Information, Relevance and Social Decisionmaking:

Applications to Non-Truth-Conditional Semantics

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Compressed Abstract: This paper submits an approach to broadly non-truth-conditional aspects of meaning in natural language which interprets 'pragmatics' substantively: in the way of C.S. Peirce and F.P. Ramsey, as a synonym for decision-theory. We outline (i) basic assumptions, (ii) some relations to other approaches, (iii) a range of results wide enough to justify the term 'approach'. A key notion is 'relevance', explicated and related to information in the traditional, stochastic way.

I. Introduction

'Information' is a local synonym of 'meaning'. There is little of that without reasoning. Within a deductive framework with classical closure operation $Cn(\cdot)$ let a theory T represent an epistemic state. Classical theory change being monotonic, one might identify the meaning of a sentence E in context T with the set-difference $Cn(T, E) - T$.

Already for sentential languages, and disregarding obstacles to computing closure, this is not a felicitous picture of human beliefs; nor, hence, of meaning. 1. Logically independent sentences A, B may intuitively stand in inferential relations. Indeed, if Hume was right, all empirical knowledge is of this contingent nature. 2. Epistemic state-change is highly non-monotonic. Beliefs can be given up; tea with Harper's Diesel Oil added is no longer tasty.

The oldest though far from ontologically leanest formalism for inductive, non-monotonic reasoning is the probability calculus (PrC). Its axioms, extending classical logic, constrain belief to be coherent. Incoherence means: being disposed, in unwitting practice, to consider favourable or fair a system of bets in which one must lose come what may (Ramsey 1926).

Now, imputing to life-sized agents as epistemic states point-valued probabilities, i.e. unique conditional probability functions $\mathrm{p}(\cdot|\cdot)$ is implausible. And even if we recognize PrC as imposing but 'roomy' (Jeffrey 1965) constraints, we still face NP-hard computation. Should this deter us from using probability theory in the analysis of natural language meaning and prima facie meaning-conditioned acceptability intuitions? No.

1. Probability is well-investigated; about as ad hoc as classical logic; and hence a natural benchmark for competence models of defeasible reasoning. At the very least it could be scout to leaner formalisms; a standard mathematical tactic.

2. Probability trades with cardinal utility, i.e. a quantitative representation of preference. Indeed it offers the one principled link, so far, between normative accounts of rational belief and conduct under conditions of uncertainty where real stakes are at issue.

3. With Ramsey (1926) we can explicate belief and meaning in terms not of 'holding true' and concomitant assent or dissent, but of *dispositions to conduct*. This is, essentially, the Maxim of C.S. Peirce's Pragmatism. Example: if you think rain 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. You will then act in a way 'extensionally' indistinguishable from the way you would act if you were sure it was going to rain. Pragmatist construal makes probabilistic belief states more plausible than will the assumption of introspectible accountability and explicit imputability required by forensic discourse about belief—a rather special language game that should not determine the class of useful theories of meaning.

4. Probability, also with decision-theory built around it, has nice mathematical structure.

5. Probability functions can be treated as personal (Ramsey, 1926). For linguistic applications here considered this means: their ostensible imputation to one or more of actual or virtual discourse participants is being imputed to competent Speakers.

6. 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, 'Signal Detection Theory' (SDT) and the developed world's industrial production of middle-sized dry goods have been running profitably since the 1940s.

7. Though it is widely held that Kahneman and Tversky (cf. Kahneman et al. 1982) showed probability not to be a serious candidate even for a competence model, the evidence has not gone unchallenged. Consider e.g. the 'taxi-cab' problem, for which Birnbaum's (1982) re-analysis showed the data to be as predicted by an SDT approach. Speculations on what people cannot unconsciously do should be evaluated against the psychophysical SDT literature.

II. Information and Relevance

In a probabilistic setting over finite 'sample spaces' W, i.e. event or proposition fields of sets, whose points w are worlds, models, or maximal consistent sets of sentences, probability weights/masses are assigned to points, normalized to distribute a fixed unit mass. Palpably, the empty set must receive zero mass, the universal set W unit mass; the mass of $A \cup B$ is the sum of their masses minus that of $A \cap B$ (not to be counted twice!). These are the axioms of finitely additive probability, in sensori-motor imagery. We can also derive them from rational action: e.g. coherently fair bets (Ramsey 1926). Conditioning on a proposition E amounts to transformation of W by set intersection with E, where all mass previously assigned to $W - E$ is redistributed evenly among points in E. Hence $\mathrm{p}(A|E) = \mathrm{p}(AE)/\mathrm{p}(E)$. $[AE = A \cap E]$

For simplicity let W be finite. Carnap and Bar-Hillel (1952) [CBH] consider two explicata of *amount of information* (phenomenologically: unexpectedness):

> $\mathrm{cont}(E) =_{df} \mathrm{p}(\bar{E}) = 1-\mathrm{p}(E) = (\mathrm{card}\{w : w \in \bar{E}\})/(\mathrm{card}\{w : w \in E \cup \bar{E}\})$ [last '=' valid only for $\mathrm{p}(\cdot)$ assigning equal probability mass to all $w \in W$]
> $\mathrm{inf}(E) =_{df} \log_2[1/(1-\mathrm{cont}(E)] = -\log_2[\mathrm{p}(E)]$

Inf is conveniently additive when A and B are stochastically independent, i.e. if $\mathrm{p}(A|B) = \mathrm{p}(A)$, equivalently $\mathrm{p}(B|A) = \mathrm{p}(B)$, then $\mathrm{inf}(AB) = \mathrm{inf}(A) + \mathrm{inf}(B)$. If $Q = Q_i$ is an element of a partition, then $\sum \mathrm{p}_i(Q_i)\mathrm{inf}Q_i$ measures the average expected information gain from an answer to the question: which element of the partition is the actual world in. (With another kind of sample space this is Shannon's entropy.)

The relation to entailment-based informativeness, prominent in seriously formal explications of Gricean conversational implicature (Gazdar 1979; Soames 1982) is: If $A \models B$ then $\mathrm{inf}(A) \geq \mathrm{inf}(B)$; and $\mathrm{inf}(A) > \mathrm{inf}(B)$ if in addition $B \not\models A$. The converse is invalid.

Inf or cont as such stronger notions have not, so far, found explicit well-informed use in linguistic pragmatics. However, the license they offer to compare informativeness even of $\models$-incomparable propositions recalls one aspect of a notion proposed by Sperber and Wilson (1986) [SW] which I'll label relevance$_{SW}$.

SW maintain that utterances U carry an ostensive presumption of optimal relevance. This practically implies, for one: if U has several alternative interpretations $\{E_i\}$, interpret as that E^* which can be deemed most relevant in the context; if these interpretations are ampliative, make requisite assumptions. I take the explanatory value of this principle for granted.

However, SW have not offered—indeed declined to offer—an *explication* of the intuitive notion 'relevant'. Relevance$_{SW}$ of an E is large to the extent that its 'contextual effects' are, and small to the extent that E in context is hard to 'process'. Both notions remain informal, and 'effects' are heterogeneous. However, SW's most formally committed and elaborately discussed kind of effect has a correlate in simple monotonic theory change.

Call E for the nonce 'non-degenerately K-informative' iff $Cn(K, E)$ is consistent and $Cn(K, E) - K$ non-empty. Call E and K 'jointly informative' iff, in addition, $Cn(K, E) - E$

is non- empty. Modulo proscription of derivations by connective introduction rules (which are of no present concern), and keeping 'processing effort' constant, jointly informative E and K would be relevant$_{SW}$ to the extent that the set-differences were large. (Other criteria of relevance informally noted do include an explanandum I'll favour below.) Without further constraints this effect makes any logically independent K and E relevant$_{SW}$ (to some non-nil extent).

The stochastic extension of $Cn(K, E)-K$ is measured by CBH's (1952) amount of conditional information of E given K:

> DEFINITION: $\text{inf}(E|K) =_{df} -\log_2[\text{p}(E|K)]$.
> FACT: $\text{inf}(E|K) = \log_2[1/\text{p}(E|K)] = \log_2[\text{p}(K)/\text{p}(EK)] = \log_2[\text{p}(K)]- \log_2[\text{p}(EK)] = \text{inf}(EK)-\text{inf}(K)$.

If extent of joint informativess were to explicate extent of contextual effect we could now explicate it, for comparison's sake:

> $\text{EFF}_1(E, K) =_{df}\text{inf}(E|K)+\text{inf}(K|E) = 2\text{inf}(EK)-\text{inf}(K)-\text{inf}(E)$. [where the 2 of $2\text{inf}(EK)$ tells us that $\text{EFF}_1(E, K)$ is always non-negative.]

By contrast, in a quantitative or qualitative stochastic setting, *relevance* is a very different and specific relation between two propositions. E is *relevant* to H iff learning its truth in a state where its truth was not assumed would affect the probability assigned to H. It is *positively* relevant to the (quantitative) extent it raises it, *negatively* to the extent that it lowers it. Thus relevance is a properly *disjunctive* notion: of positive and of negative relevance. I shall reserve for this generic notion the index-free label, under which it is familiar e.g. from Keynes (1921), Carnap (1950), and Jeffrey (1965) and, I guess, to most people with a background in stochastics.

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

This idea informs the approach to 'conversational' and 'conventional' implicature, of Ducrot (1973) and his student Anscombre (1973) [AD]. AD explained implicatural phenomena through rankings of propositions by what they called *valeur argumentative* w.r.t. an ostensible ulterior conclusion H. Often H would be explicitly given by linguistic context. Thus in AD's favourite example format some sentence 'E' is uttered in support of some immediately prior H. My pulp fictional example, a disambiguation task (a class of tasks as little discussed by AD as by H.P. Grice 1967):

> [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 bundle, the garbage? Or that she will kill him? Most likely the last, the strongest argument in favour of acting in accordance with [H]. (Here we are lucky: no appeal to processing effort seems required. Perhaps we'll be lucky most of the time.)

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_i in the taken-for-granted context K. Call this (part of) figuring out the speaker's intentions, or real intentions.

On this view, speakers S do not engage in idle gossip, do not proselytize for the sake of it, but speak to a *point*: the 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*—technically, a 'jointly randomized strategy'.

Interpersonal pragmatics on this view is interpersonal decision theory. Leaving aside the rational reconstruction of pure convention (Lewis 1969) that might well underlie stable aspects of social institutions, including any sort of language game, we cannot in general presume that social interactions have the structure of a 'team game' (of 'perfect cooperation') where all agents have identical or at least compatible *prima facie* preferences.

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 $\bar{H}$ 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 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 1994).

This lends the paradigmatic social situation the structure of a *bargaining game* [BG], proposed by Harsanyi (1977) as a widely applicable model of social interaction. (Against the backdrop of which other kinds of interaction—check: 'love', 'urbanity'—gain their distinction.) 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 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 degenerate, 'ultimatum' BGs [example: law-abiding customer vs. fixed-price store], if Pro makes a claim, Pro won't object to Con conceding more (a windfall), but will mind getting less. Con won't mind giving away less than conceded, but will mind giving away more. (Reflected in intuitions glossable 'at least', 'at most'.) This already affords a lot of useful structure (Section 4).

What is the Speaker's utility attaching to an imperative/jussive E? Prima facie, the utility attaching to the prospect of its realization. What is it for indicative/declarative E? Prima facie, E's relevance to an ulterior constraint. Can we explicate relevance as a special case of utility, i.e. a real-valued representation of preferences? As long as we are careful about degenerate cases where some measures of relevance go to infinity, yes. And the explicans turns out to be a measure 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. 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. In consequence, I believe, they were unable to compete in predictive commitment with the most rigorous work on, say, generalized conversational implicature (Gazdar 1979; Soames 1982). But their insights (all in French; though cf. Horn 1989 for useful glimpses) are the principal linguistic inspiration behind what follows.

III. Decision-Theoretic Pragmatics (DTP)

What are the implications of judging more relevant one rather than the other of two ideologies of communication: the (Neo-)Gricean view of optimal information transfer, apparently shared by SW; and the partisan, persuasion-oriented view?—Well, relevant to what?

In well-rounded philosophical discourse on information we would note that 'figuring out real intentions' already presumes scepticism, and (Austin 1946) cause for it. The objective of optimal information transmission doesn't. But philosophy, let alone aesthetics or ethics, needn't be consequential for explanation of robust linguistic intuitions. Much as one may consider one super-objective more enlightening than another about what goes on accountably, that other may be the one by which the poorly introspectible linguistic intuitions of present interest are predominantly conditioned.

Empirical commitments sharpen up with a formal definition of relevance. Ramsey-coherent epistemic updating is subject to Bayes' formula; in 'odds' form:

$$\mathrm{p}(H|E)/\mathrm{p}(\bar{H}|E) = [\mathrm{p}(H)/\mathrm{p}(\bar{H})]\cdot[\mathrm{p}(E|H)/\mathrm{p}(E|\bar{H})]$$

Posterior odds (on the left) equal prior odds times the likelihood ratio of H on E. Defining $\mathrm{Odds}(\Phi) = \mathrm{p}(\Phi)/1-\mathrm{p}(\Phi)$ and, for cognitive convenience (Peirce 1878), taking logarithms to any fixed base, say, 2 for common measure:

$$\log[\mathrm{Odds}(H|E)] = \log[\mathrm{Odds}(H)] + \log[\mathrm{p}(E|H)/\mathrm{p}(E|\bar{H})]$$

The last summand measures the epistemic context change potential of E w.r.t. H.

> DEFINITION: The *relevance* $\mathrm{r}_H(E)$ of proposition E to proposition H in an epistemic context represented by conditional probability function $p(\cdot|\cdot)$ is given by $\mathrm{r}_H(E) =_{df} log[\mathrm{p}(E|H)/\mathrm{p}(E|\bar{H})]$.

This is the log-likelihood-ratio for simple H. Call E *positively relevant* to H iff $\mathrm{r}_H(E) > 0$, *negatively* iff $\mathrm{r}_H(E) < 0$, else *irrelevant* to H. If $E \vdash \mathrm{H}\,(\bar{H})$, then $r_H(A) = \infty\,(-\infty)$. [$\mathrm{r}_H(E)$ is a continuous monotone increasing function of other measures of relevance, e.g. $\mathrm{p}(H|E)-\mathrm{p}(H)$, $\mathrm{p}(H|E)/\mathrm{p}(H)$. All purely ordinal claims thus remain true for them.]

Briefly, then: a proposition E is irrelevant to an *issue* iff its truth or falsity would not affect the degree of belief in either of the issue's possible outcomes. (No issue, no relevance!) $\mathrm{r}_H(E)$ is a function of the change in the probability of H that would be occasioned by assigning probability 1 to E. (Jeffrey 1965 extended this to more generally induced changes.) Relevance is intelligibly related to conditional informativeness:

> FACT: $\mathrm{r}_H(E) = \mathrm{inf}(E|\bar{H})-\mathrm{inf}(E|H)$.

With a taken-for-granted background K made explicit: $\mathrm{r}_{H|K}(E) = \mathrm{inf}(E|K\bar{H})-\mathrm{inf}(E|KH)$. So $\mathrm{r}_{H|K}(E)$ is *decreasing* in $\mathrm{inf}(E|KH)$ and *increasing* in $\mathrm{inf}(E|K\bar{H})$. If E were already taken for granted its assertion, a primitive notion for now, would be uninformative [$\mathrm{inf}(E|KE) = 0$]. E would also be irrelevant to any H, its epistemic impact having already been absorbed into the probability function. In this special case, relevance—to any proposition—and informativeness coincide. (In general they don't.) Both are 0. This explains why a notion irrelevance$_{SW}$, insofar as relevance$_{SW}$ incorporates 'mutual informativeness', would engage common usage of 'irrelevant' better than relevance$_{SW}$ that of 'relevant'.

Now consider the interpersonal component of linguistic explanation.

> THESIS BG: A dichotomic epistemic issue $\{H, \bar{H}\}$ is modelled by a two-person *bargaining game* (BG) between Pro and Con whose negotiation set is generated by a set Σ of interpretive or expression alternatives linearly ordered by signed *relevance* to H. Pro aims to establish, say, H, and Con $\bar{H}$. This yields *dual preferences* over Σ. If the ordering is not total, hence not linear, we have a game of 'incomplete information'.

Call *'upward cone'* for claims (of proposition) Φ the join ${}^{\geq}\Phi$ of propositions at least as relevant as the one induced by lexically explicit Φ. Then the dual *'downward cone'* ${}^{\leq}\Phi$ (join of propositions at most as relevant) represents Con's default expected counterclaim (concession), for which Pro bears no burden of evidence.

IV. Some Empirical Results

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 (Merin 1992) will be ignored. So are questions of computational complexity. (If worried about those, relax with a truth-table of 20 atomic constants, or do generalized anaphora resolution.) The set of persons to whom probability functions (p-functions) under consideration in applications are imputed is left implicit in this abstract. The default set will include the actual or virtual Addressee. Only *qualitative*,and rarely stronger than ordinal, relations among probabilities will be directly appealed to. Read p-function symbols as shorthand for sets of p-functions satisfying stated constraints.

A. 'Scalar Conversational Implicature' [SCI]

Thesis BG explains immediately the *defeasibility differential* between the 'upperbounding' (Horn 1972) implicature/default and speaker Pro's 'lowerbounded' claim/assertion: virtual or actual Con's 'at most' is *not Pro's responsibility to back*. And rationality of Con makes the Scalar implicature a computational *default*, and by *quasi-juridical* defualt. Net meaning is the rationally expected-to-be conceded claim; the intersection of 'assertion' and 'implicature'.

A1. Particularized SCI

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

is an example due to Hirschberg (1985), who explains: The context of potential Portuguese-speakers is the $\subseteq$-poset of alternatives $Pow\{husband, wife, child\} - \phi$. A generalization of Gricean 'Quantity' implicates $\bar{E}'$ for all such E' with subject denotata $s \not\leq_{Poset} \{husband\}$.

But what is the 'way of being given' of this context-set? Is the subset-structure pertinent? No. Is the poset-rule independently motivated? No. And so it won't explain (where $\sqrt{}$=$O.K.$)

> A: $\sqrt{}$\{My brother/mother/servant//Kim/Kim Bloggs\} does
> A: *\{Kim Basinger/The president of Brazil/Bill Clinton\} does. [G]

Let Q = Boss Inc., $A = W$ (Wife) at her job interview. Ask: a. Why should Q ask? and b. W answer as above? Because: (a) Q wants utility- relevant information ('Should we hire W?' [$= H$?]) and (b) W wants to be hired [H]. Suppose W doesn't speak Portuguese, but can call upon someone who does, virtually gratis; typically: kin or agnate; else friend (Kim); acquaintance (Kim Bloggs). But presumably *not* Kim Basinger. Hence the *.

Moreover, $\mathrm{r}_H(E) > \mathrm{r}_H(F) > 0$, surely. Treat E and F as potential claims. Recall that claims (demands) in bargaining are always 'at least'. And that the strongest compatible response (meanest concession) amounts to 'at most' that. So $\bar{E}$ is Boss' counterclaim, made and conceded *by default*. Indeed,

> FACT: $\mathrm{r}_{\bar{H}}(\bar{E}) > 0$ iff $\mathrm{r}_H(\bar{E}) < 0$ iff $\mathrm{r}_H(E) > 0$.

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

A2. 'Generalized Conversational Implicature':

Entailment-based informativeness has done rather well with 'strong' Scalar implicature from *or* construed as lattice join ($\vee$) to local, defeasible strengthening with intuitions appropriate to XOR (∇) (cf. Soames 1982). To make relevance predict we need another definition.

DEFINITION: A and B are *independent conditionally* on H and $\bar{H}$ with respect to $\mathrm{p}(\cdot)$ $[(A \perp B|H, \bar{H})]_p] \Leftrightarrow \mathrm{p}(AB|H) = \mathrm{p}(A|H)\mathrm{p}(B|H) \wedge \mathrm{p}(AB|\bar{H}) = \mathrm{p}(A|\bar{H})\mathrm{p}(B|\bar{H})$.

Intuitively, $(A \perp B|H, \bar{H})$ when knowing whether H or $\bar{H}$ accounts fully for any interactions between A and B. It yields additivity, i.e. compositionality of relevance:

FACT: If $[(A \perp B|H, \bar{H})]_p]$, then $\mathrm{r}_H(AB) = \mathrm{r}_H(A) + \mathrm{r}_H(B)$.

Intuitions on relevance often rest on warrant for a stochastic conditional independence presumption (CIP) that reduces computational load and the need for appeal to world knowledge. CIP, widely adopted in AI applications, enables us to use

THEOREM: If $(A \perp B|H, \bar{H})$ and $\infty > \mathrm{r}_H(A),\ \mathrm{r}_H(B) > 0$ then
(**a**) $\mathrm{r}_H(AB) > max[\mathrm{r}_H(A), \mathrm{r}_H(B)] > \mathrm{r}_H(A \vee B) > 0,\ \mathrm{r}_H(A \nabla B)$, whereas
(**b**) $\not\vdash \mathrm{r}_H(A \nabla B) \geq 0$; $\not\vdash \mathrm{r}_H(A \nabla B) < 0$; $\not\vdash \mathrm{r}_H(A \vee B) < \mathrm{r}_H(A),\ \mathrm{r}_H(B))$.

By (a), CIP rules out 'paradoxes of relevance': counterintuitive negative relevance of conjunctions or even disjunctions of positively relevant atoms. Conjoined with Thesis BG it explains 'strong' Scalar implicature for $\vee$. A reasonable candidate for a default context set *ceteris paribus* should be the Lindenbaum algebra over $\{A, B\}$. Its atoms represented by $AB, \bar{A} \wedge B,\ A \wedge \bar{B}, \bar{A} \wedge \bar{B}$ finest-partition the space of possibilities. Suppose A and B positively relevant to H, preferred by Pro. Under incomplete information (nothing e.g. is presumed known about the comparative relevance of $A \wedge \bar{B}, \bar{A} \wedge B$) Con's natural default counterclaim to Pro's $A \vee B$ is $\bar{A} \vee \bar{B}$; their meet is $A \nabla B$.

Thus, *reduced* expected (positive, evidential, partisan) *relevance* of a claim has *increased* (non-partisan) semantic *informativeness* as a byproduct since $A \nabla B \models A \vee B$ while $A \vee B \not\models A \nabla B$. (Echoes of Adam Smith's Invisible Hand ideology there!) Various epistemic conventions for the default to bite are conceivable: e.g. that Pro should know that AB if AB holds (Soames 1982).

Relevance predicts better than Neo-Gricean informativeness on some hard distributional facts. Recall that 'pragmatic/quantitative scales', of which (*and, or*) is a putative instance, are linguistically given to us most tangibly by their diagnostics (Horn 1972).

HYPOTHESIS: Expression schema *X if not indeed Y* is acceptable iff for any context of use c determined by an issue $\{H, \bar{H}\}$, probability measure $\mathrm{p}(\cdot)$ inducing a relevance function $\mathrm{r}_H(\cdot)$ and propositions X, Y satisfying CIP and finitude of relevance, either (**i**) $\models_c 0 < \mathrm{r}_H(X) < \mathrm{r}_H(Y)$ or (**ii**) $\models_c 0 < \mathrm{r}_{\bar{H}}(X) < \mathrm{r}_{\bar{H}}(Y)$.
FACT: **A or B, if not indeed A*. Proof: By Theorem (b), Hypothesis (i) is not generally satisfied. Nor (ii) w.r.t. $\bar{H}$.
FACT: $\surd$*A (or B), if not indeed A and B*. Proof: By Theorem (a), Hypothesis (i) is generally satisfied. Analogously (ii), w.r.t. $\bar{H}$.

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

A3. Negation of Scalable Attributes

Horn investigated pairs of intuitively 'positive' and 'negative' ordered subsets of lexical fields (e.g. {*boiling, hot, warm*} vs. {*cool, cold, freezing*}; etc.). Decision-Theoretic Pragmatics will recover his observation (e.g. 1989) that negations of strong (weak) positives are, respectively, weak (strong) negatives; and so on. But without having to assume, with Horn, that lexical meanings are always of the form 'at least' and, for marked cases, 'at most', together with unspecified mechanisms for picking the right one. These forms yield ordering by entailment (set-inclusion) and thence, by contraposition, the Horn-facts.

We assume instead, more plausibly, that attribute spaces given by a lexical paradigm are *partitions* into attributes of similar grain (induced pointwise by partitions of propositions). Ordering—by relevance—is induced by the independently motivated bargaining pragmatics.

Recall from Section III the definition of 'upward cone' ${}^{\geq}\Phi$. Call *'unmarked scalar complement'* the complement ${}^{<}\Phi$ of ${}^{\geq}\Phi$ and construe as the denial of a claim deemed excessive. Call *'marked scalar complement'* the dual ${}^{>}\Phi$ of ${}^{<}\Phi$ and construe as the rejection of a concession deemed insufficient; thus inheriting concession's phenomenologically marked status [Why marked? 'Don't pick a fight you know you're gonna lose' (Sen. Sam Goldwater)]. Horn's observation is then captured in the following

> THEOREM: If X and Y are elements of a partition of the space of propositions (thus inducing a partition of an attribute space) and $\mathrm{r}_H(Y) > \mathrm{r}_H(X) > 0$, then $\mathrm{r}_{\bar{H}}({}^{<}X) > \mathrm{r}_{\bar{H}}({}^{<}Y) > 0$.

B. Conventional Implicature

Traditional accounts of degree particle *even* (e.g. Karttunen and Peters 1979) note that *Kim even talks* [abstractly: $even(\alpha, \beta)$ where α is focus of *even*] indicates high 'surprise/improbability' of *Kim talks* [$= E := (\alpha, \beta)$]; the comparison class being propositions (α', β) with $\alpha' \neq \alpha$ (e.g. *Kim walks*).

Anscombre (1973) proposed superior argumentative value (AV) of E over E' w.r.t. some H. Explicate by relevance $\mathrm{r}_H(E)$. Then, for given H and a set $\{E_i\} = \{(\alpha_i, \beta)\}$ of expression alternatives, $\mathrm{r}_H(E) = max_i[\mathrm{r}_H(E_i)]$ iff $\mathrm{r}_H(E) = max_i[\mathrm{inf}(E_i|\bar{H}) - \mathrm{inf}(E_i|H)]$. In simplified words: the E_i most (positively) relevant to H is that whose truth would be the most surprising if $\bar{H}$ rather than H were accepted. And of course, there is no point arguing for an H already accepted.

Whether or not one takes AV to be primary or derived: intuitions are squared and an issue between Anscombre (1973), Kay (1990)–*contra* surprise—and Francescotti (1995)—*pro*—is accountably resolved.

Note: $\mathrm{r}_{H|K}(E) > \mathrm{r}_{H|K}(F)$ doesn't imply $E, K \models F$ for $K \not\models E \to F$. Unlike 'contextual entailment' from E to E', by which Kay (1990) offers to explicate superior 'informativeness', his explanatory ordering relation. But 'entailment' is surely a misnomer (for relevance, what else?) in view of

> Author: The hero of my novel sleeps with M******. [a media star]
> Editor: So what. The hero of our Greek dust-gatherer even sleeps with his own mother.

DTP yields an account of conjunction *but* and its interaction with *even* and *also*.

> HYPOTHESIS: *A but B* is felicitous only if there is an accessible H (a story as long as for Kripke's (n.d.) first-order anaphors for *also*) such that $\mathrm{r}_H(A) > 0$ and $\mathrm{r}_H(B), \mathrm{r}_H(AB) < 0$, relative to Addressee's ostensible probability function(s).
> HYPOTHESIS: *A CONJ even(B)* [$:= (\alpha_1, \beta)$ CONJ $even(\alpha_2, \beta)$] with VP-focus is felicitous only if there is an accessible H such that $\mathrm{r}_H(B) > \mathrm{r}_H(A) > 0$.

Suppose, for any given reading, H must be unique. This implies

> PREDICTION: **Kim splurbs but Kim even glurbs* for any English substitution instances of *splurbs* and *glurbs*; explicating AD's claim and explanation.

Note the salient special case (default case) of *A but B* where $H = \bar{B}$ and B is, therefore, by our Hypothesis, ostended as being unexpected given A, in terms of Addressee's and probably Common Sense's probability. (Example: *Kim is poor but honest.*)

> PROPOSITION: If $\mathrm{r}_H(A) > 0$ and $H = \bar{B}$ and $\mathrm{p}(AB) > 0$ then (i) $\mathrm{r}_H(B) < 0$; (ii) $\mathrm{p}(B|A) < \mathrm{p}(B)$; (iii) $\mathrm{r}_H(AB) = \mathrm{r}_H(A) + \mathrm{r}_H(B)$; (iv) $\mathrm{r}_{\bar{H}}(B), \mathrm{r}_{\bar{H}}(AB) > \mathrm{r}_H(A)$.

A-unexpectedness of B is not necessary for $\mathrm{r}_H(A) > 0$ and $\mathrm{r}_H(B), \mathrm{r}_H(AB) < 0$. (Example: *Kim is a doctor but she lives in Mozambique*; $H =$ Kim is rich.) But note:

> PROPOSITION: If $(A \perp B|H, \bar{H})$ then $\mathrm{p}(B|A) < \mathrm{p}(B)$ iff $\mathrm{sgn}(\mathrm{r}_H(A)) = -\mathrm{sgn}(\mathrm{r}_H(B)) \neq 0$.

The relevance-based analysis accounts, amongst other things, for the following apparent language universal (Merin 1995), an asymmetry between NPs and VPs: While *Kim*$_i$ *walks but Kim*$_i$ *talks* is fine for suitable contexts (shall we hire Kim as a confidential messenger?), we have *Kim walks but Sandy* $\{also/ * \phi\}$ *walks* for all contexts. The principles that generate the explanation for $*\phi$ are deeper than usually considered in linguistic pragmatics: constraints on admissible probability measures due to (i) intensionality of probabilistic contexts in quantificational inference, and (ii) demands for extendibility of discourse models (Theorem of Savage-Kemeny-Gaifman-Humburg). Overkill? A priori so, if we accept the following much-loved though rarely professed thesis: The structure of natural languages and attached bits of mind is very much simpler than that of a spot of grease.
A stochastic version of *contextual presupposition* is

> DEFINITION: A is presupposed in epistemic state p iff $\forall X[\mathrm{p}(X) = \mathrm{p}(X|A)]$.

Co-extensive for finitary cases with Stalnaker's familiar notion amounting to entailment by the epistemic state, it feeds into a notion of *sentence-presupposition*, prima facie alternative to current explications as a condition on definedness of deductive theory updates.

> DEFINITION: Sentence S presupposes$_r$ Φ iff S is irrelevant to all X logically independent of S in all epistemic states where Φ is not contextually presupposed).
> THEOREM: S presupposes$_r$ Φ iff $\bar{S}$ does.

Now, traditionally, $also(Q, a)$ (e.g. *Kim also talks*) presupposes that a (Kim) has some other contextually, i.e. anaphorically or accomodably salient (cp. Kripke n.d.) property P. In *Pa and also Qa*, 'also' marks Pa, the anaphoric anchor for $also(Q, a)$, as contextually presupposed in the state p evaluating Qa. Thus, by DEF, $\mathrm{p}(Qa|Pa) = \mathrm{p}(Qa)$ (independence). If not $P \neq Q$, then Qa would be p-presupposed, hence irrelevant. Requiring relevance implies the 'otherness' constraint, stipulated by extant accounts.

More interestingly, grant Reichenbach (1956) that A is causal for B only if $\mathrm{p}(B|A) > \mathrm{p}(B)$. COROLLARY: If A is presupposed, A lacks causal responsibility for B. PREDICTION: In *Kim fell and she (also) broke her arm* 'also' removes routine intimations of causality. Prediction confirmed. The acceptablity of *Pa but also Pb* is described along similar lines.

V. A Consequence of CIP: Cognitive Bias Towards Dichotomies

Suppose CIP generalized to issue partitions $(H_i : i = 1, \ldots, n)$. Johnson (1986) proved that for $n > 2$, at most one evidential proposition deemed atomic can be relevant to any given H_i if conditional independence of evidential atomic propositions is to be satisfied w.r.t. 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. (See also above, the 'doctor' example.) But suppose the Maker of cognitive psychology values additivity and freedom from paradoxes of relevance. This will suggest another design option for a 'competence' account: restriction to the case $n = 2$. The adoption of CIP—remember, a defeasible presumption—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 independent constraint favouring dichotomy legitimizes descriptive appeal to CIP.

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