8.

LOGICAL AND NATURAL CONNECTIVES

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1. One of the points where logical and natural languages seem to diverge is in their respective connectives. The set of logical connectives, interdefinable with negation (as a so-called 'one-place connective'), such as conjunction (A), disjunction (v) and material conditional (z), seem only in part related with their natural language counterparts and, or, if...then. Moreover, this latter set of grammatical 'conjunctions' contains other members such as but, although, for, because, whereas adverbs such as so, yet, nevertheless should also be taken as natural conneCtIves, both groups without corresponding connectives in classical logics. Connectives of classical systems, it should be recalled, are truth functional: given the truth values (truth or falsity) of component propositions (or sentences) they determine the over-all truth value of the compound proposition (or sentence). Axiomatically, they have properties of commutativity, associativity, distributivity (conjunction, disjunction) or they are transitive (conditionals).

2 The first problema arise as soon as connectives are used in non-truth-functional contexts, e.g. with modalities. The connectívity of two propositions a and 0 is not normally restricted by the 'content' of a or 0; only their truth values count, not the fact whether they are somehow semantícally related in another way. As soon as we prefix the box (O)--denoting 'necessity' (truth in all possible accessible worlds)--to the compound formula, *e.g.* as follows:0(uo $), which may also be written as a-30, where ' denotes a so-called 'strict' conditional or implication, the question arises in which respect propositions or their values can be said to be 'necessarily' connected. If we say, for example, that a necessarily or logically implies $, we might want to require that this makes sense only if W and 0 have some inherent relation, to be interpreted as a corresponding relation between truth values or facts. Since there is a systematic relation between conditional connectives and the relation of deductiva inference (I--) by the deduction theorem (af-0 ml-a=0), similar problems arise in the conditions of appropriate deduction. If, for instance, a conclusion is logically implied by the premisas, we may also desire to put some constraints on the nature of the premises, e.g. that they have at least a proposition in common with the conclusion. The conflict with the validity of formulas such as ED(a=2), -2=(2Da), (EA)=5, aD(2v-2), 2D (Eva) and ((2vg)A-p)7.5, then becomes apparent, because they enable

to derive statements about the truth value of E or q (or of a relation between them), without knowing the truth value of one of them. These and other intuitive arguments have led to call these theorems the <u>paradores of material implication,</u> which seem still more paradoxical in their strict implicational versions.
In order to avoid these and related counter-intuitive properties of certain logical connectives (and deduction), several types of so-called <u>relevance logics</u> (or connective/connexive logics) have been developed, with which are associated the flanes of, among others, Ackermann, Anderson, Dunn, Belnap, Church, Gabbay, (David) Lewis, McCall, Meyer, Routley, Stalnaker, Urquhart. The main idea behind these, often rather diverse, approaches is to design axiomatic systems and/or formal semantics for relevant connectives, especially <u>relevant conditionals</u> ('normal' and strict). Intuitively, then, the antecedent of such a conditional must 'have something to do' with the consequent, for example due to a meaning relation. Similarly, of course, for deductive inference, i.e. between premises and conclusions.

Thus, we may require that a formula with a relevant conditional, E > a, corresponding to our natural language intuitions for a conditional such as <u>if...then</u>, would take truth values only if E is true (and/or "asserted").

3. The debate about logical connectives and their required relevance especially focuses on the properties of <u>entailment</u>, taken as a (semantic) relation between propositions 717: íf a II- 8, then if a is true,8 is also (necessarily) true. In such a case, it is assume-, a necessary semantic dependency of the propositions must involve conceptual relations between the propositions. If this is so, we can hardly take the normal strict implication (-4) or deductive inference (1-), as the formal syntactic counterparts of entailment, because there, classically, no conceptual (intensional) constraints exist on connectivity or deduction. Hence, it is argued, we should take relevant (strict) conditionals as the syntactic expression for semantic entailment; especially if we would like to say that, in inferences, conclusions are 'entailed' by their premises, and not only 'follow logically from' their premises. Since we here talk 'about' conditions on deduction, the notion of relevance, as expressed in specific connectives, is also often relegated to the logical metalanguage. Much of the current work on (relevant) connectives is devoted to the construction of various entailment logics.

A crucial issue, of course, is to develop a serious formal semantics for the various relevant or intensional connect ves. The basic idea behind the different semantic accounts is that the modela contain elements which enable interpretation of propositions (sentences) *relative to* each other--instead of freely assigning them independent values as in classical systems. Thus, we may require that the respective possible worlds in which the propositions are interpretad are somehow 'connected', e.g. with respect to a third possible world, a (communicative) context, or a set of propositions (information).

Similarly, if a proposition 8 should be interpreted relative to (the interpretation of) a, we may let some function, determined by a, select the possible worlds where 8 may have truth values. One of the many open problems, both axiomatical and semantic, is a unified treatment of the various relevant or in general intensional connectives, including conjunction and disjunction, and a fundamental semantic device for 'relative interpretations'. Perhaps recent developments in intensional logic may lead to a solution for these problems.

4. Since, in natural language and theories about it, we are not only interested in truth conditions or other extensions, but also in the meaning structure of propositions and in their intensional inter-relations, *natural connectives* as those mentioned aboye, essentially seem to require a formal reconstruction in terne of 'relevant' connectives. This holds for all connectives, including conjunction and disjunction, even if, occasionally and under specific constraints, we may connect two propositions which are neither conceptually nor referentially related. More in general, it should be required that *conditions of connection* are satisfied by each compound sentence (and connected sequences of sentences in a discourse, for that matter). Although meaning relations may be involved in the coherente of compound sentences and discourse, the connection conditions rather depend on the relations between the values of the propositions in some possible world(s), i.e. on the relations between the 'facts'. These facts, in general, should actualize the sane conceptual range in semantic space--i.e. the fact-concepts, or propositions, must belong to the same *range.* Relative to a given possible world, point of view or topic of discourse the facts must be *compatible* in related (similar, identical, successive) worlds. Whereas the weakest forro, then, of natural conditionals satisfying these conditions is 'possibility' (e.g. in co-occurrence or 'allow'-condition) as expressed by conjunctions, the stronger connection is that of pro-

bability (likelihood) as in concessives such as but (where a but S, implies if a then normally [in most possible worlds] — :Ir and finally necessity as in causals and implications such as <u>because,</u> for, so, <u>therefore</u> etc., where the antecedent logically, physically, biologically, psychologically or socially 'neccessitates' the consequent in a certain possible world (or in most, or all possible worlds). Necessitation, in such a case, holds, we will say tentatively, in a world w. where a is true, if $_S$ is true in all successive worlds w• which can be reached from w. (immediately, or sometimes indirectly). If Peter falls from his chair, this may cause that he breaks his neck, necessarily <u>in that course of events</u> (given the precise physical, and other circumstances), but of course not in all possible worlds where Peter falls from his chair, as would physically be the case for the connection **between** 'rising temperature (aboye value x)' and 'melting of butter'.

Among these referential and intensional conditions on the connectivity of propositions, we have briefly mentioned that of 'information' or 'topic'. This means that not only the facts or the meanings must be related, but this must be so relative to what is known (by the speech participants) in a certain context and by the <u>topic of discourse</u> at issue, i.e. one or more propositions defining the 'over-all' meaning of compound sentences and discourse (macro-structure). Resides the conceptual constraints on the topicality of propositions, we have other conventional constraints related to the knowledge of the participants about 'typical structures' of the world (e.g. that we order food in restaurants, take an umbrella when it rains, etc.--dependent on culture). Such conventional knowledge structures are called <u>frames.</u>

In a formal semantic of natural connectives we should build in these specific conditions and constraints on natural connection. But at the moment little insight exists in the possible forms such an extension of formal semantics should take, let alone the account of the <u>pragmatic</u> connection conditions.

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