Generic sentences and subjective probability

Introduction: Cohen (1999a, 1999b, and later) has convincingly argued that generic sentences express probability judgments on a frequentist interpretation of probability. His main analysis provides an account of a wide class of generic sentences and is characterized by three additional components: (a) the use of alternative semantics to restrict the domain of the generic quantifier, (b) an alternative-based distinction between the truth conditions for absolute and relative generics, and (c) the imposition of a constraint on the homogeneity of reference classes.

In this paper, we develop a new analysis of generic sentences built on a subjective/Bayesian interpretation of probability. Our analysis is more parsimonious and uniform, relying on a sparser ontology and analytical ingredients. Specifically, it provides a simpler expression of the notion of invariant probability across admissible histories (Cohen 1999a) by invoking stationarity of probability measures, and eschews the need for a homogeneity constraint on reference classes. We also treat absolute and relative generic readings uniformly (unlike Cohen 2001), by relating the felt truth/falsity of generic sentences to comparability of probability distributions. For the purpose of this abstract, we will restrict ourselves to generics with bare plural NPs in subject position.

Problem: As observed in Krifka et al (1995) and much previous literature, generics express non-accidental regularities expected to persist in time: (1-a) is judged false. They may tolerate exceptions to extreme degrees making a simple quasi-universal analysis over 'typical' or 'normal' individuals unteneble: (1-b) is judged true, though the proportion of man-eating tigers is small. They cannot express purely quantificational generalizations: (1-c) is judged true, but (1-e) is judged false, despite picking out essentially the same set. Similarly, (1-d) is judged false even if most carpets are from Persia. Finally, (1-f) fails to be judged true.

(1)	a.	*Supreme court judges have a prime social security number.*	FALSE
	b.	*Tigers eat people.*	TRUE
	c.	*Peacocks have beautiful tails.*	TRUE
	d.	*Carpets are Persian.*	FALSE
	e.	*Peacocks are male.*	FALSE
	f.	*Girls in Saudi Arabia wear skimpy clothes.*	FALSE

Framework: An influential view in work from psychology and economics (e.g. Gärdenfors and Sahlin (1988), Oaksford & Chater (2007)) argues that human reasoning is, at least to a good approximation, based on Bayesian statistics. The beliefs of an individual underlie judgments (for instance, of truth and falsity of sentences) and are represented by probability distributions over the parameters of interest. Specifically, to judge the probability p that a proposition holds (a value between 0 and 1), the individual's belief is represented by a probability distribution on the interval [0,1]. This can be formalized in the following way:

Let BEL, representing an individual belief system, be a function from the set of propositions R into the set $\mathcal{P}([0,1])$ of probability distributions on [0,1]. For any proposition g, the area between the graph of BEL(g) and the interval $[a,b] \subset [0,1]$ is the belief or confidence in the assertion "The probability of g lies in $[a,b]$". When the graph of BEL(g) is highly peaked around a particular value p_0 it may be loosely said that "the probability of g is judged to be p_0". Then, for any pair of propositions, g, h, where $BEL(g)$ is highly peaked at p_1, and $BEL(h)$ is highly peaked at p_2, we will say that $BEL(h) \succ BEL(g)$ iff $p_2 > p_1$.

Analysis: The truth/falsity of generic sentences involves a comparison of the probability distributions output by BEL – along a taxonomic hierarchy (**salience**), and along the time dimension (**stationarity**). For any generic of the form $\phi\ are\ \psi$, we take $\phi_t\ are\ \psi_t$ to be its time-relativized version for some time t. Then, we claim,

(2) $\phi\ are\ \psi$ is (judged) a true generic iff $\phi_t\ are\ \psi_t$ is **salient** with respect to BEL for each time t and $BEL(\phi_t\ are\ \psi_t)$ is **stationary**.

a. *Salience:* $\phi_t\ are\ \psi_t$ is salient with respect to BEL iff there is a $\phi' \supset \phi$ such that $BEL(\phi_t\ are\ \psi_t) \succ BEL(\phi'_t\ are\ \psi_t)$. Any such ϕ' will be called a 'supercategory' in the discussion below.

b. *Stationarity:* $BEL(\phi_t\ are\ \psi_t)$ is stationary iff $BEL(\phi_t\ are\ \psi_t)$ does not vary with time t.

Salience formalizes the intuition of 'striking'-ness (Leslie 2007, 2008). *Tigers eat people* satisfies salience because we are confident about assigning a higher probability (a distribution that peaks at a higher value) to this proposition, than to a proposition expressed by a sentence like *Animals eat people* (where *animals* expresses a supercategory of *tigers*). Similarly for *Peacocks have beautiful tails*. Note that *Tigers eat people* and *Bears eat people* are both salient on our analysis (see Leslie (2007)'s objections to Cohen (1999)), and therefore, if they also meet the stationarity requirement, are judged true generics. *Stationarity* formalizes the intuition of generalization across a time index, and is implicit in some form in Cohen (1999) as well as previous work on generics.

A frequentist reduction of this Bayesian proposal would be to say that $\phi\ are\ \psi$ is true at some time t if $P(\psi|\phi) > P(\psi|\phi')$ at t and $P(\psi|\phi)$ is time-invariant. However, our approach provides an additional source of false generics ((3-b) below), that has the effect of eliminating the homogeneity requirement in Cohen (1999b).

Accounting for false generics: There are three ways in which generics can fail to be true.

(3) a. The stationarity requirement is not satisfied.

b. $BEL(\phi_t\ are\ \psi_t)$ and $BEL(\phi'_t\ are\ \psi_t)$ are *incomparable* in the partial order $\succ$.

c. They are comparable but $BEL(\phi'_t\ are\ \psi_t) \succ BEL(\phi_t\ are\ \psi_t)$ holds.

(3-a) is self-explanatory: only generalizations for which we believe time-invariance with confidence will be judged true, ruling out (1-a) and its like. (3-b) can itself arise in two ways: first, if either $BEL(\phi_t\ are\ \psi_t)$ or $BEL(\phi'_t\ are\ \psi_t)$ is a "spread-out" distribution on [0,1], and second, if both $BEL(\phi_t\ are\ \psi_t)$ and $BEL(\phi'_t\ are\ \psi_t)$ are highly peaked but around the same point in [0,1]. Note that a highly peaked belief distribution indicates a high degree of confidence in the probability of the proposition. In contrast, a spread-out belief distribution (which, for example, could arise from inadequate knowledge) indicates uncertainty about the probability of the proposition. Thus the falsity of (1-d) derives from the fact that for a possible supercategory like *man-made objects*, we do not know with any confidence what proportion of its members are Persian, leading to a spread-out belief distribution and incomparability. The falsity of (1-e) is rooted in the fact that for *Birds are male* (or other supercategories of peacocks), our belief is peaked at the same value ($\approx$ 1/2) as our belief about *Peacocks are male*. Finally, (1-f) is false even though one might believe it to satisfy stationarity and one's belief distributions for *Girls wear skimpy clothes* and *Girls in Saudi Arabia wear skimpy clothes* are comparable, since the ordering is in the wrong direction.

Conclusion: The Bayesian notion of representing belief by a probability distribution does not disavow the role of real world facts that underlies traditional approaches, since the belief distribution is significantly influenced by observation. Taking such belief distributions (rather than underlying facts) as primitives, we capture the perceived truth/falsity of generics in a unified manner.

Selected References: **Cohen, A.** (1999b). Generics, Frequency Adverbs, and Probability. *L&P 22*, 221–253. **Gärdenfors, P. & Sahlin, N.E.** (1988) *Decision, probability, and utility: selected readings.* CUP. **Krifka et al** (1995), Genericity, an introduction. *The generic book*, Chicago. **Leslie, S.J.** (2007). Generics and the Structure of the Mind. *Philosophical Perspectives, 21*, 375-403.