

The predicability tree. How, and why?

Abstract

The art of ranking things in genera and species is of no small importance and very much assists our judgment as well as our memory. You know how much it matters in botany, not to mention animals and other substances, or again moral and notional entities as some call them. Order largely depends on it, and many good authors write in such a way that their whole account could be divided and subdivided according to a procedure related to genera and species. This helps one not merely to retain things, but also to find them. And those who have laid out all sorts of notions under certain headings or categories have done something very useful.

Gottfried Wilhelm von Leibniz, New Essays on Human Understanding

According to the still dominant Chomskian tradition in linguistics, we are required to have *a priori* knowledge of some (universal) linguistics constraints, because otherwise it is impossible to learn a language (in such a short period of time). For this reason, a ‘language faculty’ evolved which ‘contains’ this type of knowledge. But even among grammatical sentences there is a distinction to be made between sensical and nonsensical ones. Also this distinction is based on some constraints. In this paper I will argue that one of these latter ‘linguistic’ constraints could better be thought of as ontological, or categorical knowledge: knowledge about fundamental ontological categories, or perhaps about the way we categorize our world. I will discuss whether this type of knowledge evolved as becoming part of our ‘ontology faculty’, or whether each child can learn it based on more general Bayesian principles.

The existence of ontological knowledge manifests itself through various phenomena: (i) anomalous sentences, (ii) natural co-predication, and (iii) natural classes. As for (i), we have a strong intuition that there is an important distinction between the non-true sentences (1-a) and (1-b):

- (1) a. The cow was green.
- b. The cow was an hour long.

Whereas (1-a) is an ok, but false sentence, (1-b) is not true, because it is ‘unnatural’, or ‘anomalous’: it involves a category mistake. Something very similar holds for (ii), it is easy to see that not all pairs of predicates can be combined naturally: it is ok to say (2-a), but not to say (2-b):

- (2) a. Either x is fat, or/and x is hungry.
- b. Either x is fat, or/and x is an hour long.

Intuitively, whether it is contingent whether or not (2-a) is true, sentence (2-b) cannot even be true, because no entity can both be fat and an hour long.

As for (iii), finally, according to a long philosophical tradition (starting with Aristotle, and recently defended by authors as diverse as Goodman, Lewis, and Gärdenfors), not all classes are alike: some are ‘natural’ and others are not. The famous *paradox of confirmation* is one (among many) way(s) in which this distinction manifests itself: we state a law-like sentence as (3-a) rather than as (3-b):

- (3) a. Ravens are black.
- b. Non-black things are not ravens.

The reason seems to be that we prefer the subject of a law-like sentence to involve a natural class, or kind. (Aristotle observed that even for particular sentences there is a distinction between the natural ‘Some logs are white’ versus the less natural ‘Some white things are logs’). Whereas the class, or concept of what it is to be a raven, seems to be ‘stable’, ‘homogeneous’, and ‘projectable’ (Goodman), this is not the case for the class of non-black things. Whether a term is more ‘natural’ than another, does not just depend on whether it is (logically) ‘primitive’ (like ‘raven’) or (logically) ‘complex’ (like non-black): the use of nominal, or substantive, terms as subjects of law-like sentences is much more natural than the use of adjectival terms.

These phenomena strongly suggest that the set of predicates, classes, or (if you want) ontological categories, are *structured*, and that not taking this structure into account gives rise to anomaly and ‘paradoxes’. What is this structure, and why does it exist?

Aristotle made a famous suggestion of how predicates, or ‘ontological entities’, are categorized. In the previous century, philosophers like Russell (1924) and Ryle (1938) made more concrete proposals, but only Sommers (1959, 1963) developed an extremely simple (though not very well known) theory that could easily explain the above phenomena. The distinction between term/predicate- and sentence-negation is crucial for his account. Where a modern logician would say that ‘ x is non-even’ is true for both 3 and John, because ‘it is not the case that x is even’ is true for both, Sommers more naturally claims that the former sentence is only true for 3, and neither true nor false for John. The class of things that is either ‘even’ or ‘non-even’ is called an ontological category. Something similar we do for every (primitive) predicate P , and we denote the category by $/P/$. Thus, $/P/$ is the set of objects to which the predicate P can sensibly be applied, whether truly or falsely. Predicate P is said to *span* the objects in $/P/$. The category $/Ape/$, for instance, spans all animals (including humans), just as the category $/Human/$. In Aristotelian terms, if X denotes a species, the category $/X/$ denotes the genus of X . The sets $/Socrates/$ and $/Quine/$ will (arguably) be identical (the set of all humans), and the sets $/Ape/$, $/Even/$, $/An\ hour\ long/$ will all be mutually exclusive. But not all non-identical categories are mutually exclusive. It seems reasonable to say that only human beings, and not apes, can be honest, or dishonest. But this means that $/Honest/$ is a proper subset of $/Human/$. Similarly,

/Human/ can be seen as a subset of */Animal/*, which can denote the set of all living things. Sommers' **Law of categorial inclusion** now says that categories (or predicates) can be hierarchically ordered in what is formally known as a (rooted) *tree* (which is a connected set with no cycles), also known as a 'predicability tree'. Stating it somewhat differently, it says that for any two categories */X/* and */Y/*, either (i) $/X/ \cap /Y/ = \emptyset$, or (ii) $/X/ \subseteq /Y/$, or $/Y/ \subseteq /X/$. What Sommers' law excludes is there to be an individual x such that $x \in /X/ \cap /Y/$, although neither $/X/ \subseteq /Y/$ nor $/Y/ \subseteq /X/$. In later work, Sommers called this the *M*-rule or the principle of no downward convergence.

In terms of Sommers' theory we can explain the above phenomena. Let us say that */X/* and */Y/* are *compatible*, $U(/X/, /Y/)$, iff $/X/ \cap /Y/ \neq \emptyset$. First, (1-b) is anomalous, though (1-a) is not, because the categories used in the latter sentence are compatible, i.e., $U(/Cow/, /Green/)$, because $/Cow/ \subseteq /Green/$, but the categories used in the former sentence are not: $\neg U(/Cow/, /An\ hour\ long/)$. The same explanation can be given to the second phenomenon: (2-a) is ok, because $U(/Fat/, /Hungry/)$, but (2-b) is anomalous, because $\neg U(/Fat/, /An\ hour\ long/)$. To account for the third phenomenon, we have to say what it means to be the *natural subject*, in a subject-predicate sentence. The proposal is that (3-a) is ok because $/Raven/ \subseteq /Black/$, and that (3-b) is not, because $/Non - black/ \not\subseteq /Raven/$. Notice that the latter is true iff $/Black/ \not\subseteq /Raven/$, which means that although we have come close to accounting for the traditional distinction between substantial and accidental terms (incorporated in language by the distinction between nominals versus adjectives), it seems that we haven't yet accounted for the distinction between positive and negative terms.

There seem to be some obvious counterexamples to Sommers' theory, however. Men can be white, but not even, while mathematical numbers can be even, but not white. But this means that according to the theory, there can be no predicate X that is applicable to both man and to number. But, of course, both men and numbers can be rational. What Sommers' theory predicts is that this means that 'Rational' must be ambiguous. And this seems to be a correct predication. A similar correct prediction follows from another 'counterexample': The categories */Made of wood/* and */Was dead/* are incompatible. Still, neither 'The bat was made out of wood' nor 'The bat was dead' is anomalous. We have to (correctly) conclude that the two occurrences of 'The bat' denote something quite different. Perhaps a more interesting (though more disputable) example is the pair of sentences 'Holland is flat' and 'Holland is a democracy'. A table is in */Flat/* but not in */Democracy/*. A political constitution is in */Democracy/* but not in */Flat/*. But this means that according to the theory, the two occurrences of 'Holland' must denote different entities. And perhaps that is the way we have to think about it! (For the philosophers among us, consider examples given after Ryle: 'Descartes is 1.67 meter long' and 'Descartes thinks', and conclude that Descartes is made up of two categories/substances (or can be seen from two different angles): body and mind). Thus, the most obvious counterexamples can be explained away very naturally, and the theory even enables us to detect ambiguity.

Although Sommers' theory is not uncontroversial (for instance because it depends on a primitive notion of a sentence being anomalous), there is a lot of empirical evidence that suggests it is correct. Keil (1979, 1983) found empirical evidence that both adults and children follow Sommers' law to reason about the world. Moreover, children's trees are typically simpler than the ones of adults. That Sommers' law holds (if it does) or not is a logical possibility, but certainly not a logical necessity. It can be shown that the probability of generating a matrix that satisfies Sommers' law, or the *M*-constraint, is highly insignificant. Logically speaking, there is an indefinitely large number of different ways of conceptualizing the world. Why could all different categories not be mutually exclusive, or why couldn't they give rise to a full partial order? Why is the relation between ontological categories, or is our conceptualization of the world, constrained by Sommers' law? Why are these categories hierarchically ordered, giving rise to a tree?

Giving that the *a priori* chance of a set of categories satisfies Sommers' law is so insignificant, why does our language still seem to obey it? One answer is that the world itself is organized according to a strict non-convergent hierarchy. A more plausible (rather Kantian) answer is that Sommers' law is due to our internal psychological constraints on how we can 'see' the world. Such an answer is very similar to the answer Chomsky has given to the question how we can learn a language: without any *a priori* limitation this is impossible, because there are too many possibilities. But notice that our constraint will be very abstract: no innate concepts, but rather a structural limitation on how concepts can be related to one another, which is more in line with Gärdenfors' (2000) limitation on what a natural concept can be. If this is the answer, it seems we have to explain the way we actually seem to categorize in terms of a general advantage of hierarchical organization. The nobel prize winner Herbert Simon (1969) suggested that the existence of hierchical orders might be explained by reference to phylogenetic evolution. He argued that to represent information in a tree is one of the most stable ways to represent knowledge, and thus has evolutionary advantages: the relative stability of intermediate levels enables such systems to emerge more quickly through evolutionary processes.

Simon illustrated his idea with a parable of two watchmakers, Hora and Tempus. Each makes watches composed of 1000 parts each, but while those of Tempus have to be assembled in one whole, Hora's are made up of three levels of subassemblies of 10 elements each. So, Tempus has to make a complete assembly in one go, and it is assumed that if he is interrupted, the partially completed assembly will fall apart. Hence, for each interruption, he will lose more work, and he will take many more attempts to produce a complete assembly. Hora, on the other hand, has to complete 111 subassemblies for each complete watch, but she will lose less work for each interruption and will take far fewer attempts to make a complete assembly. If the probability of interruption is about 1 in 100, then Tempus will take around 4000 times as long as Hora to assemble a complete watch. Simon argued that the same principle of faster evolution of a complex structure consisting of relatively stable sub-structures will apply to any biological or social system and so such hierarchic systems are likely to be much more common than non-hierarchic complex

systems. Sampson (2005) has argued that Simon’s argument is relevant for linguistics, but relates it to grammatical structure. Simon’s argument seems not immediately relevant for motivating Sommers’ constraint. But I think it still is: presenting knowledge of concepts/categories in a tree is very efficient (see also, among many others, Leibniz’ quote above, and Bickerton, 1990). The oldest known tree diagram was drawn in the 3rd century AD by the Greek philosopher Porphyry in his commentary on Aristotle’s categories. This tree diagram incorporates Aristotle’s traditional method of defining new categories by genus and differentiae. The species ‘Man’, for instance, is defined by the genus ‘Animal’ and the differentia ‘Rational’. This method is fundamental to artificial intelligence, object-oriented systems, the semantic web, and every dictionary from the earliest days to the present. Why? Because it allows us to define all terms without giving rise to cycles, but most of all because it greatly helps the child to figure out the fundamental categories of existence and what properties could be applied to what sorts of entities.

But it comes with a prize which I don’t know whether we want to pay: we have to assume a set of primitive (positive) properties or attributes. Consider the predicates ‘Tiger’ and ‘Non-Tiger’. The first denotes a kind (e.g. Kripke, Putnam), or natural class, but the latter does not. In terms of this distinction — or so say even extreme nominalists like Goodman (1960) and Quine (1963) — we can solve the problems of induction (and thus the possibility of doing natural science) and indeterminacy of translation, even if this distinction depends only on our (stable) interests. Even though */Tiger/* and */Non – Tiger/* denote the same category — the set of animals — there is a crucial difference between the predicates themselves: where the set of tigers can be determined by a *conjunctive* set of (primitive) positive attributes that they all have in common, this cannot be done for the set of non-tigers. Of course, this depends very much on what we take to be a primitive attribute

Perhaps this means that Sommers’ *M*-constraint is not innate — as suggested by Keil (1979) and Bickerton (1990) — due to evolution. And indeed, Schmidt et al (2006) have shown that how Bayesian model selection can be used to learn the *M*-constraint given a hypothesis space including alternative models. Thus, our desire for efficiency has not resulted in an innate *M* constraint by evolution, but forces every individual to discover the *M*-constraint anew. I will discuss in the talk whether this suggestion does presuppose a language which satisfies Sommers’ law or not.

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