Generics, Frequency Adverbs, and Probability

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For the true idea, the generic idea, cannot result from an isolated conception; there must be a series (P. J. Proudhon, The Philosophy of Misery).

Abstract

Generics and frequency statements are puzzling phenomena: they are lawlike, yet contingent. They may be true even in the absence of any supporting instances, and extending the size of their domain does not change their truth conditions. Generics and frequency statements are parametric on time, but not on possible worlds; they cannot be applied to temporary generalizations, and yet are contingent. These constructions require a regular distribution of events in time. Truth judgments of generics vary considerably across speakers, whereas truth judgments of frequency statements are much more uniform. A generic may be false even if the vast majority of individuals in its domain satisfy the predicated property, whereas a frequency statement using

e.g. *usually* would be true. This paper argues that all these seemingly unrelated puzzles have a single underlying cause: generics and frequency statements express probability judgments, and these, in turn, are interpreted as statements of hypothetical relative frequency.

1 Eight Puzzles

Generics and frequency statements[1] occur frequently in natural language. Much of our knowledge about the world is expressed using such sentences—a glance at an encyclopedia will easily provide myriads of examples. Yet it is far from clear what such sentences mean, i.e. what a given sentence entails, what it presupposes, and what it is that makes it true or false.

Perhaps the most puzzling fact about these sentences is that they are, in a sense, both very strong and very weak. On the one hand, generics and frequency statements are stronger than simple quantified statements, in being *lawlike*; on the other hand, they are weak—they are contingent on properties of the actual world, and (except, perhaps, for *always*) are even weaker than universal statements, since they allow for exceptions.

With a view towards providing a solution to this general conundrum, I will consider eight specific puzzles in this paper. I will argue that these puzzles

[1]Following de Swart (1991) and others, I distinguish between frequency adverbs, such as *usually* and *always*, and other adverbs of quantification, such as *twice*. I have nothing to say about the latter type in this paper. I refer to a sentence containing a frequency adverb as a *frequency statement*.

can all be solved if generics and frequency statements are taken to express probability judgments, if probability is given a suitable interpretation.

In what follows I will assume, for simplicity, that generics and frequency statements express a relation between properties.[2] For example, the logical forms of (1.a) and (2.a) would be (1.b) and (2.b), respectively (where **gen** is the generic quantifier).

(1) a. Birds always fly.

b. $\mathbf{always}(\mathbf{bird}, \mathbf{fly})$

(2) a. Birds fly.

b. $\mathbf{gen}(\mathbf{bird}, \mathbf{fly})$

1.1 Generalizations with no Supporting Instances

The first puzzle is the fact that a generic sentence may be judged true even if there are no instances which support the generalization it expresses. Consider the following well known examples:

(3) a. Mary handles the mail from Antarctica.

b. Members of this club help each other in emergencies.

[2]Though, in actuality, they plausibly quantify over *cases* (Lewis 1975). Probability judgments can, in fact, be extended straightforwardly to handle general open formulas rather than properties, along the lines pursued by Bacchus (1990) and Halpern (1990). The details, however, are beyond the scope of this paper—see A. Cohen (1996).

Sentence (3.a) may be true even if there has never been any mail from Antarctica; for example, if handling such mail is part of Mary's employment contract, (3.a) could be uttered truthfully. We can imagine coming to the office and asking John whether any mail has arrived from Antarctica. John may indicate that he has no knowledge of this, and refer us to Mary by saying (3.a). John's sentence may be considered true even if no Antarctic mail has ever arrived. Similarly, (3.b) may be true even if no emergencies ever occurred, say in a state of affairs where an obligation to help other members is included in the club's constitution.

Note that we are only concerned here with the *descriptive* readings of generics, and not with the *prescriptive* readings. According to the latter type of reading, (3.a) is true just in case handling Antarctic mail is Mary's job, and (3.b) expresses the existence of a rule obliging club members to help each other in emergencies.[3] Suppose mail from Antarctica does come in, but Mary does not do her job properly, so the mail gets piled in the office and nobody takes care of it; suppose emergencies do eventually occur, but it turns out that club members fail to help each other. In these cases, the sentences in (3) would remain true under their prescriptive reading, but would be false under the descriptive ones.

[3]There are languages, such as French (Carlier 1989), which distinguish overtly between the two readings.

1.2 Extensibility

I consider a quantificational statement to be *extensible* if its truth value would remain the same if the number of elements in its domain were greater than it actually is.

When quantification is expressed with determiners, the statement is not extensible; (4.a) might have been false if there were more birds in the actual world than there actually are. In contrast, (4.b) would be true even if there were more birds than there actually are.

(4) a. Most birds fly.

b. Birds (usually) fly.

It follows that if some individual which is not a bird actually were, this would not change the truth of (4.b), and, therefore, that individual would probably fly. In other words, generics and frequency statements are *law-like*; (4.b), but not (4.a), supports the following counterfactual:

(5) If Dumbo were a bird, he would probably fly.

The second puzzle, then, is how generics and frequency statements can express quantification, and yet be extensible.

1.3 Intensionality

Suppose ψ_1 and ψ_2 are two extensionally equivalent properties, i.e. at this moment in time and in the actual world, the respective sets of individuals which satisfy ψ_1 and ψ_2 are equal. If generics and frequency adverbs behave extensionally, we would expect $Q(\psi_1, \phi)$ and $Q(\psi_2, \phi)$ to have the same truth conditions for every adverb Q and property ϕ.

This does not hold in general. Consider (6), from Carlson (1989):

(6) A computer (always) computes the daily weather forecast.

Carlson observes that

> "the daily weather forecast" requires an *intensional* interpretation, where its meaning cannot be taken as rigidly referring to the present weather forecast, e.g. the one appearing in today's copy of the *Times* predicting light rain and highs in the upper thirties (p. 179, emphasis added).

For example, if today's weather forecast predicts a blizzard, this may well be the main news item. Yet, (6) does not entail (7):

(7) A computer (always) computes the main news item.

While a computer may have computed today something which turned out to be the main news item, this does not hold in general; on most days, the main news item will not be computed by a computer, hence (7) is false.

Intensionality, it is important to note, does not come in one form only. In particular, a construction may exhibit intensionality with respect to the time index, but not with respect to possible worlds, or vice versa. For example, Landman (1989), in his discussion of groups, draws the following distinction:

> The intensionality that I am concerned with here concerns... the fact that committees **at the same moment of time** can have the same members, without being the same committee. Another form of intensionality concerns the well known observation that committees need not have any members at every moment of time of their existence, and that in the course of time, they may change their members, while staying the same committee. I do not think that this kind of intensionality has the same source as the 'atemporal' intensionality that is the topic of this paper (pp. 726–727, original emphasis).

Generics and frequency statements, it turns out, behave intensionally with respect to the time index, but not with respect to possible worlds. Suppose that the weather report is Mary's favorite newspaper column. Then (8) would have the same truth conditions as (6), although there are any number of worlds where Mary has no interest in the daily weather forecast:

(8) A computer (always) computes Mary's favorite newspaper column.

I should make it clear what I am *not* saying here. I am definitely not claiming that the properties of being the daily weather report or of being Mary's favorite newspaper column have the same extensions in all possible worlds; clearly, in different worlds, there may be different weather conditions, and Mary may have different preferences. What I *am* claiming is that the truth conditions of a generic or a frequency statement do not depend on the extensions of the properties they relate in any other world but the actual one, though the truth conditions do depend on the extensions of the properties at different times.

To give another example, suppose that John fears all bats but no other animal. The set of bats is equivalent to the set of animals John fears, though the intensions of the respective terms differ; there are any number of possible worlds where John does not fear bats in the slightest. However, we can substitute the term *animals which John fears* for *bats* without changing the truth conditions:

(9) a. Bats (usually) fly.

b. Animals which John fears (usually) fly.

Similarly, there is no logical necessity for the whale to be the largest animal on earth, or for the quetzal to be Guatemala's national bird; yet (10.a) and (10.b) have the same respective truth conditions as (11.a) and (11.b):

(10) a. The whale suckles its young.

b. The quetzal has a magnificent, golden-green tail.

(11) a. The largest animal on earth suckles its young.

b. Guatemala's national bird has a magnificent, golden-green tail.

Generics and frequency statements, then, are parametric on time, but not on possible worlds; if two properties have the same extension throughout time, they can be freely interchanged in a generic sentence *salva veritate*. The third puzzle is how generics and frequency statement can be parametric on one index but not on another.

1.4 Temporary Generalizations

Generics and frequency statements do not hold of generalizations which are perceived to be temporary. For example, suppose it so happened that all Supreme Court judges had a prime Social Security number; this would not suffice for (12.a) to be true, although (12.b) would certainly be true.

(12) a. Supreme Court judges (always) have a prime Social Security number.

b. Every Supreme Court judge has a prime Social Security number.

It seems that the truth, indeed the acceptability of (12.a) requires that Supreme Court judges have a prime Social Security number not just at present, but that this property be expected to hold in the future with some regularity, say because a law were enacted which posed restrictions on the Social Security number of judges. The fourth puzzle, then, is why generics and frequency statements do not hold of temporary generalizations.

1.5 Contingency

From the lawlikeness of generics and frequency statements, and the fact that they do not hold of temporary generalizations, it might seem that they are, in some sense, necessary (see e.g. Dahl 1975). However, in general, generics and frequency statements are true or false contingently; they may be true in the actual world, yet false in other worlds, and vice versa. In the actual world, (13) happens to be true, but it might have been otherwise.

(13) Birds (usually) fly.

Generics and frequency statements, then, express contingent, rather than necessary statements. It should be emphasized that this fact does not preclude their being lawlike. The following sentences are lawlike (and true), although they do not express necessary properties, under any conceivable definition of necessity:

(14) a. A cheetah outruns any other animal.

b. Spices are affordable.

c. Gold cubes are smaller than 10 cubic meters (adapted from Koningsveld 1973, 60).

d. Dogs annoy Sam.

Perhaps running fast is a necessary property of cheetahs, but certainly not the property of running faster than any other animal, since some other animal might have been faster. Affordability is a contingent property of spices—in fact, throughout much of history, spices were extremely expensive; yet (14.b) is true nonetheless. Similarly, we would be hard-pressed to claim that gold cubes are necessarily smaller than 10 cubic meters, or that annoying Sam is a necessary property of dogs. The fifth puzzle, then, is how generics and frequency statements can express contingent facts, and yet be lawlike.

1.6 Regular Distribution in Time

Stump (1981) has noticed that a frequency statement implies a regular distribution of events in time. Thus, for example, for (15.a) to be true, it is not sufficient that there exist *some* events of John's jogging in the park:

(15) a. John sometimes jogs in the park.

b. John jogs in the park.

Rather, these events should be distributed in time with some repeated regularity, say once a week or once a month. If John jogs in the park, but in an irregular fashion (say he jogs every day for one month, and then never visits the park for three years), the sentence would be unacceptable. It would not, in fact, be judged false, but rather considered odd. It seems, then, that the regularity implication is a presupposition, and when it is not satisfied, the sentence is not false but rather infelicitous. The same holds for generics and habituals, as (15.b) has the same regularity presupposition as that of (15.a).

De Swart (1991) addresses this phenomenon, and captures it using a dynamic evaluation procedure. She does not, however, answer our sixth puzzle, which is *why* frequency adverbs and generics behave in this way.

1.7 Uncertain and Conflicting Truth Judgments

Given a state of affairs, most people will agree whether a sentence containing an overt quantifier is true or false; there is little variability across individuals concerning the truth of the following sentences:

(16) $\left\{\begin{array}{l}\text{All}\\ \text{No}\\ \text{Some}\\ \text{Most}\end{array}\right\}$ birds fly.

This is largely true even when the quantifier is vague:

(17) $\left\{\begin{array}{l}\text{Many}\\ \text{Several}\\ \text{Hardly any}\end{array}\right\}$ birds fly.

Generic sentences such as (18) are also often presented in the literature as being unproblematically true or false, but it is rarely noted that, in fact, truth judgments of such sentences are often uncertain, and vary considerably across individuals.

(18) Birds fly

When, in an informal study, I asked informants to judge the truth of (18), some agreed that it was true, but many were uncertain, and said things like, "Well, it's sort of true, but then there is the penguin." In contrast, frequency statements behave like overtly quantified sentences in this regard, and there is almost unanimous agreement about their truth values; virtually all informants agreed that (19) was true.

(19) Birds usually fly.

The seventh puzzle, then, is why truth judgments of generics and frequency statements differ in this manner.

1.8 Majority Is Not Enough

Often, a property may hold of the vast majority of individuals in the domain of a generic, and yet the sentence is unacceptable:[4]

(20) a. Israelis live on the coastal plane.

b. People in southeast Asia speak Chinese.

c. People have black hair.

d. People are over three years old.

e. Crocodiles die before they attain an age of two weeks.

f. Primary school teachers are female.

g. Bees are sexually sterile.

h. Books are paperbacks.

i. Prime numbers are odd.[5]

The majority of Israelis live on the coastal plain, yet (20.a) is not true; the majority of people in southeast Asia speak Chinese, yet (20.b) is not true; and so on. In all the sentences in (20), the majority of instances do satisfy the predicated property, and yet the generic sentence is not true.

In contrast with generics, if the adverb *usually* is inserted into the sentences in (20), they become acceptable, in fact true:

[4]Some may claim that it is false, though to me it seems more a case of unacceptability, similar to that of presupposition failure.

[5]Examples (20.e), (20.g), (20.h) and (20.i) are from Carlson (1977); examples (20.c) and (20.d) are due to Chris Manning and Henk Zeevat, respectively.

(21) a. Israelis usually live on the coastal plane.

b. People in southeast Asia usually speak Chinese.

c. People usually have black hair.

d. People are usually over three years old.

e. Crocodiles usually die before they attain an age of two weeks.

f. Primary school teachers are usually female.

g. Bees are usually sexually sterile.

h. Books are usually paperbacks.

i. Prime numbers are usually odd.

The eighth puzzle, then, is the following: what is required for a generic to be true, above and beyond having a majority of individuals satisfy the predicated, and why don't frequency adverbs have the same requirement?

2 Probability

2.1 Probability Based Truth Conditions

This paper argues for the thesis that all puzzles above can be accounted for if we assume that generics and frequency statements express probability judgments. Before presenting the arguments for this view, let me be more precise about the relation between truth conditions and probability.

It seems plausible that for *Birds always fly* to be true, the probability that an arbitrary bird flies must be 1. Similarly, *never* would require this probability to be 0, and *sometimes* would require it to be non-zero. I will follow most researchers in interpreting *usually* as being the counterpart of *most*, and require the probability to be greater than 0.5.

Plausibly, *usually* carries an implicature to the effect that the probability is substantially greater than 0.5; if the probability is only slightly higher than 0.5, a sentence containing *usually* may be judged literally true but misleading. The same requirement holds for *most*. For example, the majority of Israelis voted for Binyamin Netanyahu in the 1996 elections, and, consequently, (22) is true:

(22) Most Israeli voters voted for Netanyahu in 1996.

However, given the fact that less than 51% voted for Netanyahu, (22) can be, and in fact sometimes is, criticized for being misleading.

For now, I will treat the phonologically null generic operator, **gen**, as synonymous with *usually* (this simplifying assumption will be revised later); both require the probability to be greater than 0.5, and both implicate that the difference is a substantial one.

I propose the following truth conditions for generics and frequency statements:

Definition 1 (Truth conditions, first version)

$Q(\psi, \phi)$ *is true iff*

$$\begin{cases} P(\phi|\psi) = 1 & \textit{if } Q = \textbf{always} \\ P(\phi|\psi) = 0 & \textit{if } Q = \textbf{never} \\ P(\phi|\psi) > 0 & \textit{if } Q = \textbf{sometimes} \\ P(\phi|\psi) > 0.5 & \textit{if } Q = \textbf{usually} \\ & \ldots \\ P(\phi|\psi) > 0.5 & \textit{if } Q = \textbf{gen} \end{cases}$$

As it stands, definition 1 does not really give us truth conditions. For it to do so, we need to specify the meaning of the probability judgment $P(\phi|\psi)$. What does it mean to say, for example, that the probability that a fair coin comes up "heads" is 0.5?

The mathematical probability calculus, as developed by Kolmogorov and subsequent researchers, will not help us here, since any function which satisfies its axioms is considered to be just as good as any other function. The meaning of probability has been the topic of much debate among philosophers since at least the time of Laplace, and many different theories have been proposed. It is not my goal here to provide a general solution to this philosophical problem; the aim of this paper is a considerably more modest one. I will follow L. J. Cohen (1989), who argues that there is no single "correct" interpretation of probability: different interpretations are appropriate for different types of probability judgment. In this paper I will propose an account of that specific kind of probability judgment which is expressed by generics and frequency statements.

2.2 Hypothetical Relative Frequency

This paper is not the first one to apply probability to generics and frequency statements. Åquist *et al.* (1980), in their account of frequency statements, use an interpretation of probability as proportion. According to them, $P(\phi|\psi)$ is the ratio between the number of individuals which satisfy $\phi \wedge \psi$ to the number of those which satisfy ψ. This approach, however, would predict that frequency statements are completely extensional, and would be unable to account for their extensibility and lawlikeness.

In their account of generics, Schubert and Pelletier (1989) use a logical interpretation of probability, according to which $P(\phi|\psi)$ expresses the ratio of the number (or, more precisely, measure) of worlds where $\phi \wedge \psi$ holds to the number of worlds where ψ holds. This approach goes to the other extreme, in predicting generics to be completely intensional, and expressing necessary statements only.[6]

Neither approach has much to say on the puzzles concerning the regular distribution of events in time, the differences between generics and frequency statements with respect to truth judgments of informants and the relevance of the number of instances supporting the generalization.

An idea which goes back to Poisson (1837), and received rigorous mathematical formulation by von Mises (1957), is that the probability judgment

[6]Schubert and Pelletier (1989) are aware of this problem, and suggest preferring worlds which are close to the actual world with respect to the "inherent" or "essential" nature of things. They do not, however, explain how this can be done.

$P(\phi|\psi)$ expresses a statement of limiting relative frequency, i.e. the mathematical limit of the frequency of ϕs among ψs as the number of ψs approaches infinity. The underlying idea is conceptually rather simple. If we want to know how likely smokers are to get lung cancer, we count the number of cancer patients among smokers, and divide by the total number of smokers in our sample. We do this for large samples, over long periods of time. As the sample grows larger and the the duration of the study grows longer, the ratio will get closer to the probability we are trying to find. The limit of this ratio as the sample size approaches infinity *is* the probability. Similarly, the limit of the frequency of "heads" in a sequence of tosses of a fair coin, according to this view, is exactly the probability of "heads," namely 0.5.

To put it a little more formally, for every $\epsilon > 0$, and for every sequence $S_1, S_2, S_3, \ldots$ of coin tosses, there is some N, such that for every $n > N$, the relative frequency of *heads* outcomes over $S_1, \ldots, S_n$ is within ϵ of 0.5.

Von Mises's sequences, or *Kollektive*, as he calls them, are necessarily infinite, so that an appropriate N can always be found. There are, for example, sequences in which the coin is tossed only once and then melted. In this case the relative frequency of "heads" cannot possibly be 0.5—it will have to be either 0 or 1. This is a well known objection to the interpretation of probability as relative frequency, but it will not apply here, since a sequence of one toss is not infinite.

Von Mises claims that for any given infinite sequence it is possible to find some value of N, however great, after which the relative frequency of *heads* will get as close as we wish to 0.5. It is impossible, for example, to have an infinite sequence of coin tosses which contains nothing but heads, though such finite sequences *are* possible.

This insistence on the infinity of sequences was the cause of a number of objections raised against von Mises's theory. It should be emphasized, however, the von Mises's goal was to account for the properties of observable, finite sequences, and not for some abstract infinite sequences which can never be observed. Van Lambalgen (1996) makes this point very clearly:

> Kollektivs were so designed as to be able to account for all statistical properties of finite sequences and they do so perfectly. To that end, a certain amount of idealisation, in particular the consideration of infinite sequences turned out to be convenient. But the consideration of infinite sequences was not an end in itself and von Mises certainly had no intention to model infinite random "phenomena."

Be that as it may, infinitely long sequences are, in a sense, hypothetical, and cannot be directly observed. We cannot, for example, actually examine an infinitely long sequence of smokers; but we can extrapolate from those cases that have been actually examined to the limiting relative frequency of cancer patients among smokers. The longer the actual sequence is, the more confidence we should have in the correctness of the extrapolation. As we will see below, actual infinite sequences are not necessary for the theory presented here; we can account for the puzzling properties of generics and frequency statements without assuming that they are evaluated with respect to infinite sequences, so long as these sequences are “sufficiently” long.

2.3 Branching Time

Intuitively, when we make a probability judgment, we consider not only the sequence we have actually observed, but possible forms this sequence might take in the future. It is, therefore, particularly attractive to investigate probability judgments in a framework which regards time as nonlinear, or *branching.* That is to say, for any given time there is more than one possible future. There is a course of time where the world is destroyed in the year 2000, there is a course of time where you become the President of Dalmatia, there is a course of time where I never finish writing this paper, and so on.

I will refer to a linear course of time as a *history.*[7] History H *continues* history H', written as $H' \sqsubset H$, iff H' forms an initial segment of H.

Each sequence can be taken to represent one possible history. Hence I propose the following informal definition of probability:

Definition 2 (Probability)

$P(\phi|\psi) = l$ *iff for every* admissible *history* H *and every* $\epsilon > 0$*, there is a history* $H' \sqsubset H$*, s.t. for every history* H''*,* $H' \sqsubset H'' \sqsubset H$*, the limiting relative frequency of* ϕ*s among* ψ *will be within* ϵ *of* l*.*

For example, given a fair coin, for every history H and for every $\epsilon > 0$ there is some initial segment of H where the relative frequency may be

[7] The term is due to Thomason (1970).

significantly higher or lower than 0.5; but after this initial segment, this relative frequency will be within ϵ of 0.5.

Definition 2, combined with definition 1, now provides truth conditions for generics and frequency statements. There remains one caveat, however: not every history ought to be considered. We need to define which histories are admissible.

At this point it appears that there are at least two conditions that an admissible history must satisfy. First, note that while von Mises based his definition of probability on infinite sequences, admissible histories need not be infinite; but they are required to be sufficiently long, so that the relative frequency of ϕs among ψs in the admissible will have "enough time" to come within ϵ of the probability. In particular, histories which do not contain *any* instances satisfying ψ, will not be admissible, since the relative frequency will never be defined.

Second, recall that when we evaluate a probability judgment with respect to arbitrarily long histories, these histories are extrapolated from the relevant part of the actual history, a history which has actually taken place . I will say more below about how the relevant part of that history is determined; what can already be stated here is that only histories which continue the relevant part of the actual history are admissible.

The proposed interpretation of probability, as it stands, explains the first puzzle, namely how a generic may be true even if no instances support the generalization it expresses. While there may not be such instances *currently*, supporting instances may occur in the future. Let us reconsider the sentences in (3), repeated below:

(23) a. Mary handles the mail from Antarctica.

b. Members of this club help each other in emergencies.

Sentence (23.a) does not claim that Mary actually handles mail from Antarctica, but that she is likely to do so. While Mary may never have handled mail from Antarctica yet, mail from Antarctica may arrive in the future. All that the truth of (23.a) requires is that in all sufficiently long histories in which mail does arrive, Mary will handle most of it. We may base our prediction that Mary would, indeed, handle Antarctic mail if and when it arrives, on Mary's job description;[8] but this is not what the *meaning* of (23.a), under its descriptive reading, refers to.

Similarly, (23.b) does not require that club members actually help each other in emergencies, merely that they be likely to do so. That is to say, in all sufficiently long histories which contain emergencies, club members will help each other in most cases. Again, while the constitution of the club may (but does not necessarily) help us make a prediction about how members would behave if and when emergencies occur, the meaning of (23.b), under its descriptive reading, does not refer to the constitution.

[8] Though we may base it on other things, such as the observed fact that whenever a piece of mail arrived from an exotic place, Mary immediately became curious and asked to handle it.

An account of the puzzle of extensibility also follows immediately from the proposed interpretation of probability. The probability judgment $P(\phi|\psi)$ is not evaluated with respect to the actual number of individuals satisfying ψ, but with respect to arbitrarily long histories containing such instances. Thus, no possible way of adding additional instances would change the value of the probability.

The puzzle of intensionality requires more careful consideration. Clearly, our interpretation of probability explains why generics and frequency statements are not extensional; terms which are co-extensive at the current time may have different extensions at other times. Generics and frequency statements, then, are parametric on time, as desired.

We have seen in section 1.3, however, that generics and frequency statements, while parametric on time, are *not* parametric on possible worlds. How can we explain this? If every logically possible admissible history is considered, generics and frequency statements would end up being parametric on possible worlds. In fact, it would follow that they have to hold in all possible worlds, i.e. be logically necessary. But as we have seen in section 1.5, generics and frequency statements are, in general, true or false contingently, not necessarily. For example, although there are possible histories in which all birds evolve into ostrich-like creatures and lose the faculty of flight, *Birds fly* is true. We need to find some way to admit only histories which maintain the relevant properties of the actual world. How can this goal be achieved?

3 Homogeneity

In order to answer this question, we ought to consider more carefully the evaluation of probability judgments. Since it is impossible to observe arbitrarily long histories in the actual world, these must be *extrapolated* from the actual history that transpired and was observed. For this extrapolation to be of use, we need to assume that the observed instances provide a good statistical sample. That is to say, we need to assume that the relative frequency over the sample we do have is close to the value of the probability, i.e. the relative frequency over arbitrarily long sequences. In order for us to believe this, any history we consider ought to be such that any sufficiently large sample taken from it is a good sample. Then, if our sample is sufficiently large, we can extrapolate from it with some confidence.

This idea has already been explored by von Mises, who requires an admissible sequence to be *random*, in the sense that every sub-sequence selected from it and satisfying some constraints[9] must have the same relative frequency as that of the original sequence.

A random sequence, then, is one in which the relative frequency of a certain outcome over all sufficiently large sub-sequences approximates the probability for that outcome. A random sequence does not admit of long "chunks" where the relative frequency of ϕs among ψs differs from the relative frequency in the sequence as a whole. In the words of Fisher (1959), it must

[9]Von Mises and subsequent researchers have made a number of proposals regarding the appropriate constraints; see Salmon (1977) for an overview.

be “subjectively homogeneous and without recognizable stratification” (p. 33). Note that according to this definition, a sequence consisting wholly of ϕs is random, since the relative frequency is 1 over all sub-sequences. Indeed, it can be seen as a boundary case of a sequence generated by a “random” process with probability 1.

A useful way to formalize this notion is proposed by Salmon (1977). He discusses *homogeneous* reference classes, which he defines as follows:

Definition 3 (Homogeneity)
A reference class ψ is homogeneous with respect to a property ϕ, iff there is no suitable *set of properties Ω such that:*

1. *Ω induces a partition on ψ, i.e. $\forall x : \psi(x) \rightarrow \exists! \omega \in \Omega : \omega(x)$.*

2. *$\exists \omega \in \Omega : P(\phi|\psi \wedge \omega) \neq P(\phi|\psi)$.*

Thus, a reference class ψ is homogeneous iff there is no “suitable” subset of ψ s.t. the probability of ϕ given this subset is different from the probability of ϕ given ψ as a whole.

I would like to require that the domain of generics and frequency adverbs be homogeneous.[10] In order for this requirement to carry the burden it is

[10]This should not be confused with Link's (1995) claim that generics quantify only over homogeneous subclasses of their domain; homogeneity, according to Link, simply means that *all* individuals in the (suitably restricted) domain of the generic satisfy the predicated property.

intended for, we need to discuss the restriction of partitions to "suitable" ones.

Salmon notes that there are two trivial cases of homogeneous reference classes: when all ψs are ϕs and when no ψs are ϕs. In the former case, the probability of ϕ given any subset of the reference class would be equal to 1, and in the latter case to 0. He observes that, if every partition is considered suitable, homogeneity would only be satisfied in the trivial cases, since a partition which violates homogeneity can always be found in any non-trivial case. Suppose that at least one ψ is a ϕ, and at least one ψ is not a ϕ; now let $\Omega = \{\phi, \psi \wedge \neg\phi\}$. Ω is clearly a partition of ψ; moreover, it violates homogeneity, since $P(\phi|\psi \wedge \phi) = 1$ and $P(\phi|\psi \wedge (\psi \wedge \neg\phi)) = 0$. Clearly, then, not every conceivable way to partition the reference class ought to be considered; the class of possible partitions must be constrained in some way, so that only suitable ones be considered, if the concept of homogeneity is to play any useful role at all.

3.1 F-Admissibility

A natural way to partition the domain of a generic or a frequency adverb is according to *time*. Let us redefine the admissibility of histories in such a way that only histories in which a homogeneous sequence of individuals occurs will be admissible. We will require that for every "sufficiently long" time interval, the relative frequency of ϕs among ψ during this interval should be equal to the relative frequency over the history as a whole.

This requirement is vague on the issue of what it means for an interval to be sufficiently long. How long is sufficiently long? This issue seems to be determined pragmatically. The size of the intervals would vary from case to case, depending on what is perceived to be an appropriate sample size. For example, given (24.a), the interval size would be on the order of several minutes; given (24.b), we would consider intervals several days, perhaps weeks long; given (24.c), the interval size might be on the order of weeks or months; given (24.d), each interval would be several years long; and given (24.e) we have very long intervals, on the order of biological eons.

(24) a. This broadcast is frequently interrupted by commercials.

b. Mary often takes wine with her dinner.

c. John sometimes jogs in the park.

d. Kate spends her holidays in Switzerland.

e. Birds fly.

One more difficulty with the homogeneity constraint has to do with the requirement that the relative frequency on every sufficiently long interval be precisely equal to the limiting relative frequency over the history as a whole. This requirement is unnecessarily strong; for our purposes, a weaker requirement will suffice. Given a condition for the history as a whole, as determined by the adverb (e.g. greater than 0 for *sometimes*, or greater than 0.5 for **gen**), we will require that this conditions be either satisfied by the relative frequency over all sufficiently long intervals (in which case the sentence is true), or by none of them (in which case it is false). Otherwise, the sentence will be ruled out as a violation of the homogneity requirement.

Recall that one of the criteria for the admissibility of a history is that it must continue the relevant part of the actual history. We are now in a position to say more about this. There are cases where the relevant part of the actual history is explicitly stated:

(25) a. Moths were (usually) black in the industrial areas of Britain in the late 19th century (Manfred Krifka, personal communication).

b. Since the last election, foreign affairs have (often) been neglected.

c. In the 52nd century, robots will (never) be welcome in polite society.

Sentence (25.a) is evaluated with respect to histories continuing the late 19th century, sentence (25.b) is evaluated with respect to histories which continue the history from the last election to the present, and (25.c) is evaluated with respect to histories continuing the 52nd century.

It is important to emphasize that the temporal modifier restricts the relevant part of the actual history, not the duration of an admissible one. Sentence (25.a) is not simply about that moths that happened to exist in the late 19th century, but is lawlike; it implies that if things were today the way they were in the 19th century, moths would be black today. In an admissible history, things today (and in the future too), *are* the way they were in the late 19th century. Such a history will not be restricted just to the duration of the late 19th century, but will be arbitrarily long—it might go on to the 20th century, the 21st century, and beyond.

The year 1956, for example, will be included in an admissible history too, and it will be, just like the actual 1956, part of the 20th, not the 19th century. However, the events in the year 1956 in an admissible history will be different from those in the actual 1956: for example, the British Clean Air Act might not be enacted, as it was in the actual 1956. In fact, in an admissible history, unlike the actual history, the situation in 1956 will be very similar to that in the late 19th century.

With respect to (25.c), we obviously have no way of knowing what will happen in the 52nd century, so that we cannot determine with certainty whether a given history continues it or not. But this is the usual problem of statements about the future, and is not specific to the issues involving generics and frequency statements.

If the relevant part of the actual history is not stated explicitly, it must be inferred from the context. Of particular importance are sentences in the present tense, since generics and frequency statements usually occur in this form. In this case, the relevant part of the actual history is the longest homogeneous history ending with the present. For example, the history which is relevant for (24.c) begins with the time when John started jogging in the park with roughly the frequency with which he does so today. With regard to (24.d), the relevant history starts at the time when Kate started having her preference for Switzerland as a vacation destination, and so on.

If no relevant part of the actual history can be found, there are no admissible histories. What happens in this case? According to definition 2, for any l, vacuously $P(\phi|\psi) = l$. This is, of course, impossible; hence it follows that definition 2 presupposes the existence of admissible histories, and if none exist, the probability is undefined and the corresponding sentence is ill formed. Therefore, if no part of the actual history is relevant, the sentence is ruled out as a case of presupposition failure. This explains the fourth puzzle: generics and frequency statements do not hold of temporary generalizations because, in such cases, the present part of the actual history is not perceived to be homogeneous, since the generalization is temporary and is expected to change soon. For example, even if all Supreme Court judges do have a prime Social Security number now, this property is expected to change soon, as the composition of the Supreme Court changes, hence the actual history is not considered relevant, and there are no admissible histories. This accounts for the unacceptability of (12.a).

Let us call histories which continue the relevant part of the actual history and are homogeneous with respect to time—F-admissible histories (the reason will become clear momentarily). A history, then, is admissible just in case it is F-admissible, and probabilities are defined over admissible histories.

What sort of thing is an admissible history, then? With respect to a generic or a frequency statement $Q(\psi, \phi)$, it is a history where the proportion of ϕs among ψs remains pretty much the same. With respect to *Birds fly*, for example, an admissible history is one where the proportion of flying birds among birds is pretty much constant. There may be relatively brief fluctuations, but, on the whole, there will not be any significantly long intervals of time where the proportion of flying birds changes drastically, and there will not be prolonged discontinuities. Thus, a history in which birds suddenly lose the faculty of flight will *not* be admissible.

To take another example, let us consider (24.c). Here, an admissible history is one in which John's jogging in the park continues with pretty much the same frequency. It is possible that for a few days in a row he might be ill and not jog, or that on some week or other he might feel a lot of energy and jog every day. But, on the whole, his jogging frequency should remain pretty much constant throughout the history. A history in which John jogs furiously in the park just before the summer in order to lose weight, and then stays idle the rest of the year, will not be admissible. The reason is that there would be a sufficiently long time interval where the frequency of John's jogging is very high, and another sufficiently long time interval where that frequency is very low.

The relative frequency throughout an admissible history, then, is roughly the same as it is during the relevant part of the actual history; for example, (26) is evaluated with respect to admissible histories in which John continues to jog with pretty much the same frequency as he did last year:

(26) John sometimes jogged in the park last year.

Similarly, (25.a) is evaluated with respect to admissible histories where the proportion of black moths in these histories is roughly the same as it was in the late 19th century.

It is the restriction of histories to admissible ones which accounts for the fact that generics and frequency statements are not parametric on possible worlds. There are any number of worlds where birds do not fly and where John does not jog in the park, and correspondingly there are any number of histories where birds lose the faculty of flight and John quits jogging. But such histories will not be admissible. In order for them to be admissible they would have to continue the actual history; but in the actual history birds do fly and John does jog, so these histories would fail to be homogeneous. Only histories in which things happen pretty much the way they occur in the actual world will be admissible, hence generics and frequency statements are not parametric on possible worlds. Since these histories are similar to the actual world, with its contingent properties, generics and frequency statements are contingent and not necessary.

The notion of homogeneity also accounts for the observation, discussed in section 1.6 above, that generics and frequency statements require a regular distribution of events in time. In a state of affairs where the distribution of events is not regular, any history with respect to which the sentence is evaluated will not be homogeneous. Hence there will not be any admissible histories. Since, as we have noted, the proposed interpretation of probability presupposes the existence of admissible histories, the sentence would be ruled out as a case of presupposition failure.

Admissible histories are rather stagnant. There are no revolutions, no developments; John may decide not to jog for a couple of days, but he will jog on other days, and continue to jog with roughly the same frequency. It should be clear, then, that admissible histories are not to be confused with notions such as Dowty's (1979) *inertia worlds*, or with normal worlds (Delgrande 1987; Morreau 1992; Krifka 1995 among others), where things take their normal course. The normal course of events is actually for John to stop jogging at some point, but not so in an admissible history. Admissible histories, then, represent somewhat bizarre worlds. Why are generics and frequency statements evaluated with respect to such worlds, rather than normal ones?

For one thing, note that even if the normality approach did account for generics,[11] it would not be applicable to frequency statements in general. For example, (27.a) is claimed to be true because all normal birds fly; but then (27.b) ought to be predicted false, since, by hypothesis, all normal birds do fly.

(27) a. Birds fly.

b. Birds are sometimes incapable of flying.

Of particular importance here is the fact that normal worlds are epistemically opaque; we cannot observe them, either directly or indirectly. The

[11] And there are a number of empirical and theoretical problems with it—see A. Cohen (1995, 1996) for discussion.

only world open to our inspection is the actual one, but under any reasonable conception of normality, the actual world is not normal. How, then, can we tell what things are like in a normal world? And how can we judge the truth values of generics and frequency statements, if such judgments require knowledge of normal worlds?

Admissible histories, in contrast with normal worlds, are not opaque. While it is true that admissible histories cannot be observed in their entirety in the actual world, we are in a position to observe their initial segment, since all admissible histories continue the relevant part of the actual history. Thus, the longer the relevant actual history, the more information we have regarding the admissible histories, and the more confidence we have in extrapolating their properties. This approach provides a direct link between observations in the actual world and the truth judgments of generics and frequency statements: while not completely determining such truth judgments, observations in the actual world help us extrapolate to admissible histories, with respect to which we make our truth judgments. No such link is provided by theories which propose that generics and frequency statements are expressions of normality.

The only requirement from an admissible history is that it continue a regularity observed throughout a sufficiently long sample in the actual world. In particular, we need not postulate any rules or laws which hold in an admissible history. Presumably, an observed regularity does follow from some rule, be it physical, social, genetic, or whatever; but importantly, we need not know what this rule is, or even that there is, in fact, such a rule, in order to judge the truth or falsity of a generic or a frequency statement.

There are, admittedly, cases where the relevant part of the actual history occurs, partly or fully, in the future (e.g. (23) or (25.c)). In such cases, we may have expectations about what this history will look like, and these expectations might, though they do not have to, depend on some rule or regulation. We may judge the sentence, like we judge any sentence about the future, based on our expectations. But the important thing is what actually happens: for example, if mail from Antarctica does arrive and Mary fails to handle it, (23.a) is false (under its descriptive reading), regardless of what the regulations defining Mary's job say.

Note that the bizarreness of admissible histories derives not from their dissimilarity to the actual world, but, in fact, from their great similarity to it, as it is at the present moment. While the actual world keeps changing, and tomorrow's world is different from today's world, in an admissible history the world is always pretty much the same. Heraclitus tells us that we cannot step twice in the same river; in an admissible history, no matter how many times we step into it, the river will still remain pretty much the same river.

3.2 G-admissibility

By evaluating generics and frequency statements only with respect to F-admissible histories, we make sure that they obey the homogeneity constraint, i.e. their domain is homogeneous with respect to the predicated property. That is to say, for every sufficiently long interval, the relative frequency satisfies the same condition (e.g. greater than 0.5) as the limiting relative frequency over the history as a whole. Yet, it is obviously possible to partition a domain in other ways, not simply according to time. Do other partitions play a role in the evaluation of generics and frequency statements?

The answer to this question, I claim, is yes. While frequency adverbs require their domain to be homogeneous only with respect to the time partition, generics require homogeneity with respect to a great number of other partitions as well. Before presenting arguments for this claim, we should note that it seems to correspond rather well to the pre-theoretical notion of what a generic sentence means. Lowe (1991), for example, considers (28):

(28) Fido chases cats

He writes:

> The sort of empirical evidence which *would* support or undermine the truth of [(28)] is a matter that is broadly familiar to us all (though it is by no means a *simple* matter). If Fido is found to chase a good many different individual cats, of varying sizes, colours, ages and temperaments, then, *ceteris paribus*, we shall consider [(28)] to be empirically well supported; if not, then not (p. 295, original emphases).

Lowe's observation makes intuitive sense. Note that what this means is that it is not sufficient for Fido to chase many cats, but that he should chase cats of many varieties. That is to say, the domain of the generic has to be homogeneous with respect to many partitions, depending on cats' sizes, colors, etc.

Of course, not every logically possible partition may be considered, or, as we have observed above, generics would only be true if they held universally over all their domain. I would like to suggest that, at least in so far as generics are concerned, the suitability of a partition is a pragmatic matter. A partition is suitable to the extent that it is considered *salient*, given the context and the language user's model of the world. In other words, it cannot be any arbitrary partition; it needs to "make sense" given the context and the way we view the world.[12] The domain of the generic quantifier, then, must be homogeneous with respect to the predicated property and a set of salient partitions.

Let us assume that for any combination of a sentence, a language user, and a context, there is a set of salient partitions. We can now change our definition of admissible histories. When a generic is concerned, then, it is not sufficient for a history to be F-admissible. That is to say, the domain of a generic ought to be homogeneous not only with respect to the time partition, but also with respect to all other salient partitions. A stronger criterion for admissibility is required; I will call it G-admissibility.

[12]This should not be confused with Salmon's (1977) notion of *epistemic homogeneity*. While the saliency of partitions may vary across individuals and contexts, I take it to be an objective fact whether or not a given domain is homogeneous with respect to a particular set of salient partitions and a property.

The probability judgment expressed by a generic sentence, then, is evaluated with respect to G-admissible histories, whereas a frequency statement is evaluated with respect to F-admissible histories. This is the difference between the generic quantifier and *usually*; both express the same probability judgment, but they have different admissibility criteria: the former is evaluated with respect to G-admissible histories, whereas the latter only requires F-admissible ones.

I will not attempt here to present an exhaustive list of salient partitions, nor will I attempt to identify the conditions under which a particular partition is salient. Some comments and illustrative examples, however, are in order.

It is sometimes clear whether a partition is salient or not. For example, Jorge Lois Borges's famous taxonomy,[13] in which animals are divided into such groups as *those that belong to the Emperor* and *stray dogs*, is clearly not salient; in fact, its sole purpose is to demonstrate a classification which humans would find extremely unnatural.

Nevertheless, judgments on whether a partition is considered salient in a given context may vary considerably across cultures, languages and individuals. It is possible that a speaker of Dyirbal, for example, would consider a partition which groups together women, dogs, crickets, water, and fire to be

[13] From "The Analytical Language of John Wilkins," in *Other Inquisitions* (University of Texas Press, 1964). Of course, strictly speaking, Borges's taxonomy is not really a partition, since some categories overlap.

quite natural (cf. Dixon 1982); a speaker of English may find such a partition very bizarre.[14] Even among individuals within the same language community, opinions might vary: for a zoologist, very fine distinctions among birds might be salient; not so for the layperson.

Individuals, then, may differ on how salient they consider a given partition to be; this accounts for the seventh puzzle: truth judgments of generics are often uncertain and vary across informants. If, for a given speaker, the domain of birds is not homogeneous with regard to the property of flying, *Birds fly* would not be judged true. For such a speaker, there would be a salient partition of the set of birds, such that one of its subsets would have a majority of non-flying birds. For example, if we partition the domain of birds into biological families, and the penguin family (Spheniscidae) is a member of this partition, it would be just such a subset. Hence the domain of birds would not be homogeneous with respect to the property of flying, and the sentence would not be judged true.[15]

We noted in section 1.7 above that judgments of sentences containing frequency adverbs do not suffer from the same uncertainty and variability

[14]This is possible, but, as far as I know, has not actually been established. The answer relies mostly on whether there is any truth to (the weak form of) the linguistic relativity hypothesis.

[15]It would not usually be judged false either; people sometimes describe the sentence as "inaccurate," "incomplete," or "lazy," but not false. Indeed, (i) is not judged true:

(i) It is false that birds fly.

as judgments of generics. I propose that the reason for this difference between generics and frequency adverbs stems from the different criteria for saliency. Since for frequency adverbs, only temporal partitions are relevant for satisfying the homogeneity constraint, judgments on the truth or falsity of *Birds usually fly* do not depend on whether or not partitioning the domain according to biological families is considered salient.

Judgments on the saliency of a partition may be influenced by the linguistic form of the relevant sentence. Consider the following pair of examples:

(29) a. Mammals are placental mammals.

b. Mammals have a placenta.

The majority of mammals are, indeed, placental mammals; yet (29.a) is bad. In this case, partition into biological families, orders, or infraclasses would cause the homogeneity constraint to be violated, since some of the subsets of mammals induced by the partition would consist of marsupials. This, I propose, is the explanation for the unacceptability of (29.a). Note that (29.b) is considerably better, and many people would judge it to be true. Taxonomic partitions are less salient when (29.b) is evaluated, because, unlike (29.a), here there is no direct reference to the taxonomy of mammals.

Note that, as mentioned above, if *all* members of a domain satisfy a given property, the domain is trivially homogeneous with respect to *any* partition. Thus, since all dogs, without exception, are placental mammals, (30) is unproblematic, in fact true:

(30) Dogs are placental mammals.

The homogeneity requirement explains the eighth and last puzzle, namely why majority is not enough; for a generic to be true, its domain must also be homogeneous. Let us look in detail at the problematic sentences from section 1.8 above; this will give us an opportunity to consider some examples of salient partitions.

3.3 Some Salient Partitions

Space

One partition which is often perceived to be salient is that of *space*, i.e. a partition of the individuals in the domain according to their location. This explains why (20.a), repeated here as (31), is bad, even though the majority of Israelis do live on the coastal plane:

(31) Israelis live on the coastal plane.

If the domain of Israelis is partitioned according to the geographical regions in which they live, there will obviously be subsets of this domain whose members do not live on the coastal plane, e.g. those who live in Jerusalem or Beer Sheva. Hence, the domain is not homogeneous with respect to the property of living on the coastal plane, and (31) is ruled out.

Partitioning individuals according to their location, or, perhaps, their ethnic group, also accounts for (20.b) and (20.c), repeated below:

(32) a. People in southeast Asia speak Chinese.

b. People have black hair.

Although the majority of people in southeast Asia do speak Chinese, there are regions (and peoples) where Chinese speakers are in the minority. Consequently, the set of southeast Asians is not homogeneous with respect to the property of speaking Chinese, and (32.a) is ruled out. Similarly, while the majority of people in the world have black hair, this does not hold in all regions or of all ethnic groups. Many Scandinavians, for example, do not have black hair. If such a partition is taken into account, the domain of people is not homogeneous with respect to the property of having black hair.

Just like other partitions, the *space* partition may not always be salient, depending on the context. For example, in many contexts and for many speakers, this partition is not salient when (33) is evaluated.

(33) Birds fly.

If it were, the domain of the generic would not be homogeneous, since in Antarctica, over 80% of all birds are penguins, which do not fly. Hence, sentence (33) would be ruled out if the *space* partition were considered salient. Of course, it might be that people who judge (33) to be odd do so not because they consider the partition to biological families salient, but because they consider the *space* partition to be salient in this case.

Numerical Scales

Sentences (20.d) and (20.e), repeated here as (34.a) and (34.b), respectively, can be accounted for if *age* is considered a salient partition:

(34) a. People are over three years old.

b. Crocodiles die before they attain an age of two weeks.

The majority of people are clearly over three years old, and the majority of crocodiles do, indeed, perish in their infancy; yet (34.a) and (34.b) are bad. If we partition people according to their ages, there will be some subsets of people (e.g. babies) such that the probability for their members to be over three years old is zero. Hence the domain of the generic quantifier is not homogeneous, and sentence (34.a) is ruled out. Similarly, the domain of crocodiles is not homogeneous with respect to the property of dying before the age of two weeks. If we partition crocodiles according to their ages, there will be subsets of crocodiles all of whose members are older than two weeks; hence the homogeneity constraint is violated and (34.b) is ruled out.

We should note, once more, that the saliency of a partition is dependent on the context. Suppose the *age* partition were considered salient when evaluating the following:

(35) Birds fly.

The domain, then, would not be homogeneous with respect to the property of flying, since fledglings do not fly. Hence, the sentence would be predicted bad. Again, note that people who judge (35) to be bad may consider the *age* partition to be salient in this case.

Note that *age* constitutes a numerical scale; we can order people linearly according to their age. In many, perhaps all cases, scales may induce a salient partition. For example:

(36) a. Buildings are less than 1000 feet tall.

b. Animals weigh less than two tons.

c. Shoes are size 7 and above.

All the properties predicated in the sentences in (36) hold of the vast majority of the individuals in their domain (but not all of them), yet these sentences are odd. This can be explained if numerical scales induce salient partitions, since height, weight and shoe size are all numerical scales. An investigation into the nature of scales (see Horn 1972; Hirschberg 1985) may shed some light on the factors which determine the saliency of a partition.

Gender

Gender is often a salient partition too. Thus, although the majority of primary school teachers are female, (20.f), repeated below, is odd:

(37) Primary school teachers are female.

The reason is that, if we partition the set of teachers according to their gender, there will obviously be a set, the probability of whose members to be female is zero—the set of male teachers. Therefore, the set of teachers is not homogeneous with respect to the property of being female.

The same partition accounts for (20.g), repeated here as (38):

(38) Bees are sexually sterile.

Although the vast majority of bees are, indeed, sterile, there is a subset of bees which are not, if bees are partitioned according to their gender—the drones. Since their probability to be sexually sterile is very low, the homogeneity constraint is not satisfied.[16]

The requirement of homogeneity explains a phenomenon which poses a major challenge for any theory of generics. Every mammal which bears live young is female, but not vice versa; yet (39.a) is true and (39.b) is not:

(39) a. Mammals give birth to live young.

b. Mammals are female.

In A. Cohen (1996, 1997) I propose that the property *give birth to live young* induces a set of alternative forms of procreation, e.g. {*give birth to live young, lay eggs, undergo mitosis*}. The domain of the generic is restricted to only those mammals which satisfy one of the alternatives, i.e. procreate in some fashion; this constitutes a subset of female mammals. Since a procreating mammal is highly likely to give birth to live young, (39.a) is true.

[16] Alternatively, perhaps the relevant partition is according to reproductive ability, and then the subset of queens, which are not sterile, would also violate the homogeneity constraint.

The property *be female*, on the other hand, induces a set of alternative genders, i.e. {*be female, be male*}. Hence the domain of the generic constitutes all mammals which are either female or male, i.e. all mammals. This domain, unlike the domain of procreating mammals, is clearly *not* homogeneous with respect to a partition according to gender; there is a subset of mammals whose probability to be female is 1, and another subset whose probability is 0. Hence the homogeneity requirement is not satisfied, and (39.b) is ruled out.

Subject Matter

The majority of books are probably printed in paperback rather than in hardcover, yet (20.h), repeated here as (40), is odd:

(40) Books are paperbacks.

I suggest that in this case, the relevant salient partition involves dividing books according to their subject matter. Detective stories, for example, are much more likely to be published as paperbacks, whereas reference books are more likely to be printed in hardcover. The domain of books, then, is not homogeneous with respect to the property of being a paperback; any browser in a bookstore would see shelves where the majority of books are paperbacks, and shelves where the majority are hardcover. Consequently, the homogeneity constraint is not satisfied, and (40) is ruled out.

Abstract Domains

Sentence (20.i), repeated here as (41), is an interesting example:

(41) Prime numbers are odd.

Although the vast majority of prime numbers, indeed, all of them except for 2, are odd, (41) is bad. This seems to be the case in general for generics involving mathematical statements—they do not allow any exceptions. The explanation for this fact, I claim, is that in mathematical domains, *every* partition is salient. Mathematics is an abstract realm, where we do not have solid intuitions about what is or is not "natural"; every way to divide up the domain makes just as much sense as any other way. Since some partitions of the set of primes (e.g. the partition into even and odd numbers) include the singleton set $\{2\}$, the probability of whose sole member to be odd is, of course, zero, the homogeneity constraint is violated.

Note that sentences similar to (41), but which are divorced from the realm of mathematics, may be judged true. Suppose that, in order to reduce the risk of forgery, it were decided that the identifying number on $1000 bills be prime. Given such a scenario, (42) would be true:

(42) $1000 bills have an odd identifying number.

The domain of $1000 bills is not abstract, and some partitions (e.g. a partition based on the date on which a bill was printed) would be more salient than others. A partition which would isolate the one specific $1000 bill with the identifying number 2 would not normally be considered salient; hence the domain of $1000 bills is homogeneous, and sentence (42)—true.

Frequency Adverbs vs. Generics

We have noted in section 1.8 that all the problematic generics discussed above would be true if the frequency adverb *usually* were used instead of the phonologically null generic quantifier. This provides further evidence for the claim that frequency adverbs only require homogeneity with respect to temporal partitions. Thus, while frequency statements, just like generics, require regular distribution of events in time, they do not have similar requirements with respect to other partitions. This, perhaps, is the source of the rather pervasive intuition that the temporal sense of frequency adverbs is somehow primary, and the atemporal sense is somehow secondary or derived. I agree with Lewis (1975) that frequency adverbs may bind both temporal[17] and atemporal variables; but they only require homogeneity with respect to temporal partitions, regardless of what type of entities they quantify over.[18]

[17] Or quasi-temporal, e.g. events, situations, occasions, and the like.

[18] Alternatively, it might perhaps be proposed that the domain of frequency adverbs is always temporal, hence can only be considered homogeneous with respect to the time partition.

3.4 Quantificational Predicates

The notion of homogeneity can help account for the phenomenon of *quantificational predicates.* The term is due to Krifka *et al* (1995), who use it to designate a class of predicates such as *be common, be rare,* and *be widespread*:

> Consider the sentence *A rhino (with blue eyes) is common.* It does not express a property of a specific rhino, nor does it express a generalization over individual rhinos. Instead its meaning is 'The *chance* of encountering a (blue-eyed) rhino is high', that is, it is a statement about the distribution of rhinos (p. 96, emphasis added).

A quantificational predicate, then, is a statement about the chance of observing individuals satisfying a certain property; this naturally calls for an analysis in terms of probability. Consider (43):

(43) Rhinos are common in Africa.

This sentence would be true just in case the probability of encountering a rhino in Africa is high, i.e. $P(\textbf{rhino}|\textbf{animal-in-Africa}) \gg 0$.

Krifka *et al* go on to note that

> in *be common*, as well as in the similar *be widespread*, there is a meaning component implying that one can come across the entities in question at many places all over the universe; a sentence such as *Rhinos are common in Africa* seems to be false in case there are many rhinos in Africa, but all of them gathered at a single place, say, in the Ngorongoro crater (p. 97).

This requirement follows naturally from the homogeneity constraint; the reference class must be homogeneous with respect to the property of being a rhino, given the *space* partition. Therefore, for (43) to be true, rhinos must be distributed more or less evenly across Africa. Note that while Krifka *et al.* claim that (43) would be false in a situation where all rhinos are concentrated in one spot, it seems to me that in this case the sentence would be bad, rather than simply false. The appropriate response to (43) seems to be something like *But they are all in the same place!*, rather than a simple denial of its truth. This is explained by the fact that the homogeneity of the reference class of the probability judgment is a presupposition, rather than an entailment.

4 Summary

The goal of this paper has been to provide a unified account for a variety of puzzling properties of generics and frequency statements. I have argued that these constructions express probability judgments, interpreted as expressions of hypothetical relative frequency, and claimed that this move provides explanations for eight puzzling phenomena:

1. Generics and frequency statements may be true even in the absence of supporting instances, because they are evaluated with respect to possible future histories, where relevant instances do occur.

2. The truth value of a generic or a frequency statement would remain

the same even its domain were larger than it actually is, since it is evaluated with respect to histories already containing arbitrarily many individuals belonging to its domain.

3. Generics and frequency statements are parametric on time, but not possible worlds, since they are evaluated with respect to admissible histories which differ from one another in the way things develop in time, but not in the world they are in.

4. Generics and frequency statements do not hold of temporary generalizations, because admissible histories must be homogeneous; and an actual history which contains a temporary generalization cannot form the initial segment of a homogeneous history.

5. Generics and frequency statements are true or false contingently, since all admissible histories must continue the relevant part of the actual history, with all its contingent properties.

6. Generics and frequency adverbs require their domain to be homogeneous in time, hence they require regular distribution of events along the time line.

7. Truth judgments of generics are uncertain and vary across individuals, because perceptions of the saliency of partitions vary across individuals.

8. A generic may be unacceptable even if an overwhelming number of instances support the generalization it expresses, because for a generic

to be acceptable its domain must be homogeneous with respect to all salient partitions.

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