Information, Relevance, and Social Decisionmaking: Some Principles and Results of Decision-Theoretic Semantics

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Abstract. I propose to treat natural language semantics as a branch of pragmatics, identified in the way of C.S. Peirce, F.P. Ramsey, and R. Carnap as decision-theory. The notion of relevance plays a key role. It is explicated traditionally, distinguished from a recent homophone, and applied in its natural framework of issue-based communication. Empirical emphasis is on implicature and presupposition. Several theorems are stated and made use of. Items analyzed include 'or', 'not', 'but', 'even', and 'also'. I conclude on parts of mind.

This paper submits an approach to meaning, with a focus on broadly non-truth-conditional aspects of natural language. Semantics is treated as a branch of pragmatics, identified as decision-theory in the way of C.S. Peirce, F.P. Ramsey, and of Rudolf Carnap in his later work.

A key theoretical notion, distinguishable from, but intelligibly related to, information is the positive or negative relevance of a proposition or sentence to another. It is explicated in the probabilistic way familiar from Carnap and traditional in the philosophies of science and rational action. This makes it a representation of local epistemic context-change potential that is directional in a precisely specifiable sense and naturally related to utterers' instrumental intentions.

Relevance so defined is proposed as an explicans for Oswald Ducrot's insightful '*valeur argumentative*'. In view of possible confusion among some students of language, it is contrasted with a more recent and idiosyncratic pretender to the appellation, due to Dan Sperber and Deirdre Wilson. The latter proposal turns out, at best, to paraphrase H.P. Grice's non-directional concepts of 'informativeness' and 'perspicuity'. (More informative designations are suggested for it, and for the eponymous linguistic doctrine emanating from parts of CNRS Paris and of UC London.)

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Another key notion to be introduced as closely related to signed relevance is that of 'issue-based communication'. The paradigmatic communicative situation here, unlike in Grice's work on meaning and in its direct developments, is a bargaining game. Participants with actually or virtually inverse preferences regarding an issue negotiate constraints on joint conduct or epistemic commitments. They make claims and supply incentives. A special case thereof is evidence, the utility of which is given by its signed relevance to issue outcomes.

The first three sections below outline (a) basic assumptions, notably on the use of probability under its judgmental interpretation; (b) some relations to other approaches, notably dynamic semantics and (Neo)-Gricean pragmatics; and (c) reasons for considering the more recent homophone doctrine non-pertinent. The next four sections add some detail, with outlines of a range of results wide enough to justify the term 'approach'. Phenomena addressed with novel accounts include those familiar under the following labels: 'conversational implicature', both particularized and generalized, the latter exemplified with 'or' and the Jespersen/Ducrot/Horn facts on negation in scalar predicate contexts (Section IV); 'conventional implicature', illustrated by 'even' and 'but', an implicational universal of which is shown to engage fairly deep properties of inductive reasoning (Section V); 'presupposition' and 'accommodation' with emphasis on 'also', so as to treat 'but also' (Section VI). Assumptions guaranteeing compositionality of relevance are seen to militate for dichotomous issues (Section VII). I conclude with a thesis on the 'sociomorph' nature of some aspects of language and of parts of mind attaching to it.

I. Introduction: Probability in Meaning and Cognition

'Information' is a partial synonym of 'meaning', and there is little of either without reasoning. The most familiar framework for reasoning is that of deductive theories within a classical logic. Let such a theory, T, represent an epistemic state.[1] Changes of epistemic state will be theory changes. Information brings about changes of epistemic state. Classical theory change is monotonic: what is derivable stays derivable. New things may become derivable; and will so become, if the state transformation is not vacuous. A transformation is vacuous if induced by an uninformative and, in this sense, meaningless addition.

Let $\mathrm{Cn}(\Sigma)$ be the smallest set of consequences of a set Σ of sentences that includes Σ and is closed under conjunction and classical consequence.

[1] Or doxastic state. In strict parlance, the more familiar 'epistemic' relates to knowledge. This is belief (*doxa*) which is, at the very least, also true. I usually say 'epistemic' when meaning 'doxastic'; as many writers do.

Thus, Cn is a Tarskian closure operation. One might thus identify the meaning of a sentence E in epistemic context T with the set-difference $\mathrm{Cn}(T, E) - T$ i.e. with $\mathrm{Cn}(T, E) - \mathrm{Cn}(T)$.

Already for sentential languages and disregarding obstacles to computing inferential closure, this is not a felicitous picture of human beliefs; nor, hence, of meaning.[2] There are two main reasons. (i) Deductively independent sentences A, B may stand in inferential relations—that is: in *relevance* relations—reflected in verbal and other conduct. Indeed, if Hume was right, all empirical knowledge is of this contingent nature. (ii) Epistemic state-change is, in real life, highly *non-monotonic*. Beliefs can be given up or weakened.

The oldest though far from ontologically leanest formalism for inductive, non-monotonic reasoning is the probability calculus. Detailed theories of meaning for natural languages have not, so far, made much use of it. I suspect that some reasons for such neglect have been relatively a priori. Before proceeding to demonstrate the explanatory virtues of probability by worked example I shall, therefore, try to dispel some general misapprehensions about it. Let me start with two positive characteristics.

The axioms of probability properly extend those of classical logic. They constrain belief to be 'coherent' in the following sense: not being disposed, in unwitting practice, to consider favourable or fair a Dutch Book, i.e. a system of bets in which one *must* lose come what may (Ramsey [64]).

Such coherence is not easy to maintain in human practice. But coherence does not require the imputation of epistemic states given as unique, point-valued conditional probability functions $P(\cdot|\cdot)$. What matters is imputation of transcontextual (rationality-embodying) and contextual (local) *constraints* on possible such states. This is much as in a deductive framework. We do not require that someone's beliefs, even when represented by a deductive theory, determine a unique, completely specified possible world. A proposition, i.e. a set of worlds, will do. Analogously there is what R.C. Jeffrey ([40], p. 72) didactically called a 'probasition': a set of probability functions. It is such constraints, not numerical values, that will explain our data. Here, then, are some further praises of probability:

1. Probability is well investigated, motivated, and known. As a proper extension of classical logic it is a natural benchmark for competence

[2]Predicate languages make explicit further difficulties: the anaphoricity and denotational holism of dynamically extending, transclausal variable binding. See Ramsey [66], whose account of discourse meaning I have adapted here, closed sententially and thus trivialized for expository use; and see well-known contemporary versions of 'dynamic semantics' (e.g. Gazdar [22], Kamp [43], Heim [31], Groenendijk and Stokhof [28]) alongside Isard [38]. Some subsentential structure is engaged explicitly in Sections V and VI.

models of defeasible reasoning. At the very least it could play scout to leaner formalisms. Letting it do so instantiates a standard mathematical tactic.[3]

2. Probability trades with cardinal utility, a quantitative representation of preferences. It offers the one principled link, so far, between normative accounts of rational belief and conduct under conditions of uncertainty—one that could be relied upon when real issues are at stake. Other non-monotonic formalisms do not, as yet. A fair bit of non-monotonic inference, i.e. jumping to conclusions, can be recovered through probabilistic updating gated by utility-dependent decision-thresholds. On such a framework for statistical decisionmaking, most of the northwestern world's industrial production of middle-sized dry goods has been running profitably since the 1940s. Under the name 'Signal Detection Theory' the framework has informed much of air traffic control ergonomics and of perceptual psychophysics, the hardest branch of psychology. Probability, with decision-theory built around it, also has nice mathematical structure.

3. With Ramsey [64] we can explicate belief in terms of *dispositions to conduct* (rather than by 'holding true' and concomitant assent or dissent). This is, essentially, the Maxim of C.S. Peirce's Pragmatism. Example: if you believe rain to be more likely than dryness, don't dislike carrying an umbrella on a dry day more than being wet and are equally happy dry with or without umbrella, then take the umbrella along. In doing so you may behave in a way 'extensionally' (i.e. by inspection) indistinguishable from the way you would if you were sure it was going to rain. To the extent that meaning is seen in terms of doxastic state change potential, we can define it by the potential of meaning-bearing entities to change such dispositions.

   Pragmatist construal makes probabilistic belief states plausible. They appear less plausible if we demand introspectible accountability and explicit imputability of belief states, as required by much forensic discourse. But forensic discourse is not the only important language game of humankind. It should not, therefore, circumscribe the class of useful theories of meaning. What it should do, is raise the question of how other language games relate to it.

4. Probability functions can be treated as personal (Ramsey [64]), and thus 'judgmental' (Jeffrey [40]). This suggests an hypothesis about discourse: Competent speakers behave on the basis of assuming that

[3] See Barwise [7] for the return of classical logic in a state-subspace setting. Note also: doxastic $\Box A$ amounts to $P(A) = 1$; $\Diamond A$ to $P(A) > 0$. (See fn. 6, below.)

(sets of, or constraints on) such functions characterize the belief states of one or more of the actual or virtual discourse participants and, more importantly, codetermine their *conduct*. A well-known deductive special case of such a constraint set is the ostensible *common ground* (CG) of things firmly taken for granted by speaker and addressee (Stalnaker [75]). This suggests extending CG to a *common prior* (CP): a probability distribution that also assigns degrees of commitment to less firmly entertained beliefs or ostensible commitments. (I use 'prior' in the everyday sense that will include effects of empirical information accumulated up to some present, here the point of utterance.) CP is an idealizing construct. But so is CG; and so is, in physics, a classical particle mechanics. The suggestion for adopting a construct is, here as there: adopt, if doing so affords predictive, explanatory gains.

5. There is a base in personal probability even for a boolean semantic component or interpretive projection, and its subsentential extension. An example is Hartry Field's [18] 'conceptual role' semantics for classical predicate logic. We need not, thus, refer to extramental *sive* extrasocial truth-conditions to account for native speaker intuitions on acceptability and paraphrase.

6. Problems of sequential belief revision, related to the failure of conditional probability function spaces to be closed under conditionalization, arise analogously in non-probabilistic settings (Gärdenfors [23]).

7. Although the general probabilistic constraint satisfaction problem is in the NP-complete computational complexity class, it has company there. Example: checking a truth-table of 20 atomic constants is a long-term prospect. The general problem class is of the NP-complete type; as is generalized anaphora resolution following Ristad [69].

8. Though it is sometimes maintained that D. Kahneman and A. Tversky [KT] (cf. [42]) showed probability not to be a serious candidate component for competence models of cognition, the putative evidence has not gone unchallenged by well-informed commentators.[4] But suppose one does accept KT's central experimental finding, namely that people, in certain explicit probability assessment tasks, tend to ignore probability 'base-rates'. Then it still provides no evidence for

[4]Birnbaum's [9] re-analysis in terms of statistical decisionmaking of one of KT's evidential assessment tasks did cast some doubt on the conclusion that experimental subjects violated probabilistic reasoning so as to exhibit normative irrationality.

> the irrelevance of probability theory even to a psychologistic, descriptive theory of relevance.[5] On the contrary. KT's finding, expressed in standard probabilist terminology, is this: Subjects tend to ignore prior odds ('base rates') to the extent of setting them evens and attend only to probabilistic relevance (of current observation reports); i.e. to relevance as defined in Section III below.

Let me add a few introductory words about the specific application to be made of probability. I shall be attending mostly to phenomena which in recent years have been addressed under the heading of 'pragmatics'. Yet I think there is now nothing to be gained by using 'pragmatics' as a label for meaning-related phenomena either putatively distinct from, secondary to, or parasitic on, 'semantics proper'. For suppose we followed the late 1970's slogan 'Pragmatics = Meaning − Truth-Conditions' (Gazdar [22]). Then the central features distinguishing current Dynamic Semantics from, say, classical Montague Semantics would be part of pragmatics. And if we say: semantics is what is in the mental lexicon, then 'also', 'but' and 'even' are the province of semantics. Point (5), above, concurs; Sections IV, V, and VI below will back this up with evidence.

Accordingly we might as well let *semantics*, as an activity, mean what it presumably meant for M. Bréal, coiner of the name: the description of meaning. And that, most ecumenically, means: the specification of constraints imposed by utterances on possible contexts of use. I propose to use the label *pragmatics* for a particular approach to meaning in natural language and scientific discourse (cf. Skyrms [72]). The approach develops the pragmatism of Alexander Bain, founding editor of the journal, *Mind*, and of C.S. Peirce. Its tools and some still under-appreciated applications are, again, in large measure due to F.P. Ramsey [64].

II. Information and Relevance

Here is a brief review of probability. We start with a Boolean algebra or 'field' $\mathcal{F}$ of propositions. $\mathcal{F}$ may be identified with the set $\mathrm{Pow}(\Omega)$ of subsets of a set Ω. The elements w of Ω may be thought of as possible worlds, models, or maximal consistent sets of sentences. Probability masses (weights) are assigned to propositions and are normalized to distribute a fixed unit

[5] The chosen province of Sperber and Wilson [SW], who cite KT in apparent support of just such a contention. SW's claim, specified to probability and its import to meaning, is that it is implausible that people should be able to do unconsciously what they cannot even do consciously ([74] p.79). However, the claim is not backed by evidence specific to probability. If it is to be construed as other than unsupported special pleading, the presumption must be that it rests on a global generalization. Such a generalization could be maintained only in disregard of experimental cognitive psychology.

mass. An assignment $P(\cdot) : \mathcal{F} \rightarrow \mathbf{R}$ assigns probability values in the real interval $[0, 1]$ to propositions. Palpably, the empty set must receive zero mass $[P(\phi) = 0]$; the universal set unit mass $[P(\Omega) = 1]$. The mass of the union $A \cup B$ is the sum of the masses of A and of B minus that of $A \cap B$ (not to be counted twice!), i.e. $P(A \cup B) = P(A) + P(B) - P(A \cap B)$. These are the axioms of finitely additive probability, in standard imagery. We can also derive them from definitional constraints on rational action (Ramsey [64]).[6] Conditioning[7] a probability function $P^i(\cdot)$ on a proposition E means to transform it into a function $P^{i'}(\cdot)$ by (i) assigning zero probability mass to $\Omega - E$ (under strict coherence this amounts to transformation of Ω by set intersection with E), (ii) redistributing all probability mass previously assigned to $\Omega - E$ among points/subsets of E so as to preserve proportions of mass among them, and (iii) renormalizing so as to set $P^{i'}(E) = 1$ (i.e. $P^{i'}(\Omega \cap E) = 1$). This kinematic procedure motivates the standard, 'static' definition of conditional probability, $P^i(A|E) =_{df} P^i(AE)/P^i(E)$ [for $P(E) > 0$].[8] (Notation: $AE =_{df} A \cap B$ for sets; $AE =_{df} A \wedge B$ for sentences; $\bar{A}$ reads 'non-A'.)

A. *Informativeness, SW-Relevance, and Relevance: Preliminaries*

Against this background, Carnap and Bar-Hillel [11] [CBH] consider two explicata of *amount of information*, based on improbability.

Definition 1. $\text{cont}^i(E) =_{df} P^i(\bar{E}) = 1 - P^i(E)$.

When Ω is finite and, moreover, $P^i(\cdot)$ assigns equal probability mass to all $w \in \Omega$, then $\text{cont}^i(E)$ reduces to the relative number of worlds in $\bar{E}$, i.e. to $\text{card}\{w : w \in \bar{E}\}/\text{card}\{w : w \in \Omega\}$. The second explicatum is phenomenologically interpreted by CBH as unexpectedness:

Definition 2. $\text{inf}^i(E) =_{df} \log_2[1/(1-\text{cont}^i(E)] = -\log_2[P^i(E)]$.

[6] Recall the betting criterion for being 'coherent'. One fails to be 'strictly coherent', if one assigns zero probability to non-empty sets of possibilities. One can then be made to contract a Book by which one cannot win but *may* possibly lose. For simplicity I assume strict coherence; but only, and almost trivially so, relative to given small discourse contexts predicated on background assumptions. For strict coherence on infinite sets of possibilities there is non-standard probability measure, the range of which extends to infinitesimals (cf. e.g. Skyrms [70]).

[7] Also known as conditionalizing. Indices i individuate probability functions. In judgmental interpretation they stand for epistemic contexts, irrespective of issue-specific aspects. I make indices or strongest propositions K such that $P^i(K) = 1$ explicit where doing so makes things clearer. I suppress them where not.

[8] Jeffrey [39] generalized epistemic changes to those occasioned by shifts of probability short of epistemic certainty. I leave discussion of their uses in the present framework for another occasion. Hint: a proposition asserted may acquire greater credibility short of full commitment.

Inf is conveniently additive when A and B are stochastically independent with respect to a context i given by a probability function $P^i(\cdot)$. This means: if $P^i(A|B) = P^i(A)$, equivalently $P^i(B|A) = P^i(B)$, then $\inf^i(AB) = \inf^i(A) + \inf^i(B)$.[9] Entailment-based informativeness, which is prominent in truly formal explications of Gricean conversational implicature (Gazdar [22]; Soames [73]) is related to inf thus: If A semantically entails B ($A \models B$) then $\inf(A) \geq \inf(B)$; and if, in addition, $B \not\models A$, then $\inf(A) > \inf(B)$. The respective converses are invalid.

Inf or cont themselves have not, so far, found consequential use in linguistic pragmatics.[10] What they offer is a license to compare informativeness even of $\models$-incomparable propositions. This recalls one aspect of a notion proposed by Sperber and Wilson [74], [SW], under the name of 'relevance' and for which I propose the appellation 'SW-relevance'. I do so in view of two things: its idiosyncrasy, and its unacknowledged posteriority to a well-articulated notion of relevance which has been in common use under that generic name among philosophers and students of cognition for most of this century.

SW assume that utterances U carry an ostensive presumption of optimal relevance. This practically implies, for one: if U has several alternative interpretations $\{E_j\}$, interpret as that E^* which can be deemed most relevant in the context; if these interpretations go beyond what is minimally (literally?) said or obvious, make requisite assumptions. With Grice [26], [27], I take the heuristic value of such a principle for granted when it is stated with reference to the intuitive explicandum of relevance; and its explanatory value when it is spelt out for a pertinent explication.

However, SW have not, as intended ([74] p. 119), managed to define 'relevance' as a useful theoretical concept; i.e. have not come up with an explication of the intuitive or indeed Gricean notion. SW-relevance of a sentence E uttered in a context is large to the extent that its *contextual effects* are, and small to the extent that E in context is hard to *process*. It remains unclear how the interaction of these two notions, on any of their conceivable interpretations as variables, would determine the total relevance ordering required by the principle. Both notions remain heterogeneous and wholly informal—with one exception.

SW's sole original, formally committed and elaborated kind of effect ([74], pp. 93–117) identifies size of effect of an utterance with the *number*

[9] If Q_j is a generic element of a partition, then $\sum_j P^i(Q_j)\inf^i(Q_j)$ measures the average expected information gain from an answer, in i, to the question: Which element of the partition is the actual world in? With an intuitively different kind of sample space this is Shannon's entropy as applied in coding theory.

[10] Mandelbrot [52], reported in Miller and Chomsky [61], who derived the distributional facts of 'Zipf's Law' from statistical a priori truths unrelated to 'least effort', did not run under that label.

of non-trivial deductive consequences engendered by it, given some deductive system and a background context, and within some *lingua mentalis*. The appeal to cardinality of a set of sentences as a criterion of relevance did not, around 1980, appear well-informed to observers with a background in logic. A number of remedial accretions ensued, notably the proscription of connective introduction rules. This rules out disjunctive weakening, an obvious scourge. It also rules out conjunction introduction, i.e. the inference from, say, $\{E, K\}$ to EK. The resultant logic will thus treat the set $\{E, K, \overline{EK}\}$ as consistent. Remedy, $\wedge$-introduction, would in effect make any logically independent K and E SW-relevant (to some non-nil extent).[11] The 1995 edition still exhibits no intelligible specification of the projected logic or 'cognitive' deductive device, nor of how ampliative assumptions of a Gricean kind would be handled by it.

Suppose, then, that one omits the ill-informed detour through cardinalities. Suppose one takes, instead, the usual route of forming equivalence classes of sentences equivalent modulo classical consequence. Then one ends up with the Lindenbaum algebra of a deductive theory: the proof-theoretic correlate of a semantic Boolean algebra of propositions, where propositions may be conceived of as sets of worlds or of models. On this basis a close to closest counterpart to the SW proposal that yields a total ordering of size of effect would be some (non-negative) measure of conditional information. Call, then, E 'non-degenerately K-informative' iff $\mathrm{Cn}(K, E)$ is consistent and $\mathrm{Cn}(K, E) - K$ non-empty, where Cn is Tarskian. Think of K as a background context made explicit. The stochastic extension of $\mathrm{Cn}(K, E) - K$ is then measured by (cf. CBH [11])

Definition 3. $\inf^i(E|K) =_{df} -\log_2[P^i(E|K)]$ is the *relative amount of information* in i of proposition E *conditional on* proposition K (intuitively: additional to that of K).

This yields as a

[11] What SW would appear to have proposed ([74] p. 117n26) along such lines for the prominently featured monotone incrementation case ($\mathrm{Cns}(K) \subseteq \mathrm{Cns}(K, E)$) is that 'effect' is an increasing function of the size (i.e. cardinality) of a set $(\mathrm{Cns}(K, E) - \mathrm{Cns}(K)) - \mathrm{Cns}(E)$ of sentences of *lingua mentalis*. The interpretation of their consequence operation, here notated 'Cns', remains obscure. (My K stands for their C, my E for their P.) But suppose 'deducible' were to have a meaning more specific than, say, 'coming to mind when the mind is set going appropriately'. Then, for a context given by a (set of) sentence(s) K and a distinct simple contribution sentence E, there will be some effect if Cns demands closure under conjunction; and none if $\wedge$-introduction is proscribed. (SW do not offer a theory of nonmonotonic theory change by anything like the standards set in literature available by the early 1980s, though they assume non-monotonic revision capabilities. For something relating to such revision see fn. 12, below.)

Fact 1. $\inf^i(E|K) = \inf^i(EK) - \inf^i(K)$.[12]

This function is, like SW's cardinalities, always non-negative; and zero, when E already follows classically from K. If K is the background and is already absorbed into i, then the function reduces to $\inf^i(E)$. The function also correlates with the abovementioned schema for monotone information incrementation, familiar from Ramsey, Stalnaker, Gazdar, Kamp, and Heim. Such a function (or the variants of fn. 12) is not, of course, what SW proposed. Rather, what it represents is a closest intelligible counterpart of their apparent notion of 'effect' in a theoretical setting which does harbour a notion of relevance meeting Carnap's [10] general desiderata for the explication of a pre-theoretical notion.[13]

The 'effect' component of SW-relevance turns out, at best, to be a paraphrase or rediscovery of the first part of Gricean or Neo-Gricean Informativeness ('Be as informative as needed!'). At best: its distinctive and original features, which may have disguised the relationship to some, are just its technical infelicities. The 'effort' component of SW-relevance is essentially a conflation of the second part ('Be no more informative than needed!') with Grice's Maxim of Manner ('Be perspicuous!').[14] It has not,

[12]Proof: $\inf^i(E|K) = \log_2[1/P^i(E|K)] = \log_2[P^i(K)/P^i(EK)] = \log_2[P^i(K)] - \log_2[P^i(EK)] = \inf^i(EK) - \inf^i(K)$. Subtracting $\inf^i(E)$ as well would yield a symmetric function, $-\log_2[P^i(E|K)/P^i(E)]$, representing, modulo sign inversion, positive or negative relevance of E and K to one another (see below). Would the absolute value of that be another closest counterpart? If K represents the context of what is fully taken for granted, this function is zero. If not, and if K is still a proposition or deductively closed (set of) sentence(s), then see fn. 21, below. If, taking account of SW's mention ([74] p. 117) of erasure and of assumption strength modification, the context were to be represented by $P^i(\cdot)$ itself rather than by a proposition K in its domain, then the closest counterpart of effect size for E would simply be $\inf^i(E)$; i.e. $\inf^i(E|K)$ when K is taken for granted. This is the most likely of intelligible counterparts, all things considered.

[13]The desiderata are closeness to intuition, formal intelligibility, empirical fruitfulness, and (last and least) simplicity. SW-relevance meets none of them. As editorial comment p. 736 of *Behavioral and Brain Sciences* 10 (1987) put it, presumably regarding the first and third: '[A]re we, like St. Exupéry's star-counting businessman, just indiscriminate implication-collectors, restrained only by our limited resources?' No doubt [74] and publications invoking it discuss language phenomena that have much to do with relevance. But it is one thing to engage phenomenological intuitions that one might associate with the pre-theoretical label 'relevance' and relate them under predictively non-committal use of otherwise familiar terminology ('encoded', 'inference', 'procedure', etc.). It is another thing to have a theory of the main explicandum; or indeed one that is not pre-empted by earlier, if technically more demanding theories. The SW doctrine offers no apparent advance over prior, formally intelligible work on context-dependence of meaning, context-change, and relevance. Nor has it ever been argued to outperform, or just predict as specifically as, Ducrot's informal work on non-truthconditional meaning. The main concept of that, 'argumentative value', admits of a pertinent explication (see below).

[14]Apparently concurring now (^{2}1995) on both Informativeness and Manner: SW [74] p. 268n30.

so far, delivered value added to the plain injunction either. What SW-relevance, however, misses out on altogether is relevance.[15]

In a quantitative or qualitative stochastic epistemic setting, *relevance* is a relation between two propositions and an epistemic state ('epistemic context'). Intuitively put, E is *relevant* to H in a context iff learning its truth would affect the probability assigned to H. It is *positively* relevant to the (quantitative) extent that it raises it, *negatively* to the extent that it lowers it. Thus, relevance is relevance *to* a point, and a properly disjunctive notion: of positive and of negative relevance.[16] I shall reserve for this generic notion the equally generic designation, under which it is familiar, e.g. from Keynes [47] p. 54, Carnap [10], and Jeffrey [39]; and indeed familiar to any well-informed philosopher of science and cognition. A formal exposition is given in Section III, including a comparison with conditional informativeness. However, before proceeding there, it is worth looking at the action-theoretic concomitants of relevance thus explicated.

B. *Ducrot on the Role of Argumentation*

Relevance comes into its own when the context involves uncertainty about the resolution of an *issue*. An issue is a partition of the space of possibilities into two or more propositions to which *conflicting interests* attach. If our paradigmatic discourse situation is not one of simple 'information transfer', but of explicit or tacit *debate*, then adoption of some such proposition at issue will be the speaker's argumentative *goal*.

This idea, implicitly specialized to dichotomic issues $\{H, \overline{H}\}$, informs the approach to 'conversational' and 'conventional' implicature of Oswald Ducrot [16] and his sometime student Jean-Claude Anscombre [2]. Anscombre and Ducrot [AD] explained implicatural phenomena through rankings of propositions by what they called their *valeur argumentative* with respect to an ostensible ulterior conclusion H. Often enough, though not in

[15] As Grice also noted (see fn. 16). Nevertheless, significant numbers of students in the language sciences that have not benefited from something like rigorous prior training are now being misled by the self-conferred appellation 'Relevance Theory' (see also fn. 21). Hence, a response other than impassive neglect seems called for. I suggest, for one, use of the more specific and non-judgmental designation 'Sperber-Wilson Theory' for purposes of reference to the doctrine of which SW-relevance is the centrepiece, and [74] both the origin and citation invariant.

[16] Is not precisely this what is wanted? Recall: 'To judge whether I have been under-supplied or oversupplied with information seems to require ... the identification of a focus of relevance ...; the force of this consideration seems to be blunted by writers like Wilson and Sperber who seem to be disposed to sever the notion of relevance from the specification of some particular direction of relevance.' (Grice [27], p. 371f.) Grice's 'direction' as stated remains unspecific between two properties: being directed at a particular point, and having potentially positive or negative (besides zero) polarity of direction. The notion he criticised instantiates neither property. The traditional, probabilistic explication of relevance among propositions instantiates both: one cannot be had without the other.

general, H would be explicitly given by linguistic context. Thus, in AD's favourite didactic format, some sentence 'E' is uttered in support of some immediately prior utterance expressing H. Here is a pulp fictional example, inspired by a real case and for a task little discussed by AD, disambiguation:

> [H] *You will now give me your wallet.*
>
> [E] *If not, I'll let you have it.*
>
> [There is a bag of trash/garbage in common view. Speaker is also seen to be holding a gun.]

What interpretation, as speakers of British English, are we and Addressee (A) to give 'E'? That Speaker will let A hang on to the wallet if A doesn't hand it over? That she will present him with a disvaluable commodity, the garbage? Or with the gun? Or that she will shoot him? Most likely the last, the strongest argument in favour of acting in accordance with H.

Often enough such an H is not given, or not to be trusted as being the real, perhaps ulterior goal. And then A, or any hearer, must 'abduce' a hypothesis H^* such that the relevance of (let us simplify: unambiguous) E to H^* is maximal among the alternatives H_j in the taken-for-granted context K. This is what 'figuring out the speaker's apparent and real intentions' is all, or mostly, about. On this view, speakers S do not engage in idle gossip, do not proselytize for the sake of it, but speak to a *point*.

C. *Issue-based Communication and the Bargaining Situation*

The partisan, argumentative approach of AD can be generalized to something which, in principle, will encompass purely imperatival discourse. For note that the point just referred to is the ostensible adoption, by the interlocutor A, of a proposition H as a constraint on A's conduct or, indeed, as a *constraint on S and A's joint future*. I propose to call discourse of this kind *issue-based communication*. In game-theoretical terms, the constraint to be negotiated is a 'jointly randomized strategy' (cf. Harsanyi [30]). This joint strategy may well remain non-degenerately probabilistic, and persuasive efforts will always be attempts to shift probabilities. Interpersonal pragmatics on this view is interpersonal decision theory. Here it is, more particularly, the decision theory of bargaining.

This does not at all rule out the rational reconstruction of the stability of conventions as an equilibrium in a game of pure cooperation (Lewis [50]). Social institutions, including any sort of language game, are, as far as I am concerned, conventions in the sense of Lewis. But so are the rules of chess, which is a game of pure competition; and so are the written or unwritten rules of trading, which, if anything, is a bargaining game of mixed motives. Pure cooperation which rationalizes persistence of a convention

does not prescribe it to be, in turn, a convention of pure cooperation. We cannot, thus, in general presume what Grice, Lewis and implicitly SW do presume. This is that the linguistically *paradigmatic* forms of social interaction, even when fully conventional, have the structure of a 'team game' (of pure cooperation) where all the actors have identical or at least compatible prima facie preferences in aiming for the efficient exchange of information.

On the contrary. Whenever there is debate—whether or not you should give me your wallet; which is the most suitable meeting place; the tastiest animal to eat; which of H and $\overline{H}$ is true—proponent and sceptic have locally incompatible preferences regarding H for as long as H is an issue between them. Such agents are autonomous in the vulgar (that is: not necessarily in the technical Kantian) sense of asking

*Why ** should I (do or believe that)?*

And the answer will be: Because there are incentives in the form of sanctions, rewards, and—as a special case for the proximally pure, epistemic case—evidence (Merin [54]).

This is what lends the paradigmatic social situation the structure of a *bargaining game* (Nash [62]), proposed by Harsanyi [30] as a widely applicable model of social interaction.[17] For our purposes 'paradigmatic' means: having a theory that has a model in the kind of linguistic phenomena we want to explain. No more; no less. This empirical issue is, I believe, independent of the issue of whether or not there must be, underneath, a Lewis-construable convention.

Types of bargaining games are manifold, tokens notoriously 'brittle'. So chances are that only very robust features, shared by the whole class of bargaining games, can have predictive import for the structure of linguistic meaning. And I think: they actually do.

Even for the degenerate case, an 'ultimatum' game (example: law-abiding customer vs. fixed-price store) we know: if a proponent, Pro, makes a claim, Pro won't object to the respondent, Con, conceding more, i.e. a windfall to Pro, but will mind getting less. Con, in turn, won't mind giving away less than conceded, but will mind giving away more. Put simply: claims are such as to engender intuitions glossable 'at least'; concessions, dually, 'at most'. We shall see (Section IV) that this very robust feature of all bargaining games already affords a lot of linguistically useful structure.

Speaker's *utility* attaching to an imperative/jussive E is, prima facie, the utility attaching to the prospect of its realization. What, then, is it for indicative/declarative E? Prima facie, it is the *relevance* of E to an ulterior

[17] Against the backdrop of which other kinds of interaction—check: 'love', 'urbanity'—gain their distinction.

epistemic or deontic constraint. We can indeed explicate relevance to a given proposition as an instance of a utility, i.e. a real-valued representation of preferences.[18] And the explicans here is simultaneously a representation of epistemic state change potential (see Section III).

So we are back with Peirce's and Ramsey's notion of belief as a disposition to conduct; and with interpersonal efforts to transform those dispositions. This helps to embed into the best-developed theory of rational conduct available today AD's approach to natural language.[19] AD shied away from stochastic interpretation, eschewed formalization, and viewed argumentation as something *sui generis* rather than as a special case of a bargaining situation.[20] In consequence, they were unable to equal the predictive commitment of the most rigorous 1970's work on, say, implicature (Horn [34], as developed by Gazdar [22], Karttunen and Peters [45], Soames [73]). But their prolific and subtle insights are the principal linguistic inspiration behind what follows. Moreover, their central notion admits of an explication in terms of Carnap's notion of relevance, which does afford such commitment.[21]

III. Decision-Theoretic Semantics (DTS)

What are the implications of basing the analysis of meaning on one rather than the other of two conceivable ideologies or super-objectives of communication: (i) the (Neo-)Gricean view of optimal information transfer, apparently shared by SW; and (ii) the partisan, persuasion-oriented view, adopted for linguistic analysis by AD?

[18] The relevance function $\lambda X[P(X|H)/P(X)]$ of W.E. Johnson and J.M. Keynes [47] is a cardinal utility in the technical sense of Jeffrey [39]. Proof in Merin [58].

[19] All in French. Horn [35] and, more narrowly focussed, König [48] offer very useful and, though naturally partisan, fairminded glimpses.

[20] They also distinguished their argumentative domain from a logico-semantic one in ways that underplayed their argumentative hand, as König [48] p. 194n5 demonstrates.

[21] Among possible 'effects' mentioned in passing by SW (cf. [74] p. 109) there is an explicandum for this notion of relevance, namely strengthening or weakening of assumptions. But it is not developed nor, apparently, treated as pertinent. There is, for instance, no apparent recognition that this is in essence the distinctive concept of Ducrot [16], who is noted ([74] p. 14n7) to have 'developed a programme in some ways comparable to Grice's '. (This, indeed, is all the 1986 book says about Ducrot besides citing references. Yet, by 1978, exchanges in French journals, including one published from offices of the CNRS at Paris, had established how deeply he differed from Grice in matters of principle and prediction; cf. [4], cp. also Horn [35]. Three further 1995 footnote references are no more informative on the relevant point.) Nor is there notice given that relevance is addressed by Carnap. His [10] is mentioned (SW [74], p. 79f.) as a treatise on subjective probability, but thereupon reported solely for its general measurement-theoretic preliminaries on concept types (its pp. 8-15), minus their references to probability and subsequent conclusions. Carnap explicates relevance in [10] Ch. 6, 'Relevance and Irrelevance', on pp. 346-427.

The former has going for it common sense and paradigmatic language games such as telling someone the time. Yet, well-rounded philosophical discourse already casts doubt on the paradigmaticity of such games. For instance, 'figuring out real intentions', inevitable once Gricean implicatures by flouting of convention arise, already presumes scepticism, and cause for it.[22] The objective of optimal information transmission does not. The objectives reflected in, say, Tacitus, or in the distribution of the GNP, do. No Cartesian *malin génie* is needed there: just cunning fellow-humans.

But neither common sense nor philosophical stance need be decisively consequential for explanation of robust linguistic intuitions. One may consider a particular one of super-objectives (i) and (ii) more consonant than the other with one's introspections on what talk is really all about. Yet that other one may turn out to condition poorly introspectible linguistic intuitions. And it is those that are, today, agreed-on data for inferring structures of what might be loosely called semantic 'competence'.

Let us, then, move to empirical commitments, first with a formal definition of relevance. We ask: How does the probability $P(H)$ of proposition H (intuitively: 'hypothesis') change in the light of evidence fully represented by proposition E?

Ramsey-coherent epistemic updating on evidence deemed certain proceeds, by most accounts, by conditioning. Supposing that i' is the epistemic context obtained from i when E, and just E, is newly learned (adopted) for certain, we obtain

$$P^{i'}(H) \;=\; P^i(H|E) \;=\; P^i(H) \cdot [P^i(E|H)/P^i(E)].^{23}$$

Put in 'odds' form, where $\mathrm{Odds}(H) =_{df} P(H)/P(\overline{H})$, Bayes' rule yields

$$\begin{array}{rcl} P^{i'}(H)/P^{i'}(\overline{H}) & = & P^i(H|E)/P^i(\overline{H}|E) \\ & = & [P^i(H)/P^i(\overline{H})] \cdot [P^i(E|H)/P^i(E|\overline{H})]. \end{array}$$

Posterior odds (on the left) equal *prior odds* times the *likelihood ratio* of H on E. For cognitive convenience (Peirce [63]), take logarithms to any fixed base; say, 2 for common measure. Then

$$\log[\mathrm{Odds}^i(H|E)] = \log[\mathrm{Odds}^i(H)] + \log[P^i(E|H)/P^i(E|\overline{H})]$$

The last summand measures the epistemic context change potential [eccp] of E with respect to H in i. This is what it means to say that the eccp thus represented is *directed*. It is computed with regard to an H that is not already taken for granted, and it can be positive or negative (or nil).

[22] Check Austin [6] on 'real'.

[23] In accordance with Bayes' definitionally valid formula, $P(H|E) =_{df} P(HE)/P(E) = [P(E|H)P(H)]/P(E)$ where $P(E), P(H) > 0$.

Definition 4. The *relevance* $\mathrm{r}^i_H(E)$ of proposition E to proposition H in an epistemic context i represented by conditional probability function $P^i(\cdot|\cdot)$ is given by $\mathrm{r}^i_H(E) =_{df} \log[P^i(E|H)/P(^iE|\overline{H})]$, also known as the log-likelihood-ratio for simple H.

Definition 5. E is *positively relevant to* H in i iff $\mathrm{r}^i_H(E) > 0$, *negatively* iff $\mathrm{r}^i_H(E) < 0$, else *irrelevant to* H. E is *relevant to* H iff not irrelevant to H. We say: E is *relevant* (pure and simple) iff relevant to an H at issue.[24]

Relevance is intelligibly related to conditional informativeness, where the conditioning propositions are now the complementary pair $\{H, \overline{H}\}$ at ulterior issue:

Fact 2. $\mathrm{r}_H(E) = \inf(E|\overline{H}) - \inf(E|H)$.[25]

So $\mathrm{r}^i_H(E)$ is *decreasing* in $\inf^i(E|H)$ and *increasing* in $\inf^i(E|\overline{H})$. If E were already taken for granted at i, i.e. if $P^i(\cdot) = P^i(\cdot|E)$, its assertion, a primitive notion shorn of implicatures for now, would be uninformative [$\inf^i(E|HE) = 0$ for all i and H]. E would thus be irrelevant to any H whatever, its epistemic impact having already been absorbed into the probability function. In this special case, relevance—to at least one proposition, never mind which—and informativeness coincide. (In general, they don't.) Both are 0. Relevance to the point at issue implies informativeness. Informativeness does not imply relevance to the point at issue. The distinction between relevance and informativeness is otiose at best for pointless talk.[26]

Here is a more general view of the approach that relates it to kinematic semantics without attention to its partisan aspects. $P^i(\cdot|\cdot)$ represents a

[24] I adopt Carnap's convention that relevance of E be zero when it contradicts ostensibly immutable background belief, given explicitly or absorbed in i. This accords with Kolmogorov's definition of probabilistic independence, $P(AB) = P(A)P(B)$. If $P(H|E) = 1\,(0)$ given $0 < P(H) < 1$, then $\mathrm{r}_H(E) = \infty\,(-\infty)$. $\mathrm{r}_H(E)$ is a continuous monotone increasing function of other measures of relevance, e.g. $P(H|E) - P(H)$, $P(H|E)/P(H)$. Advantages of $\mathrm{r}_{(\cdot)}(\cdot)$ are, e.g., that it is additive under certain conditions (cf. Fact 5, below) and values all cases of entailment among contingent propositions alike. I.J. Good [24], [25], the great explorer along with A.M. Turing of $\mathrm{r}_H(E)$, calls it 'weight of evidence' (cp. Peirce [63]), and notates $W(H:E)$. I follow *inter alia* Keynes, Carnap, Jeffrey, Stalnaker and the stochastic literature. My reasons are generality (consider causal or moral relevance; cf. Merin [56], Ch. 4) and science policy. 'Relevance' should retain an explication that is both useful in language analysis and consistent with unambiguous scientific usage.

[25] Making a background K not presently at issue explicit leads to the more general **Definition**: $\mathrm{r}_{H|K}(E) =_{df} \log[P(E|HK)/P(E|\overline{H}K)]$ is the *relevance of E to H, given K*. This yields $\mathrm{r}_{H|K}(E) = \inf(E|\overline{H}K) - \inf(E|HK)$.

[26] Recall that indiscriminate implication-collecting has a closest intelligible counterpart in indiscriminate informativeness-maximization. — See Section VI, below, where the distinction relevant/informative serves to explicate 'accommodation' (Lewis [51]).

(continuous) *commitment state*: a partial function

$$P^i(\cdot|\cdot) : Prop \times Prop \to [0,1]$$

mapping pairs of propositions to a real number. It is what Ramsey [65] called a *probability theory*, as distinct from a theory defined by closure under conjunction and classical consequence.

Changing the state $P^i(\cdot) = P^i(\cdot|\Phi \vee \overline{\Phi})$ to $P^{i'}(\cdot) =_{df} P^i(\cdot|E)$ by conditioning on E ($P^i(E) > 0$) will increase / decrease / leave unaltered the probability of $X \in \text{Domain}(P^i(\cdot))$. E is then positively / negatively / not at all *relevant* to X in i. Thus we can say: A proposition E acts as a partial function

$$f_E : \mathcal{P} \to \mathcal{P}$$

on a space $\mathcal{P}$ of probability functions. Its fixed points are states i such that $P^i(\cdot) = P^i(\cdot|E)$, i.e. where E is *presupposed* (see Section VI). And it is undefined at i such that $P^i(\cdot) = P^i(\cdot|\overline{E})$, i.e. where $\overline{E}$ is presupposed.[27] Finally, we can define $\text{BF}(i) = \{X : P^i(\cdot) = P^i(\cdot|X)\}$ as the 'full belief' set at i, represented by a 'theory' closed under conjunction and consequence, and immutable by conditioning.[28]

Next consider the interpersonal component of linguistic explanation, as outlined in the paradigmatic response 'Why should I?' I shall, quite informally, cast it in the form of a

Thesis (BG): A dichotomic epistemic issue $\{H, \overline{H}\}$ in an epistemic state i is modelled by a *bargaining game* (BG) between two actors (call them Pro and Con). Its negotiation set is generated by a set Σ of interpretive or expression alternatives linearly ordered by signed *relevance* at i to H. Pro aims to establish, say, H; and Con, $\overline{H}$. Ordinally *dual* (i.e. inverse) *preferences* of Pro and Con with respect to H becoming a joint epistemic commitment then induce dual preferences over Σ.[29]

The naturalness of preference duality over Σ becomes apparent on deriving from Fact 2 the

[27] At either of such i, both E and $\overline{E}$ will be *irrelevant* to *all* propositions. This explicates a basic 'admittance' condition of the presuppositional literature. See Section VI.

[28] Consequence will be classical granted strict coherence and, with application restricted to such a properly classical, 'full belief' theory, subject to a convention (cf. Adams [1]) for *ex falso quodlibet*. To keep matters simple, I ignore the possibility of mutable *full* belief that is *not* identified with classical probability 1. The phenomena treated, or at least as far as treated, here do not require it. Others will, and I engage in forthcoming work available techniques, both probabilistic and closely related, for representing what amounts to deductive non-monotonicity.

[29] By analogy, think of two *homines oeconomici* faced with a cake on a shelf too high for one alone to reach. Who will get how much, if between them they are to get more than nothing? – *Given* that nothing is to be wasted, their preferences are strictly dual.

Corollary 3. $\mathrm{r}_{\overline{H}}(E) = -\mathrm{r}_H(E)$.

If available constraints on probabilities do not suffice to determine a linear ordering of Σ, the game is one of 'incomplete information' (cf. Harsanyi [30], p. 91). We meet an example below. I assume that we are only dealing with single issue contexts. It is, I think, a brute empirical question whether or not such pointedness or tunnel vision is to be definitional of a linguistically predictive notion of 'context'. Empirical questions no doubt attend ways of extending it to the nestings of contexts examined by early phenomenologists and contemporary computer scientists. The same goes for evolution or change of issues. I leave all this for another occasion. I also attend here only to dichotomous issues. Thus, for present purposes, I offer a

Partial Definition 6. An ordered pair $\langle i, H\rangle$ is a (simple, bi-partisan) *context* only if i determines a probability function $P^i(\cdot)$ (i.e. a common prior epistemic context, CP) and H determines a partition $\{H, \overline{H}\}$ of the domain $\mathcal{F}$ of $P^i(\cdot)$ such that the respective preferences of the (two) parties over the partition are ordinally inverse. Call $\{H, \overline{H}\}$ the *issue*, and H the *discourse topic* (DT), of $\langle i, H\rangle$.[30]

Figuring out the ostensible and/or intended H amounts to 'figuring out intentions'. Indeed, it amounts to figuring out what is being 'meant', in one of Grice's senses, by what is 'said'.[31] Let me propose an explication.

Definition 7. The *Protentive Speaker Meaning* (PSM) of a sentence S in context $\langle i, H\rangle$ is that element of the issue $\{H, \overline{H}\}$ for which the relevance

[30] To avoid complicating things in view of Thesis BG, I leave 'context' and 'issue' fairly sparse. DT refers preference-neutrally to a proposition: the descriptively most convenient element of the issue bi-partition. (Contrast Def. 7, below.) Nothing is lost in proceeding thus by way of abbreviation, instead of calling $\{H, \overline{H}\}$ the DT, as would be suggested by the discourse-analytic method of Yes-No-Questions. More generally, let a question $Q?$, as usual in the literature, denote a partition π_Q into propositions of the set of possible models. (For a yes-no-Q pick a bi-partition; for most wh-Qs, a 2^n-partition, where n is the number of possible individual constant instances of the wh-morpheme; for why- and most how-Qs, one of each.) Then define: A proposition E is *relevant to a question* $Q?$ iff it is relevant to at least one element of π_Q. Complete or eliminative partial answers will then be special cases. A *question* $Q_1?$ is *relevant to another question* $Q_2?$ iff at least one element of π_{Q_1} is relevant to at least one element of π_{Q_2}. Relevance of, and to, questions is essentially just dependence of random variables. In our simple, short-sighted scheme, call $Q_1?$ a *relevant question* (pure and simple) iff, in addition, $Q_2?$ represents the issue.

[31] That such figuring will be a non-hierarchical constraint resolution process is strongly suggested by the speech-recognition literature. 'Bayesian' probability networks are a stock-in-trade of such literature.

sign of the proposition expressed at i by the utterer equals the (short-term rational) utterer's preference sign at $\langle i, H\rangle$.[32]

PSM links up the discourse topic, DT, with the perennial question of what proposition is being expressed, and it adds structure to the disambiguation example of Section II.B. Recall, from II.C, that if I claim \$5 from you, I won't mind (i.e. won't be committed to applying sanctions) if you give me \$$n$ where $n \geq 5$. If you concede \$5 to me, you won't mind (won't be committed to applying sanctions) if I take \$$m$ where $m \leq 5$. This principle also informs discourse which is predicated on assertions and admissions.

Definition 8. The *upward* (*relevance*) *cone* $^{\geq s}\Phi$ of an element Φ of a subset $\mathcal{S} \subseteq \mathcal{F}$ of propositions in context $\langle i, H\rangle$ is the union of propositions in $\mathcal{S}$ that are at least as relevant to H in i as Φ is. The *downward* (*relevance*) *cone* $^{\leq s}\Phi$ of Φ in context $\langle i, H\rangle$ is, dually, the union of $\mathcal{S}$-propositions at most as relevant to H in i as Φ is.

With $\mathcal{S}$ selected by lexical and local relevance structure, I shall make use of the following explicatory

Hypothesis 1. The upward cone $^{\geq}\Phi$ represents Pro's *claim*, induced by lexically explicit Φ. The downward cone $^{\leq}\Phi$ represents Con's default expected compatible counterclaim (i.e. *concession*).

IV. 'Conversational Implicature' and its Relatives

In what follows, a Boolean semantics is presupposed. The possibility that it might, in turn, be induced by other semantic substrates in suitable contexts of use will be ignored.[33] The set of persons to whom probability functions are imputed which, in turn, engage the CP function is left implicit. The default set will include the Speaker and the actual or virtual Addressee, alongside a representation of transcontextual 'common sense' or Aristotelian *endoxa*.[34] In most cases, only ordinal relations among probabilities will be directly appealed to; actual number values other than 0 and 1, never. Read probability function symbols as shorthand for sets of probability functions satisfying stated constraints and indexed to a context.

[32] I propose to call the proposition expressed by S in i its *Matter-of-Fact Meaning* (MFM). The requirement on MFM is that it be a subset of, i.e. entails, the CG proposition at i. I should define two notions of sentence meaning: respectively as the union and as the disjoint union of MFMs taken over a universe of possible i. The construction and label for MFM and the first of the sentence meanings derive from work on conditionals by Stalnaker, Harper, and Jeffrey. Disjoint union amounts to an MFM-valued function.

[33] The substrates I am thinking of are linear algebras over the reals: structures familiar to natural scientists, economists, and statisticians. Cf. Merin [53], [58].

[34] Cf. Merin [56], Ch. 2 for some of the complexities.

A. *'Scalar Conversational Implicature'* [SCI]

Thesis BG motivates Hypothesis 1. The two jointly explain the *defeasibility differential* that distinguishes at the level of observation a speaker's 'lower-bounded' claim/assertion, e.g. 'Some men walk' from the 'upperbounding' implicature, e.g. 'Not all do'; cf. Horn [34]. Here is how.

Identify the content of Pro's *assertion* with the *upward cone*, and the *scalar implicature* with the *downward cone* corresponding to the counter-claim of an actual or virtual disputant, Con; cf. Def. 8. Note now that Pro's claim is Pro's responsibility to back, but that Con's counterclaim isn't: Pro bears no responsibility of evidential or other backing for it. Hence a necessary condition for its defeasibility is met. Nonetheless, rationality of Con makes the Scalar implicature a computational *default*, and indeed by *quasi-juridical* default, if Pro is not committed to backing more than the greatest lower bound of his claim. But again, there is no guarantee that Con will not irrationally concede a windfall, or that backing for a stronger least claim might not be forthcoming. (An explication of Horn's [34] gradience intuitions in terms of probabilities over various sub-cones of these cones is conceivable.) Net meaning is, finally, the rationally expected-to-be conceded claim: the intersection of 'assertion' and 'implicature'.

A.1 *'Particularized* SCI*'*:

Here is an example due to Hirschberg [33]:

> Q: *Do you speak Portuguese*? A: *My husband does.* [$= F$]
> [Scalar Implicature: Speaker A (= Wife) doesn't. [$= \overline{E}$]]

Hirschberg's explanation is: The context of potential Portuguese-speakers is the set of alternatives given as the set Σ of non-empty subsets (of family members),

$$\Sigma \;=\; \mathrm{Pow}\{husband, wife, child\} - \phi.$$

Σ is partially ordered by the subset relation, i.e. $A \leq B$ iff $A \subseteq B$. By a generalization of Gricean 'Quantity', $\overline{E}'$ is implicated by utterance of F for all E' with subject denotata $s \in \Sigma$ such that $s \not\leq \{husband\}$.

But what is the 'way of being given' of this context set? The subset structure is not pertinent. Nor is the concomitant rule independently motivated. And so it won't explain (where $\surd$ means 'O.K.')

> A: $\surd$*{My brother/servant/Kim/Kim Jones} does* $[F', F'', F''', F'''']$
> A': **{Kim Basinger/The president of Brazil} does.* $[G, G']$

Let Q = Boss Inc., $A = W$ (Wife) at her job interview. Ask: (a) Why should Q ask? and (b) Why should W answer as above? Because: (a) Q wants utility-relevant information ('Should we hire W?' [$= \{H, \overline{H}\}$?]) and

(b) W wants to be hired $[H]$. $\{H, \overline{H}\}$ is the *issue*. H is W's PSM (cf. Def. 7). Suppose W doesn't speak Portuguese, but can call upon someone who does, virtually gratis. Typically such a person will be kin or agnate; else a friend (Kim); or an acquaintance (Kim Jones). But presumably *not* Kim Basinger. Hence the *. (This gives us a relevant part of a set $\mathcal{S}$ of Def. 8, i.e $\{S \in \mathcal{S} : \mathrm{r}^i_H(S) > 0\}$.)

Moreover, $\mathrm{r}^i_H(E) > \mathrm{r}^i_H(F) > 0$, surely. Now, treat E and F as potential claims. Recall, furthermore, that claims (demands) in bargaining are always 'at least' and that the strongest compatible response (meanest concession) amounts to 'at most' that. So $\overline{E}$ is critical, sceptical ('Persuade us!') Boss's counterclaim, made and conceded *by default*.[35] Its status as a counterargument is given by the following

Fact 4. $\mathrm{r}_{\overline{H}}(\overline{E}) > 0$ *iff* $\mathrm{r}_H(\overline{E}) < 0$ *iff* $\mathrm{r}_H(E) > 0$.

That's why smart W gives an indirect, (call it) *'second-best'* answer. Surely also $\mathrm{r}^i_H(F) > \mathrm{r}^i_H(G) = 0$, and likewise on substituting F' etc. for F and G', G'' for G. Thus, W's utterance of 'E' will never implicate that the President of Brazil cannot speak Portuguese. And note again: presumably E, F, G are logically independent.

A.2 *'Generalized* SCI*':*

Entailment-based informativeness has done rather well with 'strong' Scalar implicature from *or* construed as inclusive disjunction ($\vee$) to local, defeasible strengthening with intuitions appropriate to exclusive 'or', i.e. to XOR (∇) (cf. Gazdar [22]; Soames [73]). To make relevance predict we need

Definition 9. A and B are *independent conditionally* on H and $\overline{H}$ in i $[(A \perp_i B| \pm H)]$ iff

$$P^i(AB|H) = P^i(A|H)P^i(B|H) \text{ and } P^i(AB|\overline{H}) = P^i(A|\overline{H})P^i(B|\overline{H}).$$

Intuitively, $(A \perp_i B| \pm H)$ holds when knowing which of H or $\overline{H}$ is the case will account fully for any interactions between A and B in i. The condition guarantees additivity, i.e. compositionality of relevance:

[35] Ede Zimmermann of Stuttgart University reminded me that here W will know whether or not E. Where this assumption is not met, $\overline{E}$ will not be implicated by default (cf. Soames [73]). I should say, in view of gradience (cf. Horn [34]): The addressee or hearer could not then *rely* on being able to sustain $\overline{E}$. Note that $\overline{E}$ could not be relied upon either if W could not be presumed to prefer E being sustainable. Try: $E?$ = 'Do you have a criminal record?'. Here a follow-up by Q, 'And you don't?' is advisable.

Fact 5. *If* $(A \perp_i B| \pm H)$, *then* $\mathrm{r}^i_H(AB) = \mathrm{r}^i_H(A)+\mathrm{r}^i_H(B)$.[36]

A presumption of conditional independence is widely adopted in Artificial Intelligence applications for cumulation of evidence. It reduces computational load and the need for appeal to world knowledge. Here I propose a linguistic correlate:

Hypothesis 2. Natural language interpretation is predicated, where nothing suggests or requires otherwise, on a *Conditional Independence Presumption* [CIP]: $(X \perp Y|\pm H)$ where X, Y are propositional denotata of syntactic sister nodes in coordinate construction schemata X CONJ Y.

This lends empirical import to a family of propositions which, for brevity and salience, I shall call

Theorem 6. *If* $(A \perp_i B| \pm H)$ *and* $\infty > \mathrm{r}^i_H(A)$, $\mathrm{r}^i_H(B) > 0$ *then*
(a) $\mathrm{r}^i_H(AB) > \max[\mathrm{r}^i_H(A),\mathrm{r}^i_H(B)] > \mathrm{r}^i_H(A \vee B) > 0$, $\mathrm{r}^i_H(A\nabla B)$*; whereas*
(b) $\not\forall\ \mathrm{r}^i_H(A\nabla B) \geq 0$; $\not\forall\ \mathrm{r}^i_H(A\nabla B) < 0$; $\not\forall\ \mathrm{r}^i_H(A \vee B) < \mathrm{r}^i_H(A)$, $\mathrm{r}^i_H(B)$.

By Theorem 6.a, CIP will rule out so-called 'paradoxes of relevance' such as the negative relevance to H of conjunctions or even disjunctions of propositions A, B, that are each positively relevant to H. Conjoined with Thesis BG, it explains 'strong' Scalar implicature for $\vee$. To see how, ask first:

What would be a default set of expression alternative designata in a context of use involving no atomic sentences besides A, B? A reasonable candidate should be the Lindenbaum or proposition algebra $\mathcal{F}$ over $\{A, B\}$. The atoms of $\mathcal{F}$ are represented by AB, $\overline{A}B$, $A\overline{B}$, $\overline{A}\overline{B}$. They finest-partition the semantic space of possibilities. Suppose A and B positive to H, which is preferred by Pro. Under incomplete information (nothing e.g. is presumed known about the comparative relevance of $A\overline{B}$, $\overline{A}B$) Con's natural default counterclaim to Pro's $A \vee B$ is $\overline{A} \vee \overline{B}$. The meet (intersection) of claim and counterclaim is then $A\nabla B$.

Note that a *reduction* in the expected (positive, evidential, partisan) *relevance* of a claim will in general have increased (non-partisan) semantic *informativeness* as a byproduct. (Echoes of Adam Smith's Invisible Hand ideology there!) This is because $A\nabla B \models A \vee B$, while $A \vee B \not\models A\nabla B$. Various epistemic conventions for the default to bite are conceivable: e.g. that Pro should know that AB, if AB holds ([73]).

It is an empirical question, then, whether a conventional, hypothetical imperative 'Be Relevant!' or 'Be Informative!' is our predictor. The two

[36] Without making any such independence assumptions we can state the following **Fact**: $\mathrm{r}^i_H(AB) = \mathrm{r}^i_H(A) + \mathrm{r}^i_{H|A}(B)$. Recall the definition in fn. 25 here. The epistemic kinematics appears to parallel analyses of context-change familiar from the literature on dynamic semantics. But see also fn. 64.

notions, granted our distinctive definitions for them, are not monotone increasing functions of one another. The above example is a case in point. If the criterion of success is partisan maximization of evidential relevance, *it can pay to be underspecified*—quite independently of any considerations of brevity or freedom of discourse continuation. The implicature then acts as a countervailing force, giving notice, as it were, that cheap advantages of underspecificity are not automatically available.

Relevance predicts as well as, or better than, Neo-Gricean informativeness on some hard distributional facts. Recall that the so-called 'quantitative scales', of which (*and, or*) is a putative instance, are linguistically given to us most tangibly by their diagnostics (Horn [34]). Let us adopt the following

Hypothesis 3. Expression schema '*X if not indeed Y*' is acceptable iff, for every context of use $\langle i, H\rangle$ and propositions X, Y satisfying CIP (Hypothesis 2) and finitude of relevance to H, either

$$(\mathbf{i})\ 0 < \mathrm{r}^i_H(X) < \mathrm{r}^i_H(Y) \quad \text{or} \quad (\mathbf{ii})\ 0 < \mathrm{r}^i_{\overline{H}}(X) < \mathrm{r}^i_{\overline{H}}(Y).$$

From this we can derive

Prediction 1. *'*A or B, if not indeed A*'.
Proof: Let X:= '*A or B*', Y:= '*A*'. By Theorem 6.b, Hypothesis 3.i is not generally satisfied. Nor is 3.ii with respect to $\overline{H}$.

Prediction 2. $\surd$'*A (or B), if not indeed A and B*'.
Proof: Let either X:= '*A or B*' or else X:= '*A*', and let Y:= '*A*'. By Theorem 6.a, Hypothesis 3.i is satisfied. So is 3.ii with respect to $\overline{H}$.

With or without a lexicalization constraint (Horn, Gazdar), Neo-Gricean informativeness would, by itself, mispredict for one or the other option. *Without* one, it predicts acceptability of the first, since disjuncts entail disjunctions without being entailed by them.[37] *With* such a constraint, $\{A,\ A\ and\ B\}$ does not carry a 'quantitative scale' (there is no item contrasting with *and*). If so, such diagnostics appear to diagnose relevance-based rather than informativeness-based scales, under the above definitions.

[37] Larry Horn, I presume, would counter: *'A or B'*, by implicating ignorance of whether A, would explain the * by redundancy of *'if not indeed A'*, which opens the possibility of A. I should reply: Agreed. But the crucial one of the pertinent pair of ignorance-implicatures, as modal-logically explicated (Gazdar [22]), is $\neg\mathsf{Knows}_s\neg A$. Unlike its sister, $\neg\mathsf{Knows}_s A$, it relies for its Gricean motivation derivation on the Maxim of Manner, i.e. on relative expression length. If, in line with Grice's own late doubts ([27], p. 372; cp. also Mandelbrot [52] and fn. 10), one prefers doing without Manner, one should prefer my preferred explanation. If not, then not on grounds local to the argument. For some of the global view, see the following sections.

B. *Negation of Scaleable Attributes*

Both Ducrot [16] and Horn [34],[35] investigated pairs of intuitively 'positive' and 'negative' ordered subsets of lexical fields (e.g. {*boiling, hot, warm*} vs. {*cool, cold, freezing*}; etc.). A Decision-Theoretic Semantics (DTS) will recover their observation that negations of strong (weak) positives are, respectively, relatively weak (strong) negatives; and so on. It need not merely observe the phenomenon stipulatively, as Ducrot had to. Nor need it assume, with Horn, who did offer an explanation, that lexical meanings of scaleables are generally of a logical form paraphraseable 'at least' and perhaps, for marked environments (e.g. Jespersen's *'live on'*), 'at most'.

Horn had assumed that an attribute space was generated by two disjoint sets of basic, non-negated predicates. These 'positive' and 'negative' 'scales' were each ordered by predicate inclusion. This goes with the intuition that 'boiling' surely entails 'at least hot', which in turn entails 'at least warm'. The assumption, though occasionally unkind to common sense—a dubious counsellor to science—had a real predictive payoff. In hypothesizing an ordering by entailment (set-inclusion) it yielded, by contraposition (cp. Fauconnier [17]), the observed relations among negated predicates; and, by simple complementation, Jespersen's observation that e.g. *not 5 pounds* means, usually, 'less than 5 pounds'.[38] Cases such as 'It's not hot, it's boiling!' were to be treated, in line with Ducrot, as instances of Ducrot's very general notion of 'metalinguistic negation', also instantiated elsewhere, e.g., in correction of phonetic infelicities (cf. [35], Ch. 6).

I assume instead, more plausibly, that attribute spaces given by a scaleable lexical paradigm are *partitions* into attributes of similar grain, induced pointwise by partitions of 'expression alternative' propositions (cp. the for-

[38] Horn's assumption on lexical representation of scaleables has been criticised (cf. [35]), most prominently by Carston [13], p. 174f. She favoured, with paradigmatic reference to numerals, a single linguistic meaning or sense (neither 'at least' nor 'at most' nor 'exactly') such that the proposition, i.e. truth-conditional content, actually expressed (Carston: 'explicature' *apud* SW [74]) is contextually determined. However, this plausible contention, and others concurring, did not engender explications of senses and contextual mechanisms able to yield the Jespersen/Horn/Ducrot facts. Horn's theory—something his reply [36] refrains from stating that baldly—was the only approach to these very non-peripheral intuitions that did explain them. This fact also must have blunted the edge of the formidable objections raised by AD [4] in response to Fauconnier's francophone critique of their approach.

mal definition in Gazdar [22]).[39] A context of use $\langle i, H\rangle$ induces a partition $\pi := \pi^{\langle i,H;\geq\rangle}$ linearly ordered by relevance to H. Constraints on π across possible $\langle i, H\rangle$ are, I believe, part of what counts as knowledge of language: i.e. the ability to *use* those attributes in cogitation and in communication. Assertoric communication coarsens π to an order-homomorphic bi-partition $\pi' := \pi'^{\langle i,H;\geq'\rangle}$. The two elements of π' are each topologically *connected*. I.e. neither of them has a gap, as boolean negation would yield when applied to elements of π that are non-extreme with respect to $\geq$.

The bi-partition π' is induced by the independently motivated virtual bargaining pragmatics. For recall Def. 8 of 'upward cone' ${}^{\geq}\Phi := {}^{\geq s}\Phi$. Call now *'unmarked scalar complement'* of Φ the boolean complement ${}^{<}\Phi := {}^{<s}\Phi$ in $\mathcal{S}$ of ${}^{\geq}\Phi$ and construe as the denial of a claim deemed excessive. Call *'marked scalar complement'* the dual ${}^{>}\Phi := {}^{>s}\Phi$ of ${}^{<}\Phi$ and construe as the rejection of a concession deemed insufficient; thus inheriting concession's phenomenologically marked status.[40] Ducrot's and Horn's observation is then captured in the following

Theorem 7. *If propositions X and Y in $\mathcal{F}$ are elements of a partition π of the space Ω of possibilities, such that π is linearly ordered by i-relevance to an H in $\mathcal{F}$, and $\mathrm{r}^i_H(Y) > \mathrm{r}^i_H(X) > 0$, then $\mathrm{r}^i_{\overline{H}}({}^{<_\pi}X) > \mathrm{r}^i_{\overline{H}}({}^{<_\pi}Y) > 0$.*

In words: Let X, Y belong to such a partition π, relevance-ordered in context $\langle i, H\rangle$. If X is positive to H, and Y more so, then the scalar complement of Y is positive to non-H (i.e. negative to H), and the scalar complement of X more so. Analogous relations among attributes $\lambda z X$, $\lambda z Y$ etc. are induced by abstraction over z-instances and contexts of use $\langle i, H\rangle$. Try with $X = \lambda z X(a)$ = 'It's warm'; $Y = \lambda z Y(a)$ = 'It's hot'; H = 'The temperature is high'; or, if you like, H = 'It wants a rest'. Scalar implicature, i.e. expected counterclaims, will then upperbound claims, much as above.

[39] Plausibility is here not so much a matter of introspection on meaning, let alone about the form of entries in the mental lexicon. Rather, if spaces of basic attributes were structured as sets of inclusion chains, they could not be partitions if either chain had $n > 1$ elements. One could not, then, define a probability distribution over them. Basic attributes would thus be ill-suited for computing expected values of actions conditioned by propositions they generate. This pragmatic consideration has linguistics shaking hands with philosophy and the design sciences. See Merin [60]. Partitioning will also make better sense of predicates such as 'tepid', featured in famous example pairs such as *This beer is tepid if not downright warm* and *This coffee is tepid if not downright cold.*

[40] Why marked? 1. 'Don't pick a fight you know you're gonna lose' (Sen. Sam Goldwater). 2. There is double anaphoricity: to a concession responding, in turn, to a putative claim. One need not here invoke Ducrot's and Horn's still formally unexplicated 'metalinguistic negation'.

V. 'Conventional Implicature'

Traditional accounts of degree particle *even* (e.g. Karttunen and Peters [45]) note that *Kim even talks* [abstractly: $even(\alpha, \beta)$ where α is focus of *even*] indicates highest 'surprise/improbability' of *Kim talks* [$= E := (\alpha, \beta)$]; the comparison class being propositions (α', β) with $\alpha' \neq \alpha$ (e.g. *Kim walks*).

Anscombre [2] proposed superior argumentative value (AV) of E over E' with respect to some H. Let us explicate this by relevance, $\mathrm{r}^i_H(E)$ for given H and a set $\{E_j\} = \{(\alpha_j, \beta)\}$ of expression alternatives, $= \max_j[\mathrm{r}^i_H(E_j)]$ iff $\mathrm{r}^i_H(E) = \max_j[\inf^i(E_j|\overline{H}) - \inf^i(E_j|H)]$. In simplified words: the E_j most (positively) relevant to H in i is that of which the truth would be the most surprising in i if $\overline{H}$ rather than H were to be accepted in i. Of course, there is no point arguing for an H already firmly accepted. And indeed, the intuition for the above example pair is that one is arguing with it for an H still at issue, say, H = 'Kim is doing great'. Check for the other intuitions.

Whether or not one takes the AV properties of *even* to be primary, as I do on diachronic grounds,[41] or else derived: intuitions are squared and an issue between Anscombre [2], Kay [46]–who each plead *contra* surprise—and Francescotti [19]—who pleads *pro*—is accountably resolved.

Note: $\mathrm{r}^i_{H|K}(E) > \mathrm{r}^i_{H|K}(E')$ does not imply $E, K \models E'$ for backgrounds K such that $K \not\models E \rightarrow E'$. Nor, even, will it imply $E, K \models_i E'$ when transcontextual entailment, $\models$, is replaced by a context-relative relation, $\models_i$, defined by: $X \models_i Y$ iff $P^i(Y|X) = 1$. Neither of $\models$ or $\models_i$ would license a 'contextual entailment' from E to E', by which Kay [46] intends to explicate superior 'informativeness', his explanatory ordering relation for the implicatures of *even*. But 'entailment', however weakened, is surely a misconception or misnomer—for relevance, it would appear—in view of

> Author: The hero of my novel sleeps with M******.[42]
> Editor: So what. The hero of our Greek deadwood[43] even sleeps with his own mother.

A DTS yields an account of the conjunction *but* and its interaction with *even* that recovers observations and pioneer explanations of Anscombre and Ducrot [4]; along with the much more occult interaction with *also* (Section VI). Consider, for cases not involving *also*, and simplified for exposition,

[41] *Even*, like Fr. *même* or Ge. *selbst*, originates as an emphatic particle, indicating 'importance'; as do the latter even now. Importance of objects means: high relevance of propositions involving them. Cp. Section VI on 'salience'.

[42] A 1990s media personality.

[43] 'Dust-gatherer' might be a less idiomatic, academic creole alternative for things that don't sell too well.

Hypothesis 4. '*A but B*' is felicitous in state i only if there is at issue in i a proposition H such that $\mathrm{r}^i_H(A) > 0$ and $\mathrm{r}^i_H(B), \mathrm{r}^i_H(AB) < 0$.[44]

Example:

Kim is a doctor, but she lives in Mozambique
[H = Kim is rich.]

Consider the hypothesis now in conjunction with a further

Hypothesis 5. '*A* CONJ *even(B)*' [:= (α_1, β) CONJ $even(\alpha_2, \beta)$] with VP-focus of *even* (on α_2) is felicitous in state i only if there is at issue an H such that $H \neq B$ and $\mathrm{r}^i_H(B) > \mathrm{r}^i_H(A) > 0$.

And suppose, as we did, that, for any given reading, H must be unique. This implies

Prediction 3. **Kim splurbs but Kim even glurbs* for any English substitution instances of *splurbs* and *glurbs*; explicating AD's claim and explanation.[45]

Frege's view ([20] § 7) was, it seems, that 'A but B' required B unexpected in view of A. A stock example is:

Kim is poor but (she is) honest.

But, as the 'doctor' example shows, such *A-unexpectedness* of B is not intuitively necessary for felicity of 'A but B'.[46] Nor is the obvious explication

[44] $P^i(\cdot)$ represents the CP, the evolution of which is under negotiation; more intuitably (also) the speaker-ostended epistemic state of the Addressee or of third parties ('common sense'). The hypothesis part-explicates Ducrot ([15] p. 128ff.; [16]), for whom 'A but B' presents A as an argument for some R, and B against, such that B inhibits the conclusion, R, which the hearer would draw in view of A. Cf. Merin [57] and [56] for some 270 pp. on 'but', including occurrences translating Ge. *sondern* or Sp. *sino*, which are ignored here.

[45] A referee noted that the * might be due to violation of a requirement for pronominalization, fielding as a likely counterexample *Mary tried as hard as she could but {she/?Mary} even couldn't lift the newspaper.* Looking at *Kim splurbs but she even glurbs*, I still feel that it sounds better with *but then* in place of *but*: compare e.g. *Kim walks but {then/*ϕ} she even talks.* Contrast *Kim walks and {she / Kim} even talks.* So perhaps phrasal heaviness along with the intensionality of *try as hard as one can* linking with that of *cannot* introduces complications. Cf. Merin [56], Ch. 5 on atemporal *but then*; and Section VI, below, on *also*.

[46] Sharper example: [A] *Wilkins is a man of principle, but* [B] *he is now Chancellor of Crowford.* No aspersions need be cast on Crowford, nor Wilkins. Simply imagine yourself discussing the moral decline of Batbridge and suppose that *A but B* presents A as an argument *for* some issue proposition H (e.g. 'Wilkins can stop the rot at Batbridge') and B *against*; with B ostensibly carrying the day.

by $P^i(B|A) < P^i(B)$ or, equivalently, $\mathrm{r}^i_B(A) < 0$ formally necessary for $\mathrm{r}^i_H(A) > 0$, $\mathrm{r}^i_H(B) < 0$, and $\mathrm{r}^i_H(AB) < 0$ jointly to hold. The condition $\mathrm{r}^i_B(A) < 0$ is not even necessary, more generally, for A and B to be *H-contrary* at i, i.e. for $-\mathrm{sgn}(\mathrm{r}^i_H(A)) = \mathrm{sgn}(\mathrm{r}^i_H(B)) \neq 0$. (NB: $\mathrm{sgn}(X) =_{df}$ 1/0/-1 for $X > / = / < 0$.) But note the following

Theorem 8. *If* $(A \perp_i B| \pm H)$, *then* $P^i(B|A) < P^i(B)$ *iff* $\mathrm{sgn}(\mathrm{r}^i_H(A)) = -\mathrm{sgn}(\mathrm{r}^i_H(B)) \neq 0$.[47]

H-contrariness yields A-unexpectedness of B under CIP. A prominent special case of Hypothesis 4 obtains when $H = \overline{B}$ (cp. [3]). Note here

Theorem 9. *For any* A, B *and context* $\langle i, H\rangle$: *if* $H{=}\overline{B}$, *then* $(A{\perp_i}B|{\pm}H)$.

Likely instances of $H = \overline{B}$ are the stock example or the 'aspersions on Crowford' reading for 'A but B' of footnote 46. $H = \overline{B}$ is apt as a default interpretation, not least in linguists' out-of-the-blue uses. For one, it avoids introducing new atomic H into the propositional universe of discourse, i.e. into the minimal field $\mathcal{F}$ of $P^i(\cdot)$. And it yields all basic (a,b), prototypical (c), and formally elegant (d) properties of 'but':

Theorem 10. *If* $\mathrm{r}^i_H(A) > 0$ *and* $H = \overline{B}$ *and* $P^i(AB) > 0$, *then*
(a) $\mathrm{r}^i_H(B) < 0$;
(b) $\mathrm{r}^i_{\overline{H}}(B)$, $\mathrm{r}^i_{\overline{H}}(AB) > \mathrm{r}^i_H(A)$;
(c) $P^i(B|A) < P^i(B)$; *and*
(d) $\mathrm{r}^i_H(AB) = \mathrm{r}^i_H(A) + \mathrm{r}^i_H(B)$.

The relevance analysis also accounts for an apparent language universal (Merin [55]). This is the following asymmetry between NPs, which prototypically denote 'particulars', and VPs, which typically denote 'universals': While for

Kim_k walks but Kim_k talks

a felicitous context can always be found (e.g. Shall we hire Kim as a confidential messenger?), we have

**Kim walks but Sandy walks*
Kim walks but Sandy { *a l s o walks / walks too*}

[47] Established in all essentials by Reichenbach [68] in discussion of causal relations. Cp. remarks on Def. 9 and check intuitions suggesting $(A \not\perp_i B| \pm H)$ for the context $\langle i, H\rangle$ of fn. 46.

for all contexts.[48] On present evidence,[49] any language having bona fide, specific translation equivalents of 'but' and 'also' obeys the pattern, first noted for English, and classified as a brute syntactic fact, by Harris [29].

The apparent asymmetry of, simply speaking, subject (particular-like) and predicate (universal-like) calls for an explanation.[50] Let $P^i(\cdot)$ be defined on a monadic first order quasi-English language fragment. Consider now, adapted from Carnap [12], the following

Definition 10. $P^i(\cdot)$ satisfies *non-negative instantial relevance* [NNIR] when, for arbitrary Q, a, b: $P^i(Qb|Qa) \geq P^i(Qb)$.

Under NNIR a proposition Qb cannot be Qa-unexpected in i.[51] Now, as we saw above, A-unexpectedness of B is not generally necessary for acceptability of 'A but B'. But recall also that the special case $H = \bar{B}$ of H-contrariness makes B A-unexpected and is a prime candidate for an interpretive default (Theorem 10). Let us embed this fact into a more general setting and adopt as a

Hypothesis 6. Every natural language L obeys a *Default Satisfiability Principle* [DSP]: Let L have a default condition Γ on preferred interpretation of a class $\Sigma \subseteq L$ of expressions. Let $\sigma \in \Sigma$. If σ satisfies Γ for no context $\langle i, H\rangle$ of non-degenerate use, then σ is unacceptable [write: $^*\sigma$].

Suppose now that Γ has for an instance the Conditional Independence Presumption, CIP (Hypothesis 2). Recalling Theorems 8 and 9, we have as a

Corollary 11. *Given* DSP, *instantiated either by* CIP *or more narrowly by the antecedent of Theorem 10: if the probability functions $P^i(\cdot)$ of contexts $\langle i, H\rangle$ of use for sentence schema 'Qa but Qb' generally satisfy* NNIR, *then* **'Qa but Qb'.*

Will NNIR obtain merely as a brute, albeit evolutionarily plausible fact? Not necessarily so. For the linguistically pertinent class of probability functions, it can be motivated discourse-semantically. Here is how. Argumentation involving H-contraries uses an inference rule of Universal Probabilistic Instantiation [UIP]. To see its workings recall the earlier example sentence

[48] The *ed sentence is single-speaker and has concomitant default prosody.

[49] Latest: see LinguistList 9.240 (1998) for the result of an Internet query.

[50] Cf. Merin [56], Ch. 5 for a much fuller version.

[51] If a, b designate individual events of tossing a coin, NNIR thus tells you not to let an observation of 'heads' lower your probability for 'heads' on the next toss of a coin if you have no extra evidence (say, Tb, of a trick about to be played). By contrast, NNIR does not rule out, say, Qb being Rb-unexpected for logically independent Q and R, nor, say, its being Ra-unexpected.

Kim is a doctor but she lives in Mozambique. As before, grant as background knowledge in typical i that Mozambique has a very low GNP; as United Nations statistics say. The presumption then must be that a resident of Mozambique is unlikely to be rich. But doctors, presumably, are likely to be rich. The formal argument then includes steps of which the following one is representative:

1. $\forall x[P^i(\text{rich}(x)|\text{doctor}(x)) = \alpha \ (1 > \alpha \gg 0.5)]$ [Ass.]
2. $P^i(\text{rich}(Kim)|\text{doctor}(Kim)) = \alpha$ [1,UIP].

Is the instantiation of x to Kim indeed valid? Recall that probability creates an intensional context. A reminder of this fact is that doxastic necessity may be interpreted as doxastic probability 1 (see fn. 3). To state conditions for validity, we first need, appropriately specialized and phrased for brevity of argument, a standard technical

Definition 11. A probability function $P(\cdot)$ on sentences with first-order models is *symmetric with respect to a sequence* $(\pm Qa_j)_{j\in J}$ *of sentences* (Q a fixed predicate, possibly differing in polarity Q vs. $\overline{Q}$ among sequence elements) iff the probability $P(\bigwedge_j \pm Qa_j)$ of the conjunction of sequence elements stays invariant under all finite permutations of the set of individual constants a_j. $P(\cdot)$ is *symmetric* iff symmetric with respect to any such sequence in its domain.[52]

The crucial theorem is here stated briefly and informally:

Theorem 12. (Skyrms [70]) *Validity of* UIP *requires that no $P(\cdot)$-relevant information be conveyed by the individual constant. Names must be treated as properly arbitrary and thus $P(\cdot)$ must be symmetric.*

Present use of it rests on something I shall adopt as an empirical

Hypothesis 7. Natural language semantics satisfies an *Embeddability Desideratum* [ED]. Models (or Discourse Representation Structures) generated by a small, finite universe of individuals (or their discourse referents) should be embeddable in larger models of arbitrary finite or of infinite cardinality.[53]

[52] Symmetry extends the permutation-invariance that characterizes deductive logical relations to that of inductive relations; appropriately so to those of a relatively aprioristic kind.

[53] Unless, as Tim Fernando of U. Texas at Austin pointed out, the candidate structures for embedding correspond to theories that have only infinite models to start with or only models of bounded finite cardinality. Such cases would naturally arise in mathematical discourse. Discourse Representation Structures are due to Kamp [43].

This hypothesis, and a reminder that a countable first-order model may be represented by a set of first-order sentences (a 'state description'), in turn, lend linguistic import to the following pair of

Theorem 13. (Savage-Kemeny-Gaifman-Humburg) *A symmetric probability function $P(\cdot)$ on finite first order models m extends to symmetric $P'(\cdot)$ on extensions m' of m of infinite size only if $P(\cdot)$ satisfies* NNIR.[54]

Corollary 14. ED (*cf. Hypothesis 7*) *and validity of* UIP *imply* NNIR.

One might now think that such appeal to deep results is a case of theoretical overkill. And one should indeed do well to think so if ready to accept the following thesis, rarely professed though frequently implicit in casual pragmatico-semantic argumentation: The structure of natural languages and attached bits of mind is very much simpler than that of, say, the hydrogen bond. I see no compelling evidence for the truth of such a thesis.

To test the stochastic approach empirically, we must now ask what explains the healing power of *also*. A serious answer requires an independently motivated account of *also*. Hence, I shall propose one. This takes us into the phenomenon of presupposition. I treat some of its traditional instances in [59]. Here I just outline what is required to sustain the argument regarding *but also*.

VI. Presupposition: 'also' and 'too'.

Current formal accounts of presupposition, following Stalnaker [75], are based on a notion of *being presupposed in a context*. The context or *common ground* (CG) is one of discourse participants' ostensible joint and firm, epistemic or other commitments: a conjunction of propositions, hence a proposition. Proposition A is presupposed iff entailed by CG. Let us say that an *utterance* of sentence S *presupposes* A iff the utterer presumes it context-presupposed. If need be, and subject to conditions left vague in the literature, it will be so presumed by 'accommodation' (Lewis [51]), i.e. by being taken for granted as context-presupposed, even if it was not actually so context-presupposed. Call A *sentence-presupposed by* S iff every felicitous utterance of S utterance-presupposes it.

Consider now the conservative probabilistic extension CP of CG. We identify, as before, an epistemic state with a probability measure, a *common prior* (CP) over a field $\mathcal{F}$ of propositions, and adopt as a

[54]Proofs: Gaifman [21], Humburg [37]. The convergence to a class of probability functions satisfying NNIR is rapid already for fairly small, finite m'. So, to all intents and purposes, one may read *infinite* as *arbitrarily large finite*.

Definition 12. Proposition A is *presupposed in epistemic state (context) i [i-presupposed]* iff $\forall X[P^i(X) = P^i(X|A)]$.

This implies $P^i(A) = 1$, and we can say: $\mathsf{CG}^i =_{df} \{A : P^i(A) = 1\}$. Intuitively, A has spent all its relevance in coming to be presupposed. Now consider the focus particle, *also*. Let the first, x-argument of the schema $also(x, y)$ be the focus of *also*. Traditionally, use of $also(b, B)$ as e.g. in

Kim a l s o talks

utterance-presupposes that some individual a other than b (Kim) has the property B. Kripke [49] objected,[55] with counterexamples similar to

Kim and Sandy will come. The boss will also come.

This discourse sequence, now, presents a context for $also(b, B)$ in which

$$\exists x[\text{come}(x) \wedge x \neq \text{the boss}]$$

is satisfied even when, contrary to linguistic intuition, Kim *is* the boss. For $also(b, B)$ to be appropriately utterable, some Ba must be an *anaphorically salient* part of the context.[56] The 'presupposition', says Kripke, is that, for any such a: $b \neq a$; in our example, that the boss is neither of Kim or Sandy. I will show that this follows from a much more general presupposition, and that one of the premisses of the derivation is a presupposition in the traditional sense, which, in turn, is part of what Kripke identifies as anaphoricity.[57]

First, I explicate salience and (a very special case of) anaphoricity as applying to *propositions*. Salience is, no doubt, always implied by anaphoricity. The presuppositional condition will further characterize the important special case. It will not do so fully; for one, because it makes no reference to syntactic entities.

Definition 13. Proposition D is *topic-anaphorically salient* for proposition E in context $\langle i, H\rangle$ iff **(i)** $\mathrm{r}_H(\dot{E}) \neq 0$, and **(ii)** D is i-presupposed ($P^i(D) = 1$), and **(iii)** the last (or close to last) preceding context with index $i - k$ such that $P^{i-k}(D) < 1$ satisfies $\mathrm{r}_H^{i-k}(D) \neq 0$ [where $k = 1$ or small positive integer].

[55] Arguing for 'too', which differs from 'also' in ways inessential here.

[56] 'Some' here admits sets $\{a_j\}_{j\in J}$ of antecedents. For brevity, I treat formally only the '=' case $j = 1$ in what follows. I treat '$\in$' and predicate-focus quite analogously in a forthcoming paper on 'also' and 'too' that contains an earlier, full account.

[57] More generally so, van der Sandt [77]. See Beaver [8] for assessment; and for a state-of-the-art survey.

Intuitively: (i) demands $\langle i, H\rangle$-relevance of E; (ii) and (iii) jointly demand that D has just or recently come to be presupposed, and has spent non-negligible relevance to H in the process. So D is, at the very least, related to E via H. The *intuition* that D is nonetheless relevant to H at a point of utterance indexed to i is, so to speak, ambicontextual.[58]

Hypothesis 8. *also*(b, B) is felicitous only if there is a (proposition expressible as) Ba topic-anaphorically salient for (the proposition expressed by) Bb and the appropriate one of the following specific felicity conditions is met:

For (*and*) *also*(b, B) : $\mathrm{sgn}(\mathrm{r}_H^{i-k}(Ba)) = \mathrm{sgn}(\mathrm{r}_H^{i}(Bb))$.
For *but also*(b, B) : $\mathrm{sgn}(\mathrm{r}_H^{i-k}(Ba)) = -\mathrm{sgn}(\mathrm{r}_H^{i}(Bb))$.

Re *salience*: In uttering *Kim a l s o lives in New York*, one might well take for granted that millions live there (Kripke [49]). Now, is one Jane Doe's living there of relevance to the issue, H? Let H = *Do we have sufficiently many friends in N.Y.?* Then, without any more ado, it isn't. But suppose we have just come to agree that J.D. lives there (cp. Def. 13.ii,iii). Then presumably we did so for a reason, namely, that she is a friend. So quasi-perceptual 'salience' is at least in parts domesticated—as relevance—into the realm of action.

Re *presupposition*: By Hypothesis 8 and Def. 13.ii, i-felicity of *also*(b, B) implies $P^i(Bb|Ba) = P^i(Bb)$. I.e. Bb is i-irrelevant to (i.e. stochastically i-independent of) its i-presupposed, topic-anaphorically salient antecedent. This yields as a

Corollary 15. *If $b = a$, then $P^i(Bb) = P^i(Bb|Bb) = 1$. Hence, Bb will be i-irrelevant to any possible H. Thus, if Bb is to be i-relevant at all (whatever H might be), $b \neq a$ is required.*

The familiar non-identity constraint for *also* becomes derivable. Kripke's notion of 'presupposition' arises out of obedience to 'Be relevant!'. This maxim, now, properly extends the requirement 'Be consistent!', which might be said to motivate the naive and apparently vacuous classically semantic notion of presupposition that admits only the tautology as a presuppositum.

Re *accommodation*: When can it take place? How is it distinct from context-presupposition and assertion? A standard example type of accommodation ([32]) is the presumption arising that there is a duke of Paris,

[58] For technical options explicating it, see Skyrms [71]. Feasibility is realistic: limitation to short-term memory (small integer k of updates) characterizes our conversational phenomenon, here particularly the use of *also*.

when someone says '*The duke of Paris is not bald*', negation being deemed boolean with sentence scope (cp. [22], p. 90 on why 'duke'). Kripke mentions theoreticians' folklore observation that accommodables should be 'uncontroversial'. But what does this mean? I.e. where is a theory that gives it explanatory significance? The DTP framework suggests explicating uncontroversiality by *irrelevance to the issue*. Context-presuppositions are thus uncontroversial by Def. 12.

Partial Definition 14. A proposition Θ is *properly accommodable* at $\langle i, H\rangle$ only if $0 < P^i(\Theta) < 1$ and $\mathrm{r}^i_H(\Theta) = 0$.

The duke's existence, for example, will *in itself* presumably be irrelevant for, say, our sales prospects of pate-polish. His not being bald, materially conditional on existence, might not; and the relevance of that might—indeed would [59]—increase once his existence was properly accommodated.

Consider now an utterance of $also(b, B)$ when no instance of Bx is presupposed. Could one accommodate a salient Ba? Not properly so. The proposed constraint $\mathrm{r}^{i-k}_H(Ba) \neq 0$ (default: $k = 1$) for *anaphoric* salience at i is motivated by the semi-theoretical intuition that Ba is relevant to H at the same order of magnitude as Bb. Its current irrelevance is due to its relevance having been spent when it turned from, say, an assertion at $i-1$ into a presupposition at i. But if Ba has to be accommodated, then it has not yet become irrelevant through having spent its relevance. Thus, to be relevant to H, it must still be so at i. Hence, proper accommodability is ruled out.

This explains the well-known observation that 'also' is reluctant to license accommodation of an antecedent. I *can* say, 'Kim also talks', and hope you will get my meaning: that our friend, Sandy, talks. But, as likely as not, you will respond with puzzlement, even hostility, instead of smug complicity. Your reaction need not be due to ignorance[59] ('Who else could there be?'), but due to a reluctance to let me take for granted what should not be granted without argument, i.e. what is really an assertion. Here is the essential, properly epistemic distinction between *accommodables* and *assertables*.

Part-explication of anaphoric salience by Def. 13 has more striking, less arcane consequences, too. Consider *Sandy walks and Kim a l s o walks*. Def. 13.i implies that i-felicity of *'Aa and also Ab'* implies $P^i(Ab|Aa) = P^i(Ab)$. Next, following Reichenbach [68] and Suppes [76] grant a

[59] Beaver [8], Section 6.1, reports Henk Zeevat's suggestion that anaphoricity requires explicit mention for textual coherence. This speaks against unitarian tendencies for presupposition treatment. My proposal would speak for them. I should be surprised if they could prevail, but think it useful to explore how much language structure *is* motivable by constraints on rational conduct.

Partial Definition 15. A has *prima-facie causal responsibility* for B according to i only if $P^i(B|A) > P^i(B)$.[60]

This implies

Corollary 16. *If A is i-presupposed, then A lacks prima facie causal responsibility for (any) B according to i.*

The corollary and the previous fact lead to the following

Prediction 4. In *'Kim fell and she (also) broke her arm*, 'also' removes routine intimations of causality (causal implicature).

This prediction is readily confirmed. To confirm the semantics of 'also' further, consider the following simple

Fact 17. *If* $P^{i'}(\cdot) =_{df} P^i(\cdot|A)$, *then* $\mathrm{r}^{i'}_H(AB) = \mathrm{r}^{i'}_H(A) + \mathrm{r}^{i'}_H(B)$.[61]

Note a similar decausalizing effect of 'plus' or stressed 'and', near-synonyms to 'and also'.[62] Thus, presuppositional independence induced by 'also' guarantees the very property which makes the characterization of 'also' and 'too' as 'additive' particles (König [48], Ch. 4) so apt.[63] For note that relevance is now additive for arbitrary A, B, H.[64] Such evidence for a relevance-semantics of 'also' now gives some weight to the following

Hypothesis 9. 'also' in *'A but also B'* pre-empts the A-unexpectedness default for *'A but B'*, and thus CIP, in forcing conditioning on A prior to that on B by Hypothesis 8 and Def. 13.

This coheres well with an intuition (check!) that *A but also B* intimates or favours for DT an $H \neq \overline{B}$. The condition of Hypothesis 4 that, nevertheless,

[60] 'Prima facie cause' is Suppes' notion, label credited to Hintikka. *Secunda facie*, the cause may turn out to be spurious, i.e. a case of spurious stochastic correlation. I doubt that the language faculty deals extensively in second sight.

[61] Proof: $P^{i'}(A) = 1$, hence $\mathrm{r}^{i'}_H(AB) = \mathrm{r}^{i'}_H(B) = 0 + \mathrm{r}^{i'}_H(B) = \mathrm{r}^{i'}_H(A) + \mathrm{r}^{i'}_H(B)$.

[62] Jeff Kaplan [44] notes kinship of 'a n d' with 'too'.

[63] This result has most striking implications for intuitions attending whole-sentence focus interpretation, an otherwise occult phenomenon.

[64] The difference between plain *and* and *and also* poses a problem for the extendibility, to non-deductive inferential relations, of any dynamic semantics (e.g. Heim [31, 32] and other contemporary theories) which represents simple 'and' by way of sequential updates. Our evidence makes this representation appropriate in general for 'and also' only. Thus, updating of epistemic, 'world-information' constraints and of discourse-internal constraints will fall apart in the case of plain 'and' whenever the second clause contains an anaphoric reference to a discourse-referent introduced by the first. For on current understanding that referent must become part of the discourse-context to license anaphoric linkage to a pro-form in the second clause.

A $(= Ba)$ and B $(= Bb)$ have inverse signs of relevance with respect to H is explicated in modified form by the appropriate specific felicity condition of Hypothesis 8.[65] For recall that intuitions are now explicated ambicontextually, or, if you will, as being more properly kinematic.

VII. Dichotomic Issues

One might ask what motivation there is for assuming dichotomic issues $\{H, \overline{H}\}$. A socio-political motivation is the two-person bargaining framework, since dichotomies yield relevance functions that determine dual quasi-utilities or indeed cardinal utilities by indexing to a single proposition. But again, there is a trans-partisan cognitive rationale being served. Recall the use made in Sections IV and V of the conditional independence presumption, CIP, in deriving linguistic predictions. Let CIP now stand for the general, extralinguistic compositionality principle noted. This principle has a more general consequence yet.

For suppose CIP were to generalize to issue partitions $(H_j : j = 1, \ldots, n)$. R.W. Johnson [41] proved that for $n > 2$, at most one evidential proposition deemed atomic can be relevant to any given H_j if conditional independence of evidential atomic propositions is to be satisfied with respect to each element of the issue partition and its complement.

Cognitive engineering cannot always reasonably restrict itself to dichotomies. It will occasionally give up CIP thus generalized. (Recall also the 'doctor' example, Section V.) But suppose the Maker of cognitive psychology values additivity and thus freedom from paradoxes of relevance. This will militate for restriction to the case $n = 2$. The adoption of CIP would thus predict a cognitive bias towards dichotomizing issues. Anecdotal evidence speaks for such a bias being evolutionary fact. Of course, more obvious reasons for it can be thought of. That's fine by me. Any prima facie independent constraint that favours dichotomy will also favour descriptive appeal to CIP.

VIII. Conclusions

Decision-Theoretic Semantics is the label I have given, for want of a more informative one, to the pragmatic approach to meaning illustrated above. The aim has been to show some consequences of taking seriously the view of language as an instrument of rational action and attendant cognition.

The theory of action and cognition assumed is that which largely informs today's curricula in political science, economics and business studies;

[65] I.e., $\mathrm{sgn}(\mathrm{r}_H^{i-k}(Ba)) = -\mathrm{sgn}(\mathrm{r}_H^i(Bb)) \neq 0$, for small $k \geq 1$. By Fact 17, this entails $\mathrm{sgn}(\mathrm{r}_H^i(BaBb)) = \mathrm{sgn}(\mathrm{r}_H^i(Bb))$, i.e. $\mathrm{sgn}(\mathrm{r}_H^i(AB)) = \mathrm{sgn}(\mathrm{r}_H^i(B))$.

for better or worse. It generates more structure and thus, if you will, more readily falsifiable hypotheses than common sense discussion of desires, beliefs, intentions, and cognitions is wont to do. It also links up significant parts of the philosophy of language with the tradition of inductive argumentation that is central to the philosophy of science. One example of this is the semantics of 'but'. Another such point of rapprochement is the distinction drawn in terms of relevance relations between assertion, implicature, accommodatum, and presupposition. There is some reason, then, to invest in applying the theory to what is perhaps the most fundamental of social institutions.

Relevance of assertions—a directional, signed notion as defined in this framework—and the political structure of partisan negotiation are two sides of the same coin. Partisan structure is inherent in the notions of argument, debate and deliberation. It is familiar in pre-Socratic reasoning and contemporary logic alike. It is what underlies and promotes *talking to a point*, rather than merely adding information to a context, never mind to which end. A pertinent concept of relevance will, as Grice noted, explicate this latter intuition, not tacitly rely on it.

Partisan structure does generate trans-partisan structure, one flight of description up. This is not merely, as common sense plausibly suggests, a matter of cancelling partisan atavisms or heuristics by taking both points of view in sequence or in parallel. We have in fact seen a very specific 'invisible hand' type effect in 'scalar implicature' (Section III.2.A). Another, more abstract instance of such trans-partisan constraints is the multiply predicted bias towards dichotomies.

Both findings are consistent with the assumption that cognitive structures are *sociomorph* in being predicated on simple, though far from simplistic structures of social action. This, in turn, should lend some formal and predictive substance to a thesis often advanced in more general terms, though less often made to yield empirical consequences. The thesis is that intricate basic mechanisms of language and of mind are social phenomena.[66]

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