An Analysis of the Meaning of Generics*

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摘要　我们知识中的绝大部分是由概称句表述的。建立概称句的形式语义对非单调推理以及人工智能中的知识表示等研究都有非常重要的意义。概称句意义分析是建立其形式语义的基础。目前关于概称句意义主要有两类研究：基于概率论的研究和基于可能世界语义学的研究。本文对概率论的研究进行了分析，指出其本质是外延的解释这一根本缺陷，在可能世界语义学研究提出的正常性概念的基础上，进一步深化研究，强调对正常性概念的内涵分析，提出了概称句的典范形式，进而提出正常个体选择的三个原则，以及据此建立了正常个体的选择函数，避免了原来研究中对正常性概念的外延性处理。本文建立了一个新的概称句形式语义的理论基础，提供了该语义建立的技术关键。

I. Motivation

Our knowledge about the world where we live consists mostly of statements like "Birds fly," "Potatoes contain vitamin C," and so on. While we refer to them as *generic sentences*, or *characterizing statements*, a precise definition is hard to provide. The existence of massive generic sentences indicates that much of our information about the world is captured by these characterizing statements. People observe the regularities in the world and codify them in the generic sentences to express their law-like nature.

The prominent usages of generics inspire us to believe that these sentences have truth values. It would be harsh to claim that no generic sentences, even like "Snow is white," have truth values. Nor does it ease our mind to claim that they are just sloppy ways of talking, and that strictly speaking they are all false. Pelletier and Asher (1997) criticize these two bad attitudes towards the truth values of generics. Sharing their intuition on this matter, we wish to go further and analyse what the truth conditions of generics are.

The truth value of a generic sentence seems, on the one hand, related to its corresponding episodic statement; on the other hand, it is not determined by the truth values of its instances. The connection between these two ends is somewhat loose, but they are not completely irrelevant. For instance, some birds like sparrows fly, but some others like penguins do not. Nevertheless they do not to the same degree support or detract from the truth value of the generic statement "Birds fly." People tend to grant "Birds fly" rather than "Birds do not fly," regardless of nonflying penguins. The statement "Birds fly" seems to tolerate exceptions like penguins. Our analysis of the meaning of generics will have to account for this phenomenon by explaining where the truth conditions of generics stem from.

本文已在《中国社会科学》发表（Social Sciences in China, Autumn, 2003）。
* This research is supported by the MOE Project of Key Research Institute of Humanities and Social Sciences in Universities, 02JAZJD720017.

Speaking of generic sentences in general, they consist of a large spectrum ranging from describing kind-level objects to attributing to individual-level objects. In the literature of the researches on generics, Krifka et al. (1995) distinguish between *d-generic* and *i-generic* sentences. “Dinosaurs are extinct” is an example of d-generic sentence, since kinds of animals can be extinct, but individuals of those kinds can only be dead. “Birds fly” is an example of i-generic sentence, because it attributes to individual birds the property of flying.

We do not attempt to provide a uniform meaning interpretation for all sorts of generics. Our goal is rather modest: we will mainly study the i-generics. While this narrows the scope of generics that we want to study, it does not seem to lower the level of difficulty. The key conundrum of generics is still within this narrowed scope: their truth conditions connect them at best only very loosely with particular facts about the world. They tolerate exceptions. It is this hallmark that has attracted the interest of researchers. The term “generics” hereafter is meant to be used in a limited sense.

II. Criticizing the Probability Approach

The following generic sentences are all presumably true, but what is it that makes them true?

(1) Whales are mammals.
(2) Birds fly.
(3) Ducks lay eggs.
(4) Turtles live to an old age.
(5) Unicorns have one horn.

As noted by many researchers (Pelletier and Asher, 1997; Cohen, 1999; etc.), the truth of these sentences calls for different relative numbers or proportions of instances of the subject term satisfying the predicate term. Sentence (1) seems to hold for all whales, (2) for most birds, (3) for most adult female ducks (presumably less than half the total number of ducks), (4) for rather few turtles (the majority of turtles die when they are still quite young) and (5) for not a single existing unicorn. Facing such a flexible range, there is no univocal quantifier among usual quantifiers like “all,” “most,” “many,” “some,” and “few” etc. that will be able to cover all needs and provide a uniform interpretation for all generics.

Nevertheless, some people like Cohen still argue for a probability analysis of generics. The simple-minded “a significant number” or “majority” reading for generics is obvious wrong because of the examples listed in (1)-(5). To save the quantificational view, the theory becomes quite sophisticated. In what follows, we will go into some details to investigate Cohen’s theory of generics, as a representative of taking “significantly many” approach in a sophisticated appearance. It is intended to show that, regardless of how sophisticated the theory goes, the bottom line of the “significantly many” approach is on the wrong track.

Cohen proposes that the meanings of generics are probability judgments. He argues that generics are not evaluated in isolation, but with respect to a set of alternatives under the consideration. The set of alternatives is derived by the focus, the presupposition, and the topic of a generic statement. For example,

(6) People have a hard time finding Carnegie Mellon University.

The set of alternatives for (6) contains various levels of difficulty in finding CMU such as "very easy," "easy," "a little difficult," "very difficult" etc. (6) is true, because the ratio of these people who experience difficulties is higher than that of those who find it easy. Cohen formalizes the notion of likelihood in terms of probability, as shown in the definition below.

Definition 1: Let $Gen(\psi, \varphi)$ be a generic sentence, where ψ and φ are properties. Let $A = ALT(\varphi)$, the set of alternatives to φ. $Gen(\psi, \varphi)$ is true iff $P(\varphi|\psi\wedge\bigvee A)>0.5$, where $P(\alpha|\beta)$ indicates the conditional probability of α given β, and $\bigvee A$ is the (possibly infinite) disjunction of all the properties in A.

There is an advantage provided by this probability account over the simple-minded, purely extensional, quantificational account which naively claims that $Gen(\psi, \varphi)$ being true is because the majority of ψ's are φ's. According to the above definition, (6) is correctly predicted true even though the vast majority of people never try to find CMU.

However, Cohen's probability account still cannot avoid having problems that are essentially caused by using quantificational measurement to interpret generics. With $P(\varphi|\psi\wedge\bigvee A)>0.5$, the generic sentence $Gen(\psi, \varphi)$ could still be intuitively false.

(7) People are over three years old.

Intuitively, (7) is false. On the contrary, Definition 1 predicts that it is true, since (7) is so likely to happen than its alternatives. The solution that Cohen provides is to introduce the homogeneity constraint on the reference domain. Relying on such a constraint, Cohen explains that (7) is false because it violates the homogeneity constraint.

But this would exempt virtually all generic sentences from applying Definition 1, even sentences like (2), of which the definition is supposed to provide truth. The domain of birds can be partitioned into biological families, one of which is the penguin family. Since this family is quite incapable of flying, the domain of birds does not satisfy the homogeneity constraint. Cohen realizes this problem, and couples the homogeneity constraint with a notion of salient partition.

Distinguishing partitions into salient and otherwise does not help much to solve the problem in hand. Let $Gen(\psi, \varphi)$ be a generic sentence. According to Definition 1, its truth value is evaluated against the domain $\psi\wedge\bigvee A$, where A is a set of alternatives to φ. Then this set of alternatives partitions the domain, that is, $Par(A) = \{\psi\wedge\varphi'|\varphi'\in A\}$. The factors that determine the set of alternatives also determine a salient partition. Any set of alternatives appears to be a salient partition of the domain in question. Whenever $P(\varphi|\psi\wedge\bigvee A)>0.5$ and hence $Gen(\psi, \varphi)$ should be true, the partition $Par(A)$ based on the set A of alternatives indicates that the domain violates the homogeneity constraint and the truth of $Gen(\psi, \varphi)$ is not guaranteed. This is self-contradictory.

Having shown the problems with Cohen's theory, we may conclude that the extensional probability approach is on the wrong track. We intend to argue that the heart of generic statements is a statement that all normal individuals of the subject term have the property expressed by the predicate term. We will introduce a canonical form to interpret the meaning of generics in the next section.

III. A Canonical Form of Generics

Generics express law-like regularities, and hence they are intensional. "Club members help each other in an emergency" is true, even were none of club members to have ever actually done so because they had never run into an emergency. Generic sentences cover possible instances as well as actual ones.

To require the implicit "*Gen*" quantifier to range over all actual objects has been shown to be too demanding and leaves no room for exceptions. It is out of the question to request it to range over all objects even including possible ones. However, generic sentences do sometimes display strongly universal nuances. A very few numbers or a very small portion of counter-examples can destroy the truth of a generic like "Bees are sexually sterile" and falsify them. This is a feature of universal quantifiers.

The claim we would like to make is that generic statements are about *all* instances in a *restricted* subset of the domain which contains all *possible* objects relevant to the main assertion of the statement. A similar position can be found in a number of writings, e.g., Morreau (1992), Krifka et al. (1995), Pelletier and Asher (1997), and Eckardt (2000) etc. Many authors, ourselves included, find it quite natural to use the notion of "normal" to select a set of normal objects out of all possible objects addressed by the subject term in the generic statement.

After a brief review the modal conditional approach of Asher and his coauthors and Eckardt's prototypical approach, we will propose a canonical form to represent generics. Our theory is an enhanced and refined version of previous work by Asher et al., and also borrows some useful ingredients from Eckardt.

1. The modal conditional approach

The formalization of generics and its semantics proposed in Asher and Morreau (1991), and Pelletier and Asher (1997) is often referred as the modal conditional approach. It introduces a binary modal operator into the formalism of generics and set their semantics in terms of possible worlds. This theory reads generic sentences like "Birds fly" as "Birds *normally* fly," where "normally," as a modal operator, reflects the intensional nature of generics.

However, their theory faces the drowning problem.

(8) Lions have manes.

(9) Lions give milk to their young.

Both sentences are intuitively true, and yet there is not a single normal lion that has a mane and gives milk to its offspring. Their theory cannot make both of them true in the same model.

Besides the drowning problem, their theory has another weak side. They make the universal quantifier ranges over all of individuals of a kind like "birds" and hence all of individual birds are taken into account to evaluate the truth value of "Birds fly."

For any exceptional bird that does not fly, it will be brought to a "bird-normal world" and make to fly there. This uniform treatment of exceptions makes no difference between "being an abnormal something" and "a normal something in an abnormal environment."

For the exceptions that are caused by external obstacles, the strategy of evaluating the statement against a normal world where none occur is quite acceptable. However, the attempt to save the exceptions caused by internal properties via the same strategy suggests a view like this: what is abnormal of Tweety if it doesn't fly is not because it is abnormal in being a bird (suppose Tweety is a penguin), but because it is in an abnormal world/situation/environment where it was born as a penguin (not, say, a sparrow). To handle the second type of exceptions via normal world strategy is an extra burden imposed on their semantics.

2. The prototypical approach

Eckardt (2000) is labeled as a "normality based theory." Eckardt has a similar goal to capture in her semantics the analysis that generics universally quantify over normal or prototypical individuals. There are two main ingredients in her theory. One is "a family of functions N_n," and the other is "the dispositional orbit of the world of evaluation." N_n is designated to select normal objects of a kind out of all objects in the kind (e.g. select normal birds from all birds). The use of dispositional orbit is a semantic wheel to explain the modal component "normally." According to Eckardt, "Birds fly" is read as "It is normally true that normal birds fly."

Under this analysis of generics, the modal operator "normally" takes a wider scope over the quantifier on prototypical individuals. Letting the modal operator rather than a quantifier take the wider scope is to treat the notion of normality as if it is a necessity-like operator, and hence the context sensitivity of selecting normal possible worlds is lost. Moreover, the function to select normal objects or normal sequences of objects is extensional. For example, it takes a set containing all birds and returns a subset that is thought to contain all normal birds. These drawbacks indicate that Eckardt's theory needs some improvements.

3. Normal objects *vs.* normal doings

We agree with Pelletier and Asher that generic sentences must be either true or false, and that they are not indeterminate or sloppy ways of talking. "Birds fly" is a true generic statement. Any precise readings that try to provide an equivalent meaning for "Birds fly" should have the same truth value as that of "Birds fly." That is, were they to be candidates for the meaning of "Bird fly," they must be first of all true statements. Let us consider the following two candidates:

(10) Normal birds fly.

(11) Birds normally fly.

Is (10) a true statement? The answer is no. We can imagine that Tweety, as a bird, is very normal in all aspects. It has strong wings, good vision, and perfect bone structure. She's not too fat to stay in the air. Nor is it too light to be blown away by the wind. In a short word, every piece of its body perfectly matches the scientific definition of being a normal bird. Nevertheless, Tweety does not fly. Why not? Because the poor creature is locked inside a tiny cage that just fits. The counter-example that we could come up with to argue against (10) is that there is a nonflying normal bird that happens to be trapped in a cage. One might object: there is an ambiguity in the word “fly,” between the sense that birds have the *ability to fly* and the sense that they *are flying*. If we are concerned with the sense of “the ability to fly,” Tweety, a normal bird, still has the ability to fly even though it is locked in a cage. Thus, a nonflying Tweety would not be a counter-example.

To deal with this objection, let us modify our example. Instead of putting it into a cage, Tweety is now in a weird environment in which air vibrates at a certain frequency. The existing air vibration in the weird imaginary world is just strong enough to cancel out the potential air vibration that will be caused by the movement of Tweety’s wings when it tries to fly. There will thus be no difference in air pressure on the upper and lower sides of its wings. As a result, no matter how hard it tries to fly and no matter how normal each part of its body is, Tweety is simply unable to fly. An abnormal circumstance makes a normal bird lose its ability to fly. (10) cannot bypass this modified example and become a true statement.

Our opponents could further argue that the word “fly” in the sentence “Birds fly” should actually be understood as “the ability to fly in normal circumstances.” This clarification is in fact welcome, because it helps us make the point that we are trying to dig out: besides the notion of being a “normal bird,” there is a notion of “normal circumstances.” No matter how normal a bird is, it is out of its control always to be in normal circumstances. Keeping the layer of “normal birds” only and leaving out the layer of “normal circumstance” opens a back door for counter-examples.

Let us turn to examine. Is (11) a good candidate to provide a precise meaning for “Birds fly”? Unfortunately, (11) does not have a better luck than (10). Here is a counter-example for (11): this time, suppose Tweety is a penguin. As a penguin, Tweety has small, degenerate wings, but it is fat and heavy. Its wings are too weak to support herself in the air. Even though the environment it is in is quite normal, Tweety simply cannot fly.

A possible objection to this counter-example runs as follows: Tweety is not in a normal world where it actually has strong wings and a slim body—indeed it flies there. Now the question is whether Tweety would still be the same penguin “Tweety” if its properties were dramatically changed in such a magical “normal” world where it can fly. The “normal world” where Tweety is a flying bird sounds quite abnormal to most of us.

In the process of rejecting (10) and (11) as the possible candidates for a precise understanding of “Birds fly,” a new form (12) is emerging to stand itself as a correction for both (10) and (11).

(12) Normal birds normally fly.

It is (12) that we would like to exhibit as a sample of the canonical form for generic statements like “Birds fly.” For generic statements with plural noun phrases like “birds” in general, here is our working thesis:

Canonical form thesis: All generic sentences with subject-predicate (SP) structure can be rewritten into their canonical form S (normally P). If S is a plural noun phrase, it can be further refined to be (normal S) (normally P).

Under this canonical form, “Birds fly” means “normal birds normally fly.” This form has an outer layer of universal quantification over normal individuals with respect to the subject term S and the predicate term P, and an inner layer of universal quantification over normal circumstances with respect to a statement that something x is a normal S. The exceptions of nonflying abnormal birds are excluded in the first layer of quantification. The exceptions of normal birds that do not fly because they are in abnormal environments are taken care of by the restriction placed by “normally.” This analysis suggests a clear generalization relation between “Birds fly” and “Tweety flies.” The former is a generalization over instances like the latter.

IV. Selecting Normal Objects

“Normally” in the canonical form can be represented by a modal operator, which have been quite thoroughly studied in conditional logic. “Normal” is a new function that is introduced by our theory to select normal objects of kind α with respect to a property β. The selection of normal objects will be based on the “meaning” of α and of β. In a formal semantics, the meaning of α can be interpreted as the intension of α, a function which determines the extension of α in every possible world. We use the term “intension” in the same sense as that is used in Montague Grammar and in the intensional logics. The set of normal birds in a certain possible world is the extension obtained from applying the “meaning” of normal birds to this particular world. The meaning (i.e., the intension) of normal birds for the statement of “Birds fly” is determined by the meaning of “birds” and of “the ability to fly.” We give formal definitions of intension space and the normal objects selection function N below.

Definition 2 (Intension space INT of W and D): Given a set of possible worlds W and a set of objects D, $INT(\mathrm{W}, \mathrm{D}) = \{int \mid int \text{ is a function from W to } \wp(\mathrm{D})\}$.

For the sake of simplicity, the intension space defined in Definition 2 contains only intensions of unary predicates. It can be easily extended to include all intensions of n-ary predicates. We would rather stay with this simple form regarding the technical details, as our focus is on the conceptual analysis.

Definition 3 (Inclusion of two intensions): Given any int_1, int_2 in $INT(\mathrm{W}, \mathrm{D})$, $int_1 \subseteq int_2$ iff $int_1(w) \subseteq int_2(w)$ for all w in W.

Definition 4 (Complement of two intensions): Given any int_1, int_2 in $INT(\mathrm{W}, \mathrm{D})$, $int_1 = (int_2)^c$ iff $int_1(w) = (int_2(w))^c$ for all w in W.

Definition 5 (Normal objects selection function N): N is a function taking two inputs from $INT(\mathrm{W}, \mathrm{D})$ and returning an output in $INT(\mathrm{W}, \mathrm{D})$: $INT(\mathrm{W}, \mathrm{D}) \times INT(\mathrm{W}, \mathrm{D}) \rightarrow INT(\mathrm{W}, \mathrm{D})$ satisfying

(a) For all int_1, int_2 in $INT(\mathrm{W},\mathrm{D})$, $N(int_1, int_2) \subseteq int_1$;

(b) For all int_1, int_2 in $INT(\mathrm{W}, \mathrm{D})$, $N(int_1, int_2) = N(int_1, (int_2)^c)$.

The normal objects selection function N is designed to interpret the “normal” operator in canonical form. There are two conditions required for the function N to select normal objects, given the meanings of the subject and predicate terms. In non-technical terms, one is that normal birds with respect to the ability to fly must first of all be birds. The other constraint guarantees that the predicate term, as the second argument of the function *N*, only provides an aspect with respect to which normal objects are selected. The selected objects are not requested to satisfy the predicate term. For example, the same set of normal birds will be selected for the consideration of the truth values of “Birds fly” and “Birds do not fly.” In such a way, we will not be accused of circularity in choosing normal objects.

V. Conclusions

Our analysis of the meaning of generics is intensional, and reflects their exception tolerance nature. A formal semantics can be built upon the traditional possible worlds semantics for conditional logics and the normal objects selection function that is introduced in the previous section. The drowning problem will be solved in such a semantics.

The solution lies in the normal objects selection function *N*. The generics with the same antecedent will no longer have to share the same group of normal instances. Both (8) and (9) are true in virtue of their own groups of normal instances. There is no race or competition for normal objects between them. Lions who are normal with respect to being hirsute have manes. Lions who are normal with respect to their method of feeding, give milk to their young. (8) and (9) can both be true in peace. This idea is implemented via the binary function *N*, whose second parameter reflects the aspect with respect to which the normal instances of the first parameter are selected. Normal lions that have manes could be selected differently from normal lions that give milk to their young. Thus the drowning problem vanishes.

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