer illusion. Less than that, and comparing the parts of organisms with mousetraps does not seem to be metaphorical, and, because mousetraps have conscious designers, intuitive inference leads to postulating the same cause for detailed functional complexity—unless people can be taught that they need to "Look again." That's at least an important part of the answer, as well as the challenge.

NOTES

1. Central to all mechanist views was the passivity of matter and the requirement that all forces be external. Mechanists also tended to stress the comparison between machines and the inner workings of nature (Boyle [1686] 1996, 11; Descartes [1629–33] 1985, 99–100). They differed over the role of teleological explanations (Descartes [1641] 1984, 258; Boyle [1688] 1965, 395–402).
2. Examples include Sober 2000, 30–36; Mackie 1982, 137–39.
3. I work in an area where "equal time" legislation is proposed *every year.*
4. For good, brief overviews of most of the options and debates over the past twenty-plus years see Tourangeau and Sternberg 1982; Fludernik, Freeman, and Freeman 1999; Bowdle and Gentner 2005.
5. As indicated in the previous section, some of the impulse toward artifactual and teleological explanations seems to be innate. This does not, however, diminish the clear role of cultural reinforcement in both strengthening and putting a particular face on these impulses. The religiosity of the surrounding culture further entrenches the propensity toward mapping machines onto organisms and their parts, and preferring agent-based explanations for detailed functional complexity. This further highlights the need for continuous and in-depth exposure to Darwinian evolution throughout science education. One needs to *feel* conflict before he or she will be cued to look again at what appear to be obvious truths.

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