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Dennett's Canon and Major Cognitive Transitions

Hayley Clatterbuck

RESUMEN

A lo largo de *From Bacteria to Bach and Back*, Dennett argumenta que deberíamos abstenernos de atribuir comprensión cuando la mera competencia bastaría para explicar la conducta, y concluye que la comprensión genuina es un rasgo únicamente humano. Al igual que todos los principios de psicología comparativa, el Canon de Dennett depende para su justificación de fuertes supuestos sobre los tipos de mentes que existen y los principios evolutivos que los gobiernan. Examino alguna de las metáforas biológicas que usa Dennett para hacer esos supuestos más explícitos y arrojar luz sobre el paso desde mentes que meramente actúan de acuerdo con razones a aquellas que genuinamente las representan.

PALABRAS CLAVE: *Canon de Lloyd Morgan, psicología comparativa, evolución cognitiva, principales transiciones evolutivas*.

ABSTRACT

Throughout *From Bacteria to Bach and Back*, Dennett argues that we ought to refrain from attributing comprehension when mere competence would suffice to explain behavior and concludes that genuine comprehension is a uniquely human trait. Like all principles in comparative psychology, Dennett's Canon depends for its justification on strong assumptions about the types of minds that exist and the evolutionary principles that govern them. I examine some of the biological metaphors that Dennett uses in order to make these assumptions more explicit and to shed light on the transition from minds that merely act in accordance with reasons to those that genuinely represent them.

KEY WORDS: *Lloyd Morgan's Canon; Comparative Psychology; Cognitive Evolution; Major Evolutionary Transitions*.

Evolutionarily-informed comparative psychology faces several central challenges. First, the mental lives of others are not directly observable,[1] and they often resist indirect observation as well. As Dennett has pointed out for decades, there are few (if any) token behaviors that could only be accomplished through sophisticated, higher-order cognitive processes. Even the simplest processes can produce sophisticated looking behaviors, given the right context, experience, and innate structure.

When there are multiple available mechanisms that could have produced some behavior, should we posit the least sophisticated? The most human-like? Or what? To answer (or elide) such questions, comparative psychologists have turned to methodological principles that tell in favor of certain available psychological explanations.

The natural place to look for such principles is a causal theory of how the minds of humans and animals came to be, and since Darwin, evolutionary theory has been a central pillar of comparative psychology (along with theories of learning, the other main causal determinant of our minds). If minds are biological traits like any other, then the same principles of variation, selection, and common ancestry ought to govern their evolution and hence structure our inferences about them. Unfortunately, Darwin's theory does not give us a univocal answer about what to expect the minds of other animals to be like. On the one hand, phylogenetic parsimony would seem to support the attribution of human-like traits to close primate relatives.[2] On the other, isn't it simpler to explain the wide swath of phenotypic differences between humans and other primates (with respect to language, social cognition, tool use, causal reasoning, etc.) by positing one really momentous change in the human lineage than by positing separate changes to explain each difference?

A good theory in comparative psychology should provide a dual specification of the structure of the mental traits under examination and the evolutionary processes that lead to the current distribution and nature of those traits. These two components can interact in interesting ways, and indeed, they are often wholly intertwined. A theory of mental trait evolution will spit out different answers depending on what we think those traits are like, and what we think those traits are like will depend on our evolutionary story.

In *From Bacteria to Bach and Back*, Dennett provides a comprehensive mental ontology – a specification of the different kinds of minds that exist and the nature of traits such as consciousness and language – and a complementary evolutionary story to explain how minds came to be. In the process, he both relies upon and defends a methodological principle for attributing mental states to ourselves and other organisms: "the rule of attribution must be then, if the competence observed can be explained without appeal to comprehension, don't indulge in extravagant anthropomorphism" [Dennett (2017), p. 90]. This prescription, not unlike the one embodied in Lloyd Morgan's Canon, favors explanations in terms of "lower" psychological processes when plausible, saving explana-

tions of behavior in terms of top-down conceptual comprehension for a restricted set of uniquely human behaviors.

Like Dennett, I believe that one of the most important data points that a theory in this area must explain is how (or, at least, how it is possible that) humans beings came to possess cognitive capacities that so far surpass those of other animals in a shockingly short amount of evolutionary time.[3] Applying Dennett's oft-used thinking tool, it certainly seems that if a Martian scientist were to come to Earth, high up on their list of things to explain would be the fact that while humans and chimpanzees look virtually identical, one of them talks, builds cities, and shoots the other into space (and never vice versa).

In light of this striking fact, comparative psychological theories have to thread a very small needle. The mechanisms of human thought have to be different enough from those of non-human animals to explain the plethora of uniquely human behaviors, but not so different that there could not be an evolutionary bridge between them traversable in six million years. Likewise, the evolutionary component of the story can't make the evolution of human-like minds too easy, or it would become baffling why no other creature had made such a leap [*ibid.*, pp. 251, 258]. So human minds must be different but not too different, and their evolution had to be hard, but not too hard. In order to evaluate Dennett's own creative solution to threading this needle, a brief foray into two other famous solutions to this perplexing cluster of questions will help to set the stage and to motivate Dennett's alternative approach.

In *Descent of Man* and *Expression of Emotions in Man and Animals*, Darwin lays out his preferred methodological principle for attributing mental states to animals, which we might call Darwin's Canon [Radick (2007), p. 66]:

> I can see only one way of testing our conclusions. This is to observe whether the same principle by which one expression can, as it appears, be explained, is applicable in other allied cases; and especially, whether the same general principles can be applied with satisfactory results, both to man and the lower animals [Darwin (2009), p. 25]

Using this principle, Darwin argues that "there is no fundamental difference between man and the higher animals in their mental faculties" and though the chasm between the apes and even the lowest fishes seems even wider, "this interval is filled up by numberless gradations" [Darwin (2004), p. 86]. According to Darwin's mental ontology, all minds are

constituted by a small number of mechanisms and processes – namely, the ones found in Hume's associationism – that can operate at different rates [Clatterbuck (2016)]. To create a man from an ape or a Newton from a child, all one needs to do (and indeed, all one can do) is heighten the powers of memory, ease of association, attention, and so on. Hence, reasoning and intelligence are quantitative traits subject to gradual, directional selection, and there is no room in either his evolutionary or psychological theory for any real leaps.

Darwin's dual theory of psychology and evolution is implausible on both counts. First, Humean associationism arguably cannot explain many facets of human or even animal cognition. Second, his account doesn't respect the crucial data point of human uniqueness, and indeed, Darwin's comparative psychological work is remarkable for its stunning anthropocentrism and over-attributions of sophisticated mentality to animals. Third, it is not obvious how turning the knobs on a set of existing traits could yield human behaviors that seem to be genuine discontinuities with what we find in even closely related species. And if that really is all it takes, why hasn't evolution so amplified these traits in other species as well?

Lloyd Morgan formulated his famous Canon as a corrective to the rampant anthropomorphism that resulted from Darwin's Canon. It states:

> In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale [Lloyd Morgan (1920), p. 53].

The Canon is offered against the backdrop of a philosophy of mind that posits a hierarchy of three distinct levels of mental faculties, in which the higher faculties depend on and entail the presence of lower ones (both phylogenetically and ontogenetically).The lowest faculty is blind instinct (corresponding to Dennett's Darwinian creatures), the second is intelligence (Dennett's Skinnerian creatures), and the highest is reason (Dennett's Popperian and Gregorian creatures, which Lloyd Morgan conflates). Unlike merely intelligent creatures, reasoners can represent the relations that intelligent creatures merely obey – in Dennettian terms, they actually *possess* the free-floating rationales that guide behavior [Dennett (2017), p. 51] – and this capacity opens up new possibilities for language, scientific inference, and creative problem-solving.

Putting aside the question of whether Morgan has provided a plausible account of human and non-human psychology,[4] his hierarchical account does respect the real differences between kinds of minds found in the living world, between automata like bacteria and impressive learners like birds, and between intelligent non-human animals and theorizing, talking, reasoning humans. Further, because lower mental faculties provide the inputs on which higher levels operate and must already be in place before the latter can evolve, Morgan finds an evolutionary justification for his Canon [Lloyd Morgan (1896), Sober (1998)].

However, I have some concerns about Lloyd Morgan's evolutionary account of the transitions between levels. Suppose the theory is that a single genetic change turned intelligent creatures into reasoning ones. This genetic change has to do a heck of a lot of work to account for such a huge leap in cognitive abilities. As Dennett notes with respect to Chomsky's hypothesized Merge mutation, "the idea that a random mutation can transform a species in one fell swoop is not a remotely credible just so story" [Dennett (2017), p. 280]. A rare mutational event may better satisfy the "hard but not impossible to evolve" desideratum than does Darwin's directional selection hypothesis. However, we know from many cases of rapid evolution that improbable mutational events can actually occur quite frequently when population sizes and selection pressures are ripe. In the last 15,000 years, blue eyes arose only once in humans [Eiberg, *et al.*, (2008)] while lactose tolerance arose many times [Tishkoff et al. (2007)]. Which one is the purported Merge mutation more like?

If, on the other hand, the transition between levels is not explicable by a single mutational miracle, if it is much more gradual and/or requires changes in many different traits (like the transition between, say, not flying and flying), then it no longer seems like there is such a sharp discontinuity between kinds of minds, and we're also back to the same problem of trying to account how so many changes could have all happened in six million years.

These historical attempts at providing comprehensive theories of the evolution of the human mind illustrate two chief explanatory hurdles for any such account. First is the "big jump" problem of explaining how a single evolutionary event could yield dramatic trait changes. Second is the "why not everybody?" problem of explaining why that event hasn't occurred in other lineages. To these, we can add two more. Third is the "chicken and egg" problem. If a new trait is only adaptive if a second trait is already in place, and that other trait is only adaptive if the first is

present, then it is difficult to explain how the pair could have gotten off the ground.[5] Fourth, and less obvious, is the "source of novelty" problem; how does variation arise at a level of organization (cognitive or biological) to produce novelties that can be acted upon by selection, perhaps at a higher level?

Dennett relies on a different kind of evolutionary process, the kind underlying major evolutionary transitions, that biologists have utilized to great effect to answer the above four questions in other domains. Significant discontinuities in evolution can often be explained by positing *separate* evolutionary histories that came together, from which genuinely novel traits can emerge. Sometimes these unions are abrupt, bringing together individuals who have separately evolved complex traits, as in the event that created the first eukaryote. In other cases, such as in the origin of multicellular creatures, there is a more extended process in which individuals at one level of organization begin to reap the benefits of cooperation and selection starts to act on these collections of individuals. This may lead to processes of de-Darwinization that reduce competition at the lower level, ultimately yielding genuinely new Darwinian individuals at higher levels of organization [Godfrey-Smith (2008)]. There are also intermediate scenarios in which two species co-evolve, perhaps with a level of integration that falls short of creating a new individual, such as in the case of humans and their gut microbiota.

Such processes can explain big jumps in phenotypes, as the union of separate individuals can have non-additive effects. When these unions are fortuitous events, like in the case of eukaryotes' origin, or when precise conditions are required for cooperation to be stable and beneficial, it is clear why such transitions are rare, once-in-many-lifetimes events that can't be expected to occur in any lineage in which they would be beneficial. This latter fact motivated G.C. Williams to posit a methodological principle akin to Lloyd Morgan's and Dennett's Canons for higher-level selection more generally:

> The ground rule- or perhaps doctrine would be a better term- is that adaptation is a special and onerous concept that should be used only where it is really necessary. When it must be recognized, it should be attributed to no higher a level of organization that is demanded by the evidence. In explaining adaptation, one should assume the adequacy of the simplest form of natural selection, that of alternative alleles in Mendelian populations, unless the evidence clearly shows that this theory does not suffice [Williams (1966), pp. 4-5].

These transition events can also solve the chicken and the egg problem. Even if it's the case that each of two traits would not be adaptive without one another for a particular individual, they might have been adaptive separately in different individuals with different backgrounds and environments (call it the "two great tastes that taste great together" hypothesis). Lastly, when there exist evolutionary processes at multiple levels of organization, selection processes at the lower level can be a source of variation at the higher level. De-darwinizing traits that reduce competition at lower levels can have various levels of effectiveness, with the fittest aggregates striking the right balance of permitting sufficient rates of "mutation" and preventing destruction from within.

Throughout *From Bacteria to Bach*, Dennett mines these evolutionary concepts for a great many evocative ideas. For example, populations of individual neurons cooperate to govern organisms at a higher level of organization (like us), and there are safeguards in place to ensure that they are subordinate to our needs (neurons don't get to reproduce, their genetic fate is our genetic fate). However, this process of de-Darwinization is not complete, and when neurons compete to make connections and hence survive, the result is the flexible learning of Skinnerian minds. Likewise, in Dennett's telling, one of the functions of consciousness is to serve as a bottleneck for the many memes that are competing to be thought, exerting control on which ones get expressed in our behavior or linguistic expression and hence aligning them with our evolutionary (and other) interests.

While the tools of evolutionary transitions and multilevel selection theory are often gestured to throughout Dennett's account of major cognitive transitions, the details are sometimes left unspecified, even with respect to which general kind of process is supposed to be involved. In particular, it would be interesting to hear how Dennett thinks that the transition from Skinnerian creatures (who can learn by trial and error) and Popperian creatures (who have internal models that they can use to test hypotheses, a trial and error in the mind) occurred. This seems like a significant advancement; indeed, it is precisely the step that Lloyd Morgan thought required a wholly different kind of mind. While the Bayesian predictive coding mechanisms that Dennett attributes to Popperian creatures have received considerable attention, there is no suggestion here (that I could find) of how they might have evolved from their Skinnerian predecessors.

In contrast, in Dennett's discussion of the cognitive transition from Darwinian to Skinnerian minds, it is somewhat clearer what the entities at different levels of organization are, what individuals are competing

for, and how pressures at the higher level select for different lower-level organizations. Neurons compete to persist, and they persist by forming lasting connections with other neurons. Those connections that are positively reinforced are maintained. Hence, neurons compete to produce behaviors that are reinforced. Organisms with the right kinds of reinforcement patterns, the ones that maintain useful associations among stimuli and adaptive responses, are more fit; "those variants born with the unfortunate disposition to mislabel positive and negative stimuli, fleeing the good stuff and going for the bad stuff, soon eliminate themselves" [Dennett (2017), p. 98].

Popperian creatures don't have to wait for the external environment to judge the predictions made via their learned associations. They have internalized models of situations that they can run off-line; "eventually they must act in the real world, but their first choice is not random, having won the generate-and-test competition trials runs in the internal environment model" (*ibid.*). A model generates expectations about what the organism will experience, and the various possible outcomes of the model compete for *confirmation* or *error minimization*. Seemingly, then, sensory experience provides the selective environment for these model outputs, and creatures with models that generate low-error outcomes are more fit. Crucially, for Dennett, users of such models need not comprehend them. If this is correct, then it is unclear how it is possible for such models to "pretext *hypothetical* behaviors offline, letting 'their hypotheses die in their stead'" (*ibid.*). If the organism is not checking the prediction against the world by actually behaving, and there is no homunculus that judges the outputs of the model for their utility or coherence with other beliefs, then what is selecting among the outputs of the model?

The transition that Dennett focuses on most intensely, and the one that I also find the most interesting given the project of explaining human uniqueness, is the one between Popperian minds and Gregorian minds, the latter of which have a suite of different models and can think *about* these models, i.e. which are appropriate to use, which are in conflict, and so on. According to Dennett (and I think he is probably correct), only humans are full-fledged Gregorian creatures. Exactly how this transition is supposed to have taken place is somewhat obscured by Dennett's use of many different models of the evolutionary process at work. In a characteristic passage, Dennett remarks:

> Words are the *lifeblood* of cultural evolution. (Or should we say that language is the *backbone* of cultural evolution or that words are the *DNA* of cultural

> evolution? These biological metaphors, and others, are hard to resist, and as long as we recognize that they must be carefully stripped of spurious implications, they have valuable roles to play) [*ibid.*, p. 179].

The DNA metaphor suggests, perhaps, that human culture already comprised a type of superorganism, where words serve as its method of reproduction. Or words may serve as a type of central nervous system, coordinating the far-flung activities of the organism of a human society. [Elsewhere we find the metaphor of domestication, according to which words are a separate species that gradually develop features that are appealing to humans (perhaps without us being aware this fact), eventually becoming highly dependent on humans for reproduction [*ibid.*, p. 197]. The virus metaphor is the one most commonly used by Dennett. Viruses co-opt existing reproductive machinery in another species to reproduce themselves. Often these viruses are harmful or neutral to their hosts, but occasionally they are beneficial and can indeed be integrated into the genetic code of the host and used to produce valuable new proteins. Likewise, on this model, words co-opt our ability to generate Popperian models of the environment, sometimes yielding benefits and becoming incorporated into our brains.

My complaint here is not with the use of different models to shed light on the phenomena, nor is it required that the evolution of Gregorian minds fit precisely into one of these categories. However, these models make different claims about what must have already been present in order for the evolution and subsequent de-Darwinization of words to take off, and by mixing models, we risk taking for granted that the initial conditions of the models obtained. This question regarding the preconditions of meme evolution becomes important when we consider the desiderata of an evolutionary account of human uniqueness that we started with. First, as he is well aware, Dennett's account ought to answer the "why not everybody" question. Why didn't words take root in other minds (or, if they did, why didn't they yield the enormous dividends that they did with us?), and why do bonobos and dogs whose environments are saturated with human language still not seem to exploit the information in words the way humans do?[6]

Second, words themselves are supposed to be responsible for the great leap in human cognition; however, if uniquely human cognitive mechanisms must have already been in place for words to yield any benefits, then Dennett's account will not evade the "chicken and egg" problem either [*ibid.*, Ch. 12]. If the evolution of language requires antecedent com-

prehension of relations, in particular, then the evolutionary undergiding of Dennett's Canon becomes questionable. If comprehension exists in Popperian creatures, then we ought to attribute it to nonhuman animals. If it doesn't, then it's not clear that the major transition to Gregorian minds can account for it.

My best attempt at briefly summarizing the evolutionary transition that is supposed to explain the origin of distinctly human Gregorian cognitive faculties is as follows. According to Dennett, this transition involved the coincidence and resultant de-Darwinization of two somewhat independent evolutionary processes, one operating on ancestral Popperian minds and the other on words (and other memes). The origin of words was a distinctive event, which Dennett compares to the origin of life itself. Once on the scene, words competed for access to our brains and for the opportunity to be reproduced by humans, both in thought and in overt language. The fittest words are those that resonate with our brains in one way or another. Sometimes these are nonsense syllables with no clear benefit to us. Sometimes, however, words yield a benefit for their users (either humans or communities of humans) by picking out new affordances, regularities in nature that can be exploited in behavior, in which case such words "earn their keep". Finally, the beneficial cooperation of words and minds led to a process of de-Darwinization, in which a new Gregorian individual arose that controlled the memes that guide its behavior, selected among the best memes at its disposal, and so on. Nevertheless, some independent evolution of memes persists, providing a continual source of cognitive and cultural variation.

How do words create new affordances, and how are these affordances beneficial for their users? Dennett suggests that words are sometimes correlated with states of affairs for which a creature might not have an existing affordance. When there is a repeated association (e.g. I keep hearing the word "hammer"), a creature may start to pick up on the features of the environment that co-occur with the experience of the word ("hammer" situations are ones where a thing shaped like *that* is present and used to join things). The word can serve as an anchor for perceptual features and make previously unnoticed perceptual relations more salient. Hence, a necessary condition for the creation of a new affordance is that there is a robust regularity between the word and a set of perceptual features and that this is a regularity that the organism is capable of picking up on. This account of early word learning is akin to the traditional empiricist account of words, according to which words are just

another feature of the environment that can figure in associations, albeit one with a digitality that makes them very effective associative anchors.

These affordances offer a variety of benefits for their users. They make them aware of new opportunities for action or prediction (I can use this "hammer" to join these pieces of wood). They allow for displaced reference. Importantly, the shared use of a word allows individuals to tap into knowledge stored in other word users' brains (if I say "hammer" to the carpenter, she'll join these pieces of wood in a more effective way than I could even imagine). This last feature is particularly fascinating since it suggests a way that a word can yield benefits for users without those users having much comprehension at all of what the word means. A word will earn its keep if it can yield beneficial effects for its user, regardless of whether the user's own actions or someone else's bring about those effects and perhaps regardless of whether the user ever recognizes that the word reaps such benefits. This raises the possibility that there is selection on words not merely at the level of individual humans but at the level of human groups, a suggestion in line with recent work on externalist content and the extended mind [O'Madagain (forthcoming)].

If this story is correct, then what conditions must be in place for words to generate new adaptive affordances? Dennett is, of course, aware of the enormous difficulties in answering such questions, and it would be too much to demand that he sticks his neck out on all of the minutiae. Here, I will just point to a few traits that might need to have been present in order for words to do their work, in addition to the ones that he discusses. In general, in order for an individual to form an association between a word, *w*, and some property, *p*, in the environment, she needs to experience a correlation between *w* and *p*, and *p* must be some property that she is equipped to track.

To satisfy the first condition, words must be used regularly, in the same contexts.[7] Individuals must be disposed to use the same word in the same context, and here Dennett suggests that pre-existing human instincts for cooperation and imitation were key [Dennett (2017), p. 251]. Can we explain these dispositions without assuming that the players already had the capacity to comprehend word meanings, to reason about the relations between people, words, and states of affairs? This is a thorny issue. Tomasello (2014), for one, argues that joint attention and cooperation created our ability to flexibly reason about relations and hence the evolution of the preconditions of language already bestowed on us a different kind of mind. Dennett grants this point, arguing that even so, "when language arrived on the scene, this enabled *cumulative* cul-

tural evolution" [Dennett (2017), p. 260]. This would be the DNA model or central nervous system model of words, according to which they replicate and coordinate activities of human cultural groups. While that model might be correct, it would still leave open the question about how our unique relational reasoning abilities arose.

Another sort of answer to the "why not everyone?" question suggests itself here. Suppose we do not have to posit a new type of representational ability in humans to account for their ability to use words (as Dennett's Canon would prescribe). Perhaps nonhuman primates were capable of using words to create new affordances, and perhaps words even took root in their brains, but they just didn't yield any dividends in their social contexts. This is the domestication model, on which "first words – both in infants today and in the deep history of language in our species – are thus best seen as synanthropic species evolved by natural selection to thrive in human company" [Dennett (2017), p. 197]. In addition to the right sort of environment ("neither too hot – chaotic – nor too cold – unchanging" [*ibid.*, p. 257]), it seems that the ability to use words to tap into knowledge in other creature's minds depends on a background of cooperation (if I say "hammer" to the carpenter, she fixes something instead of throwing the hammer at me). Again, the challenge is to provide an account of the kind of human cooperation that makes words useful without positing the antecedent existence of those capacities that words are supposed to explain.

What about the second condition on learning a new affordance, that the regularity the word attaches to must be one which humans are capable of tracking? A chicken and egg situation arises here too. According to one prominent view, the difference between humans and nonhuman animals is not in our ability to attach words to things but to attach words to types of abstract relations that are beyond the representational ken of other primates [Penn *et al.* (2008), Clatterbuck (forthcoming)]. Hence, the ability to represent sophisticated, novel relations must have already been in place in order for words to create genuinely novel affordances. This problem motivated Lloyd Morgan to ditch the language-first account of his early work – "by means of language and language alone has human thought become possible" [Lloyd Morgan (1882), p. 524; Radick (2007), p. 75] – in favor of a relational cognition-first view. He argued that some more fundamental faculty must have evolved prior to language, for "we cannot describe, still less explain without rendering the relationships explicit and focal" [Lloyd Morgan (1894), p. 239]. Here, words are modeled as viruses, taking advantage of our pre-existing ca-

pacity for generating new affordances, but that capacity that has not yet been accounted for.

Despite these challenges, by placing cognitive evolution in terms of evolutionary transitions, Dennett opens up fruitful new avenues for constructing more precise and evolutionarily plausible models of the language-aided transition to genuinely comprehending human minds. That is, he's given us a suite of useful new tools for thinking about our minds and the minds of our fellow creatures.

University of Rochester
Department of Philosophy
Box 270078
Rochester, NY 14627-0078 USA
E-mail: hayley.clatterbuck@rochester.edu

NOTES

[1] If Dennett is right, *other* minds aren't unique in this respect.

[2] "By far the simplest assumption regarding the social behavior of the chimpanzee, for example, is that if this species' behavior resembles that of ourselves then the underlying psychological processes *must* be similar too" [de Waal, (1991), p. 298].

[3] De Waal (2016) argues that explaining human uniqueness should not be the central motivation of comparative psychology any more than explaining the uniqueness of any other species should be. De Waal may be right that an undue focus on explaining the differences between humans on the one hand and all other animals on the other might distort our thinking about other minds and close us off to certain interesting questions. However, it seems to me that human uniqueness is objectively unique and therefore one of the facts most in need of comparative psychological explanation.

[4] There is good reason to think that he underestimates the cognitive powers of nonhuman animals by denying that they can represent relations. However, perhaps his central insight remains if we accept that a creature can represent some relations but deny that they can represent some particular types of relations [Penn, *et al.* (2008), Clatterbuck (forthcoming) or that they comprehend the relations that their cognitive systems track].

[5] This is, of course, the basis of Intelligent Design theorists' "irreducible complexity" argument against Darwinism.

[6] This is a bit overstated, since symbol possession yields great cognitive benefits even for non-human animals, facilitating enhanced relational reasoning [Thompson and Oden (2000)]; but see Penn *et al.* (2008) and perhaps even the

kind of affordance-creating linguistic bootstrapping that Dennett holds to be uniquely human [Carey (2014), esp. section 13].

[7] Of course, there will have to be significant biases for picking up on some correlations and not others for word learners in order to solve problems of indeterminacy [Quine (1970)]. See Smith, *et al.* (1995) for a discussion of attentional biases that guide early word learning, such that children do not need large bodies of data to learn new words. On Dennett's picture, such biases might have evolved to better prepare our brains for the linguistic environment.

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Anthony Kenny

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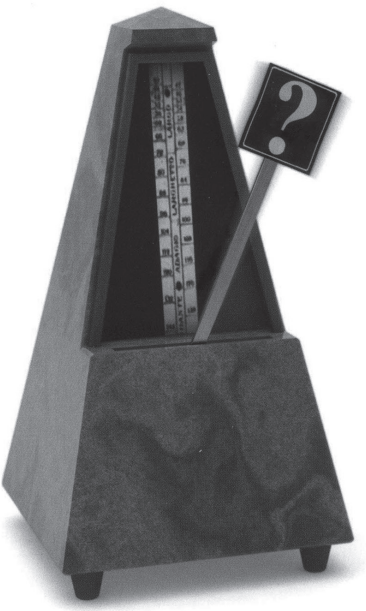

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