ACCOUNTING FOR VARIABILITY IN LANGUAGE USERS' JUDGMENTS REGARDING PATTERNS OF DEDUCTIVE CONNECTIONS AMONG NATURAL LANGUAGE (NL)CHARACTER STRINGS

1. PURPOSE AND BACKGROUND

1.1. Purpose of Study. The purpose of this study is to sketch a formal framework[1] within which to account for the wide range of variability in language users' judgments regarding valid patterns of deductive connections among given natural language (NL) character strings, that is, judgments regarding whether the certain character strings necessarily follow from others.

Footnote 1. The framework as described in this paper is partial, and mostly concerned with syntactic issues in accounting for variability in making judgments of deductive connections, and deferring semantic issues to other papers [6],[7],[8] and [9], by the author.

1.2. Patterns of Deductive Connections. A *pattern of deductive connections* among NL character strings in a set of sentences can be minimally characterized as a relation R between the subsets of S and the elements s of S such that (i) R holds between every subset S' of S and each of its elements, and (ii) For all subsets S' and S'' of S and for all elements s of S such that R holds between S′ and s, if R holds between S′′ and every element of S′, then R holds between S′′ and s. R can be read more succinctly as a deductive consequence relation which is such that: (i) every sentence in a set of sentences is a deductive consequence of that set, and (ii) every deductive consequence of a set B of sentences all of whose members are deductive consequences of a set A of sentences, is itself a deductive consequence of the set A.[2]

Footnote 2. This is a variant of a notion due to Tarski [3]. By a "minimal" characterization I mean one that is implied by any reasonable characterization of deductive connections.

1.3. Character Strings (CSs). By *characters*, I mean alphabetic and numeric characters, punctuation marks, and spaces, such as would occur in any written[2] language. By a *character string* (CS) I mean a sequence of characters.[2] We treat character strings as sequences of characters underlying meaningful natural language expressions; beyond their status as sequences, character strings are devoid of meaning.

Footnote 3. While we could alternatively have treated characters as phonological rather then as graphical entities, it is not essential to our general purpose.

1.4. Interpreting natural language character strings as sentences. By an NL character string *interpreted as a sentence* we mean a way of organizing its component substrings into units which are collectively organized and assigned meanings in a manner which renders them amenable to being regarded as true or false in a given context of use. A natural language character string can be interpreted as a sentence in many different ways, even in a given context of use. We assume[4] that a language user's judgments regarding patterns of deductive connections on natural language sentences are induced by the way that he or she interprets the character strings underlying them.[2]. By interpreting a character string I mean endowing it with a syntactic and semantic structure that makes it meaningful. Indeed, interpreting a character string as a "sentence," that is, as a linguistic expression that can be judged as true or false, involves the imposition of a particular syntactic and semantic structure on that character string in terms of which a truth value can be assigned to it.

Footnote 4. While intuitively fairly obvious, we state this as an explicit assumption to the effect that ways of interpreting natural language character strings induce particular patterns of perceived deductive connections among sentences which they underlie. The manner in which patterns of deductive connections are induced by interpreted character strings can be properly described only after formalizing the notion of “interpreted character strings.” A particular approach to such formalization is described later in this paper in Sections [***]. Throughout Part 1 of this paper, however, our use of this notion is intuitive rather than precise.

1.5. Interpreted Character Strings (ICSs). By an interpreted character string ICS I mean a *character string CS* together with: (i) an identification of its meaning bearing substrings and their combinations, and (ii) an assignment of meanings to those meaning bearing substrings and combinations.[5] Interpretations of a given character string can vary widely among language users. We refer to the CS which the ICS interprets as its *basis*.

Footnote 5. These notions are formalized in [7] and [9], where an interpretation of a given CS is a pair <syn(CS), sem(CS)>, where syn(CS) syntactically structures and interrelates the meaning bearing substrings of the CS, and sem(CS) assigns set-theoretic meanings to them.

1.6. Context of Use (CU) of a CS. The way that a language user interprets a given character string depends[6] also on the context in which it is used (i.e., in which that CS is spoken or heard). By a *context of use (CU)* of a CS I mean a publicly ascertainable physical circumstance in which that CS is used.

Footnote 6. We can also state such dependency as an explicit assumption, say, to the effect that a language user’s interpretation of a particular character string depends on the context in which it is used.

1.7. Perceived Context of Use (PCU) of an ICS. By a perceived context of use (PCU) of a given ICS, I mean a perception[8] (by the language user) of the CU in which the underlying CS of that ICS is used and with which that ICS is consistent[7]. The CU on which the PCU is based is referred to as the *underlying CU of that PCU,* and we refer to that underlying CU as the *basis of that PCU*. PCUs of a given ICS with the same underlying CS will tend to vary among language users as their interpretations of that CS vary.

Footnote 7. Consistency is a logical notion which can be properly characterized only relative to a formalization of the language in which ICSs and PCUs are more precisely formulated.

1.8. PCUs as Sets of interpreted character strings. It is convenient to treat a PCU of a given ICS as a set of ICSs which are consistent[8] with that ICS, and which elaborate certain aspects of it. A PCU can be thought of as a set of character strings whose meaning bearing substrings and combinations have been identified and assigned meanings.

Footnote 8. A language user might interpret the CS “John loves Mary” as expressing, not that John loves Mary but as expressing something quite different, depending on the context CU in which it is used and on the hearer’s perception PCU of that context. As an example, consider a dinner conversation in which the particular CS, “John loves Mary,” is spoken by the host, in a context CU which the hearer perceives as a PCU which includes the perception (on the part of the hearer) that the host does not really believe that John loves Mary, and that he is here speaking ironically. So the language user in this example interprets this CS as a ICS consistent with this PCU and expressing not that John loves Mary, but as expressing its opposite, namely that John does not love Mary.

1.9. Interdependency of an ICS and its PCU. The way that a CU in which a given character string CS occurs is perceived (i.e., as a PCU) by a language user is inevitably conditioned by – and conditions - the way in which that language user interprets that CS (i.e., as an ICS). The nature of this interdependency is complex and its discussion would go beyond the scope of this paper, but it seems reasonable to assume at this point that it derives from an inherent disposition on the part of a language user to render the constituent ICSs of the PCU consistent with the ICS which has that CS as its basis.

1.10. Degree of normality of a pattern of deductive connections on a set of ICSs. The degree of normality of a given pattern of deductive connections on a given set of ICSs is the degree to which most language users would find that pattern to approximate their own deductive intuitions on a set of typical ICSs on the same base.

1.11. Degree of normality of a PCU of an ICS. The degree of normality of a given PCU of an ICS is the degree to which most language users' perception of the underlying CU of that ICS approximates the given PCU.[9]

Footnote 9. For example the degree of normality of the PCU in Footnote 7 which the hearer associates with the CS "John loves Mary" in the CU of the dinner is low inasmuch as the degree to which most language users would perceive that CU would fail to approximate the PCU which the hearer in question associates with that CS.

1.12. Normality of a set of ICSs. A set of ICSs is said to be *normal to the degree that the* pattern of deductive connections which it induces tends to approximate the degree to which most language users find those connections to approximate their deductive intuitions.

1.13. Normality of a set of ICSs relative to a given PCU.[10] A set of ICSs is said to be *normal relative to a given PCU to* the degree *that the* pattern of deductive connections which that set induces tends to approximate the degree to which language users whose perceptions of the CU underlying that PCU approximate that PCU find those connections to approximate their own deductive intuitions.

Footnote 10. This notion is stronger than that of 1.12 in the sense that it implies it.

1.14. Planned development of paper. In section 1.5. (above), we suggested that considerable variation may occur among language users in forming a given ICS from the same underlying (CS) base. Then in section 1.7. we suggested that judgments regarding patterns of deductive connections among given ICSs would likely vary among language users as the ICSs made on the same CS base varied. In the course of this paper, we will indicate how, for a wide set S of CSs and for any pattern of deductive connections on S, meanings can be assigned to the ICSs of these CSs in S and to the PCUs of their context of use (CUs) which induce that pattern of deductive connections.

2. EXAMPLES.

2.1. A person who interpreted the character strings “John loves Mary,” “Mary is loved by John,” and “Something loves Mary,” relative to a typical PCU, would be expected, at least in principle, to adopt a normal pattern of deductive connections among them, that is, to judge the pattern of deductive connections that held among them to include the judgment that that the truth of each of the first two character strings necessitated the truth of the third, and that the truth of the third was necessitated by the truth of each of the first two but did not necessitate the truth of either of them.

2.2. If a person persistently failed to recognize any part of this pattern of deductive connections as, for example, he were to accept the truth of “John loves Mary” but not accept the truth of “Mary is loved by John,” we could not regard him as properly interpreting both of these character strings, at least in a customary way.[9] However, we could still regard this person as holding an idiosyncratic way of interpreting these character strings and a consequently idiosyncratic pattern of deductive connections among these character strings which his interpretation of them induces. One such idiosyncratic way of judging deductive connections among these character strings might be that, while the truth of “John loves Mary” necessitated the truth of “Something loves Mary,” the truth of “John loves Mary” did *not* necessitate the truth of “Mary is loved by John.”

2.3. Consider the following continuation list of the above sample character strings:

(1) John loves Mary.

(2) Mary is a person.

(3) John loves a person.

(4) John does not love Mary.

(5) Something loves Mary.

(6) Mary is loved.

(7) John knows Mary.

(8) Mary is loved by John.

There are various possible ways of interpreting each of (1) – (8), each of which is normal relative to the PCU indicated below.

2.4. Let W1 be a set of interpreted character strings with CSs (1) – (8) as their bases relative to a typical PCU with which those interpreted character strings are consistent. This PCU includes the following four ICSs as elements (i.e., assumptions), described here in summary form rather than exhibited[11]:

Footnote 11. To exhibit these ICSs would require recourse to exhibiting their formalizations, which is beyond the purposes of this paper.

ICS (i) is to the effect that: In the interpretation of each of the character strings (1) – (8), John is an entity that bears the relation of loving to the entity Mary; Mary is an entity that has the characteristic of being a person, and so on, through character string (8).

ICS (ii) is to the effect that: All occurrences of the same word or word part have the same meaning throughout the interpretations of character strings (1) – (8).

ICS (iii) is to the effect that: Mary may or may not be a person.

ICS (iv) is to the effect that: Loving a person means in part that one knows that person.[4]

2.5. A Partial pattern (A) of deductive connections among character strings (1) – (8) induced by the set W1 relative to the above described PCU which, it will be recalled, included assumptions (i) through (iv) above. The set W1 would induce a pattern (A) of deductive connections among these character strings that would include the following: character strings (1) and (2) together deductively imply (3) [but (1) alone does not]; (1) deductively implies each of (5), (6), and (7); (1) and (8) deductively imply each other, hence (8) deductively implies each of (5), (6), and (7); [(1) does not deductively imply (4), nor does (4) deductively imply (1)]; and so on. This pattern (A) would be normal relative to a typical PCU which was consistent with W1.

2.6. Let W2 be a set of interpreted character strings with CSs (1) – (8) as their base relative to a typical PCU with which those interpreted character strings are consistent, and which includes the ICSs (i), (ii), (iii) (above), while dropping ICS (iv) (which is to the effect that loving a person means in part that one knows that person). This way of interpreting character strings (1) – (8) would induce a pattern (B) of deductive connections among them in which the truth of (7) did not necessitate the truth of any of the other character strings among (1) – (8).

2.7. Let W3 be a set of interpreted character strings with CSs (1) – (8) as their base relative to a typical PCU with which those interpreted character strings are consistent, and which induces a yet different normal pattern of deductive connections among them: That PCU includes ICSs (i), (ii), (iv) as elements (i.e., assumptions) but which replaces ICS (iii) (which is to the effect that Mary may or may not be a person) by ICS (iii’) which is to the effect that Mary is a person. W3 induces a pattern (C) of deductive connections among the interpreted character strings in W3 which includes, in addition to those deductive connections induced by W1, also that the truth of (1) alone necessitates the truth of(3).

2.8. Let W4 be a set of interpreted character strings with CSs (1) – (8) as their base relative to a PCU with which those interpreted character strings are consistent, and which induces a pattern (D) of deductive connections among them which would not be normal relative to typical PCUs with which those interpreted character strings are consistent. Failure of normality would derive from the circumstance that that induced pattern would not be consistent with most language users’ deductive intuitions regarding typical ways of interpreting character strings (1) – (8). Such a PCU could be one which retained ICSs (i) and (iii) as assumptions, but replaced ICS (ii) by two ICSs (ii’) and (ii’’), where ICS (ii’) is to the effect that: “John” and “loves” may or may not have the same meanings in (1) as they have in (3), and ICS (ii”) is to the effect that: “love” in (1) and (8) has its usual meaning, but in (4), (5), and (6) “love” has a meaning opposite to that usual meaning, such as would by conveyed by an ironic use of that word. This way W4 of interpreting (1) – (8) would induce a pattern of deductive connections which would not be normal because it would induce a pattern in which the truth of (1) and (2) together no longer necessitated the truth of (3), and the truth of (1) no longer necessitated the truth of either (5) or (6), and the truth of (1) now necessitates the truth of (4) and conversely.

3. INTERPRETED CHARACTER STRINGS

3.1. External Structure of interpreted character strings.

An interpretation of a character string is a pair consisting of: (1) a syntactic representation of that character string, and (2) a semantic representation of that character string. Different interpretations of a given character string are obtained by varying either its syntactic or semantic representation.

3.2. Syntactic representation of a character string.

The syntactic representation component of a character string identifies its meaning bearing substrings and their combinations. The minimal meaning-bearing parts of a syntactic representation of a character string are called *representational morphemes*. The syntactic representation of that character string is recursively built out of representational morphemes into a syntactic representation of the entire character string.

3.3. Semantic representation of a character string. The semantic representation of a character string assigns set-theoretic meanings to every meaning-bearing part identified in its syntactic representation. The semantic theory component is specified in *semantic axioms*, which state the set theoretical meanings to be assigned to meaning bearing parts.

3.4. Parts: of character strings and parts of their syntactic representations. Parts of character strings will be distinguished from parts of syntactic representations of character strings. The notion of "part," as it applies to character strings, is to be regarded in the sense that the sequence of letters and blanks comprising the part in question is a (not necessarily contiguous) subsequence of the sequence of letters and blanks comprising the containing character string, and is not intended to be semantically interpretable. On the other hand, the notion of "part," as it applies to syntactic representations of character strings, is intended to be regarded as a *meaning* *bearing* part, that is, capable of having a set theoretic meaning assigned to it.

3.5. Implicitly and explicitly realized natural language morphemes. Consistent with linguistic usage, I regard the notion of a natural language morpheme as a theoretical construct, i.e., as an abstract entity that is “realized” in a given character string in one of two ways: (a) explicitly, indicated in part by and corresponding to a specific part of that character string called a “morph”; (b) implicitly, indicated solely by global relations among the parts of that character string, involving factors such as order of occurrence, juxtaposition, intonation patterns (if oral), perceived grammatical and semantic relationships among character string parts, etc. A natural language morpheme that is explicitly realized in a part of (i.e., as a morph occurring in) a given character string is also said to be explicitly marked in that character string by that part (i.e., by that morph). A natural language morpheme that is implicitly realized in a given character string by certain global relations among its parts is said to be implicitly marked in that character string by those relations.

3.6. <u>Logical and lexical morphemes.</u> The intended distinction between logical and lexical morphemes is an intuitive semantic one: roughly, a lexical morpheme is one which intuitively denotes an entity, relation, or characteristic of an entity or relation, such as “boy,” “walks,” “hits,” “tall,” “slowly,” etc; whereas a logical e morpheme is one that intuitively denotes a way of operating on what lexical morphemes denote, and expressed by characters such as “all,” “and,” “not,” “many,” “after,” etc.

3.7. <u>Representational Morphemes.</u> We distinguish the notion of a natural language morpheme, as indicated here from that of a *representational morpheme*, which is an actual expression of a syntactic representation of a character string that occurs as an explicit part of that syntactic representation.

3.8. <u>Convention.</u> For simplicity of exposition, we shall adopt the usual custom of not always distinguishing between natural language morphemes that are realized in morphs and the morphs in which they are realized. For example, we shall sometimes speak of the morphs “boy,” “walk,” “all,” “s,” and so on, as natural language morphemes rather than merely as the morphs in which those morphemes are realized.

3.9. <u>Morphemic Base Assumption.</u> We assume that a language user’s intuitive judgments regarding the degree of normality of a given pattern of deductive connections among given character strings derive from his or her intuitive judgments regarding semantic interconnections among the logical natural language morphemes realized in those character strings, and regarding semantic interconnections among the lexical natural language morphemes realized in those character strings.

3.10. <u>Application of Morphemic Base Assumption to Our Earlier Example.</u> We recall character strings (1) – (8) from Section 2.3, which we repeat here for easy reference:

(1) John loves Mary.

(2) Mary is a person.

(3) John loves a person.

(4) John does not love Mary.

(5) Something loves Mary.

(6) Mary is loved.

(7) John knows Mary.

(8) Mary is loved by John.

As remarked in Section 2, there are various possible patterns of deductive connections among (1) – (8) which could be considered “normal” relative to “typical” PCUs. The pattern of deductive connections with the highest degree of normality (among those given there) was the one labeled (A), which included in part that (1) and (2) together deductively implied (3), but (1) alone did not; that (1) deductively implied each of (5), (6), and (7); that (1) and (8) deductively implied each other, hence that (8) deductively implied each of (5), (6), and (7); that (1) did not deductively imply (4), nor did (4) deductively imply (1).

3.11. Semantic interconnections among logical natural language morphemes realized in (1) – (8).

Applying the Morphemic Base Assumption to this pattern (A) of deductive connections, we would conclude that the particular deductive connections of (A) derived ultimately from intuitive judgments regarding semantic interconnections among the logical natural language morphemes realized in the character strings (1) – (8), which included in part, the explicit logical natural language morphemes “not” and “is,” as well as various implicit logical natural language morphemes (to be indicated later).

We are suggesting, then, that the typical English speaker who interpreted the meanings of these logical natural language morphemes would assent to the above pattern of deductive connections even if he did not interpret the meanings of the lexical natural language morphemes “John,” “Mary,” “love,” and “person” occurring there.

3.12. Semantic Interconnections Among Lexical Natural Language Morphemes Realized in (1) – (8). On the other hand, an English speaker’s intuitive judgment that (1) deductively implied (7) would derive both from his intuitive judgments regarding semantic interconnections among the logical natural language morphemes occurring in character strings (1) and (7, and from his intuitive judgments regarding the semantic interconnections between the lexical natural language morphemes “loves” and “knows” (such as, for example, that loving a person meant, in part, knowing that person).

3.13. More on the relationship between logical and lexical natural language morphemes of (1) – (8).

We regard a language user's intuitive judgments pertaining to lexical natural language morphemes as dependent in part on his judgments pertaining to logical natural language morphemes. For example, a language user's intuitions regarding the semantic interconnections among the lexical natural language morphemes of (1) and (7) which would underlie his intuitive judgment that (1) deductively implied (7), would require also the intuitive comprehension of the semantic interconnections among the logical natural language morphemes of (1) and (7), for these latter would provide logical structure to these character strings relative to which the interconnections among the lexical natural language morphemes occurring in (1) and (7) are framed.

3.14. Logical and Lexical Normality.

We can separate language users' intuitions regarding logical and lexical natural language morphemes, and separately regard the normality of a pattern of deductive connections among character strings with respect to logical and lexical morphemes. Accordingly, we say that a pattern of deductive connections among character strings (such as (1) – (8)) is logically normal if that pattern is consistent with language users' intuitions regarding semantic interconnections among the logical natural language morphemes occurring among those character strings in typical PCUs. And we say that a pattern of deductive connections among character strings is <u>lexically normal</u> if that pattern is consistent with language users' intuitions regarding semantic interconnections among lexical natural language morphemes occurring among those character strings in typical contexts of their use.

We note that we can readily generalize logical and lexical normality of patterns of deductive connections to relative degrees of logical and lexical normality.

3.15. <u>Methodological Significance of the Morphemic Base Assumption.</u> The methodological significance of the Morphemic Base Assumption is that a pattern of deductive connections is normal if it is both logically and lexically normal, and that it has a high - or low - degree of normality according as its relative degrees of logical and lexical normality are high or low.

3.16. <u>Regarding the Morphemic Base Assumption as a Factoring Assumption.</u> The Morphemic Base Assumption can, in a certain sense, be viewed as a factoring assumption, asserting that a language user's intuitive judgments regarding deductive connections among character strings can be “divided” – as it were – into his intuitive judgments regarding semantic interconnections among the logical natural language morphemes that occur among them and his intuitive judgments regarding semantic interconnections among lexical natural language morphemes that occur among them.

4. MORE ON REPRESENTATIONAL MORPHEMES

4.1. Representational morphemes in the narrow sense. A *representational morpheme in the narrow sense* is a meaning bearing part of a syntactic representation of a character string that contains no proper (i.e., smaller) syntactic meaning bearing parts. A representational morpheme in the narrow sense then is a syntactically minimal meaning bearing part of a syntactic representation of a character string, and is intended to be the formal counterpart of the intuitive notion of a natural language morpheme.

4.2. Representational morphemes in the wider sense. A *representational morpheme in the wider sense* is a meaning bearing part of a syntactic representation of a character string that contains no proper (i.e., smaller) syntactic meaning bearing parts that determine the meaning of the containing morpheme.

4.3. Representational compounds. A *representational compound* is a meaning bearing part of a syntactic representation of a character string that contains a proper syntactic meaning bearing part whose meaning determines the meaning of the containing morpheme.

4.4. Some Interconnections. A meaningful part of a syntactic representation of a character string is said to be *syntactically minimal* if it contains no proper meaning bearing syntactic parts, and is said to be *semantically minimal* if its meaning is not determined by the meanings of its proper syntactic parts. We note that representational morphemes in the narrow sense are both syntactically and semantically minimal, whereas representational morphemes in the wider sense are semantically but not syntactically minimal, and representational compounds are neither syntactically nor semantically minimal.

4.5. Logical and lexical representational morphemes.
We separate the representational morphemes entering into syntactic representations of natural language character

strings into two types: logical representational morphemes, which are intended to be the formal counterparts of logical natural language morphemes, and lexical representational morphemes, which are intended to be the formal counterparts of lexical natural language morphemes.

4.6. Logical and Lexical Semantic Axioms.

We also separate the semantic axioms which define the semantic theory of a deductive interpretation into two types: *logical semantic axioms*, which are intended to specify the set-theoretic structures which are to count as meanings of logical representational morphemes (and, recursively, of representational compounds), and *lexical representational axioms*, which are intended to specify the set-theoretic structures which are to count as meanings of and connections among the lexical representational morphemes, and are expressed in terms of the set theoretic structures of the logical representational morphemes as specified in the logical semantic axioms. This practice strongly parallels procedures already customary in formalizations of branches of mathematics, where the semantic theory of the underlying logic, through suitable "interpretation rules," specifies the meanings of the so-called "non-logical" constants," i.e., the terms of the mathematical theory being formalized, simply by forwarding so-called “non-logical postulates” formulated in the language of the logic with no additional direct specification of how the mathematical (as opposed to logical) terms are to be interpreted, beyond that imposed by the mathematical axioms themselves. Logical constants are analogous to our logical representational morphemes, and the interpretation rules of the semantic theory of the underlying logic are analogous to our logical semantic axioms. Non-logical constants are analogous to our lexical representational morphemes, and non-logical postulates are analogous to our lexical semantic axioms.

Thus our semantic theory needs only to directly specify the set-theoretic meanings of its logical representational morphemes; the meanings of the lexical representational morphemes are then to be specified indirectly by simply formulating suitable syntactic representations into which those lexical representational morphemes enter.

5. EXAMPLE: LOGICAL AND LEXICAL NATURAL LANGUAGE MORPHEMES REALIZED IN CHARACTER STRINGS (1) AND (5) FROM SECTION 2

5.1. We recall the character strings (1) and (5) from Section 2: (1) John loves Mary.

(5) Something loves Mary.

We recall also the deductive connection between them which was part of the “most normal pattern (A) of deductive connections among the character strings displayed there.

In this section we are concerned to describe the interpretations of character strings that induce that deductive connection. We could not earlier specify their interpretations inasmuch as that would have required essential reference to the logical and lexical representational morphemes associated with these two character strings, and to the logical and lexical natural language morphemes which they represent.

Accordingly, my purpose in this section is (i) to identify some of the natural language morphemes realized in character strings (1) and (5), and (ii) to introduce those representational morphemes that are to formally represent them in the deductive interpretation that is to induce the pattern (A) of deductive connections as it relates to these two character strings.[12]

Footnote 12. My purpose does not include showing how the representational morphemes realized in the character strings (1) and

(5) induce the indicated deductive connections among them. To show this would require discussion of the set theoretic meanings that would be assigned to them. In other words, this paper stops at the level of indicating syntactic structures of the subject character string, and defers an indication of their semantic structures which are discussed elsewhere {].

5.2. Preliminary remarks. The natural language morphemes realized in character strings (1) and (5) reflect aspects of the general character of what I refer to in this study as "thing-relation" languages (the nature of which will be indicated later). Our present discussion is still informal in the sense that we do not give: (i) a precise description of the way that the respective syntactic representations of (1) and (5) are to be built out of the representational morphemes we introduce in this section, and (ii) the (set-theoretic) semantic interpretations of these representational morphemes and, recursively, the respective interpretations of the syntactic representations of (1) and (5).

5.3 The logical natural language thing-morpheme realized in character string (1). The logical natural language *thing-morpheme*, whose associated logical representational morpheme we write simply as "T" (for Thing), and which, when attached to the syntactic representation of a character string, (such as to the syntactic representation of "John" or "Mary" in (1) or when standing alone, indicates that the syntactic representation resulting from such attachment, (and, derivatively, the character string it represents), designates a thing of some kind as opposed to, say, a relation. In more detail: The logical natural language thing-morpheme is an implicit rather than an explicit morpheme of English, being indicated primarily by various global properties of the character-string in which it is (implicitly) realized. This thing-morpheme signals that nay character string part with which it is associated is to be interpreted as a "thing" relative to other character string parts which occur with it within a containing character string.

For example, in the character string (1), the lexical natural language morpheme (explicitly) realized in the character string "John," by virtue of having the natural language thing-morpheme associated with it in a normal deductive interpretation, is to be interpreted as a "thing."

As indicated, we use the letter "T" as the associated logical representational morpheme associated with the natural language thing-morpheme. Now, the syntactic representation of the lexical natural language morpheme "John" (in a normal deductive interpretation of (1)) is a lexical representational morpheme which we write as “JOHN.” (Here we use capital letters to distinguish lexical natural language morphemes from their morphs.) When the logical representational morpheme “T” is attached to the lexical representational morpheme “JOHN” to form

(i) JOHN
T

The presence of the logical representational thing morpheme “T” directly under the lexical representational morpheme “JOHN” indicates that the compound lexical representational morpheme (i) designates a thing.

5.4. Logical natural language relation morphemes realized in character string (1).

(b) The logical natural language *relation morphemes*, whose associated logical representational morphemes we will write as “R,” “R^1,” “R^2,” “R^3,” etc., where “R” stands for *base-relation*, “R^1” for *one-place relation*, “R^2” for *two-place relation*, etc., and which, when attached to the syntactic representation of a character string (such as to the syntactic representation of “loves” in (1), indicates that the syntactic representation resulting from such attachment, (and derivatively, the character string it represents), designates a relation among things, a one-place relation among things, a two-place relation among things, etc.

As with the preceding case involving the representational thing-morpheme "T," the symbols "R," "R^1," "R^2," "R^3," etc., are placed immediately below the symbol to which they are attached (as we shall shortly illustrate).

5.5. Logical natural language case morphemes realized in character string (1). *Case morphemes* are logical natural language morphemes which indicate the respective roles of thing-expressions relative to a given relation expression, and are attached to a relation expression in a manner that coordinates with the thing expressions that are to assume those roles. The two case morphemes that are realized in the character string (1) are "A" for Agent, and "D" for Direct Object.

5.6. Compounding of relation-morphemes and case-morphemes in character string (1).

The logical natural language relation morphemes are implicit rather than explicit morphemes of English, being indicated dominantly by global properties of character strings in which they are implicitly realized. The relation- morphemes signal that any character string parts with which they are associated are to be interpreted variously as a base relation, a one-place relation, a two-place relation, and so on. For example, the lexical natural language morpheme “loves” (which is explicitly realized in the character string (1)), by virtue of having the natural language two-place relation morpheme “R^2” associated with it in a normal interpretation of (1), is interpreted as a two-place relation relative to the two character string parts “John” and “Mary.” As indicated, we use the symbols “R,” “R^1,” “R^2,” “R^3,” etc., as the associated logical representational morphemes associated respectively with the natural language relation morphemes of base-relation, one-place relation, two-place relation, three-place relation, etc.. Now the syntactic representation of the character string “loves” (in a normal deductive interpretation of (1)) is a lexical representational morpheme in the wider sense[5], which we build up out of a lexical representational morpheme that we write as LOVE together with the successively attached logical representational morphemes “R,” “R^1,” and “R^2, and the two representational morphemes: the agentive case morpheme A, and the direct object case morpheme D. While generally, when any of the logical representational morphemes “R,” “R^1,” “R^2,” etc., is attached to any syntactic representation, the resulting syntactic representation designates, respectively, a relation, a one-place relation, a two-place relation, and so on, for deductive interpretations of character strings (such as “love”), that are to designate relations, we construct their syntactic representations by a succession of constructions like the following:

```
LOVE,  LOVE  ,   LOVE  A ,   LOVE   A ,   LOVE   A  D ,
         R          R           R   /        R   /  /
                                   /            /  /
                                R^1          R^1   /
                                                  /
                                              R^2
```

where A and D are the special lexical representational morphemes associated with lexical natural language “case” morphemes. This mode of composition involving case morphemes will be partly described in the present series of examples and detailed more fully later. (see (e) and (f) below for a discussion of the specific case morphemes that enter into the syntactic representation of “love” in (1); also see (1’) on page ? to see these examples in context.)

5.7 The logical natural language individuator morphemes realized in character string (1). The logical natural language individuator morpheme has the associated logical representation morpheme IND (for Individuator), and which, when attached to the syntactic representation of a character string, indicates that the syntactic representation resulting from such attachment (and, derivatively, the character string it represents) designates an individual (rather than say a class).

For example, by attaching the symbol IND to the compound symbol

```
   JOHN
    T
```

to form

```
IND JOHN
   \ T
    \|
```

we thereby (i.e., by attaching IND in this way) indicate that a certain containing (compound) symbol designates an individual.

Note here that

if we were, further, to attach T to

```
IND JOHN
   \ T
    \|
```

To form

```
IND JOHN
   \ T
    \|
     T
```

we thereby indicate that the thus resulting (compound) symbol (and, derivatively, the character string "John" that it represents) designates an individual thing rather than, say, an individual relation. We also note here that a given natural language character string, such as "John," which occurs as part of a containing natural language character string, such as "John loves Mary," can be syntactically represented by t most one sub-character string of the syntactic representation of the containing character string. Thus "John" in the character string "John loves Mary" under a normal interpretation of that character string is syntactically represented only by the sub-character string

```
IND JOHN
   \ T
    \|
     T
```

Of the syntactic representation (1') (see page??) of "John loves Mary," and not by any of its constituent sub-character strings:

```
JOHN,   T,   JOHN,   IND,   IND JOHN
                               \ T
                                \|
```

Which have entered into its construction.

5.8. <u>The logical natural language present tense morpheme realized in character string (1).</u> The logical natural language present tense morpheme (explicitly realized in (1) by the terminal "s" in "loves"), whose associated logical representational morpheme we write as PRESENT and which, when attached to the syntactic representation of an character string to which the relation morpheme R has already been attached (as it would be to the syntactic representation of "loves"), indicates that the syntactic representation resulting from such attachment (and, derivatively, the character string it represents), designates a relation that occurs at the present time. (See (1') and (5') ona page ??.)

5.9. <u>The lexical natural language agentive case morpheme realized in character string (1).</u> We write the lexical natural language Agentive Case Morpheme as "A," (for "<u>A</u>gent") and which, when attached tot the syntactic representation to which the logical representational relation morpheme “Rn”, for some non-negative integer n, has already been attached (such as in the syntactic representation of “loves)to indicate that the n+1st place of the relation is to correspond to the agent of the relation. (See (1’) and (5’) on page ??.)

5.10. <u>The lexical natural language direct object case morpheme realized in character string (1).</u> We write the lexical natural language Direct Object Case Morpheme as “D,” (for “<u>D</u>irect Object”) and which, when attached to the syntactic representation to which the representational relation morpheme “Rn”, for some non-negative integer n, has already been attached (such as in the syntactic representation of “loves” in (1))to indicate that the n+1st place of the relation is to correspond to the direct object of the relation. (See (1’) and (5’) on page ??.)

5.11. <u>The lexical natural language morpheme “John” realized in character string (1).</u> The lexical natural language morpheme “John” which is explicitly realized in the morph “John,” is associated with the lexical representational morpheme JOHN.

5.12. The lexical natural language morpheme "Mary" realized in character string (1). The lexical natural language morpheme "Mary" which is explicitly realized in the morph "Mary," is associated with the lexical representational morpheme MARY.

5.13. The lexical natural language morpheme "love" realized in character string (1).

The lexical natural language morpheme "love" which is explicitly realized in the morph "love," is the initial part of the character string "loves" in (1), is associated with the lexical representational morpheme LOVE.

5.14. Natural language morphemes realized in character string (5) which were not realized in character string (1).

We turn now to the natural language morphemes realized in (5) under the normal interpretation (A) of (5). All but one of the natural language morphemes realized in (5) were also realized in (1), and have already been covered above. The natural language morpheme realized in (5) that is not among the morphemes realized in (1) is the one we refer to now as the logical natural language indefinite morpheme.

5.15. The Logical Natural Language Indefinite Morpheme.

This morpheme is realized in (5) by the morph "some," which is the initial part of the character "something" in (5), whose associated logical representational morpheme we write as INDEF (for "INDEFinite") and which, when attached to the syntactic representation of an character string, indicates that the resulting syntactic representation (and, derivatively, the character string it represents) designates an indefinite entity (rather than, say, an individual, a class, or the null entity).

5.16. <u>The Logical Natural Language Thing-morpheme Implicitly Realized in (1) But Explicitly Realized in (5).</u>

Recall our remarks in Section 6.2 regarding the logical natural language "thing-morpheme," to which we had associated the logical representational morpheme "T" (for <u>T</u>hing), and which, when attached to the syntactic representation of an character string, (such as to the syntactic representation of "John" or "Mary" in (1) or when standing alone, indicates that the syntactic representation resulting from such attachment, (and, derivatively, the character string it represents), designates a thing of some kind as opposed to, say, a relation. Unlike the situation in (1), where this natural language morpheme is realized implicitly, in the character string (5) here it is realized by the morph “thing” as the terminal part of the character “something.”

6. SYNTACTIC REPRESENTATIONS OF (1) AND (5) AS SYNTACTIC COMPONENTS OF THEIR DOMINANT SENTENTIAL INTERPRETATIONS.

6.1. For the sake of definiteness, as well as to motivate the future discussion, we exhibit below syntactic representations (1’) and (5’) of (1) and (5) respectively, which would be the syntactic components of their respective dominant sentential interpretations. Each of these syntactic representations is built up out of representational morphemes discussed above.

```
(1’)  IND JOHN      LOVE  A D  PRESENT    IND MARY
         \  T         R  / /  /             \ T
          \ |         | / /  /               \|
            T         R1 /  /                 T
             \        | /  /                 /
              \       R2  /               /
               \      |  /              /
                \     R2             /
                 \    |           /
                  \   |         /
                   \  |      /
                    \ |    /
                     \| /
                      |/
                      T
```

```
(5’) INDEF  T       LOVE A D  PRESENT    IND MARY
         \  |         R / /   /             \ T
           \|         |/ /   /               \|
            T         R1/   /                 T
             \        |/   /                 /
              \       R2  /                /
               \      |  /              /
                \     | /            /
                 \    R2          /
                  \   |        /
                   \  |     /
                    \ |   /
                     \| /
                      T
```

While the full interpretations of (1) and (5) would include also the semantic theory that assigns meanings to all the meaning bearing syntactic parts of (1’) and (5’), we can indicate the pre-critical sense of those meanings as (1*) and (5*) respectively, below. We indicate the meaning of a natural language character string by double underline.

(1*) The individual thing John stands as an agent of the two-place relation present-love relative to the individual thing Mary that stands as a direct object of that relation.

(5*) Some-thing stands as an agent of the two-place relation present-love relative to the individual thing Mary that stands as a direct object of that relation.

6.2. Exhibiting Character strings With Their Associated Syntactic Representations.

When we wish to explicitly exhibit the relationship between natural language character strings and their syntactic representations, we join those character strings to their associated syntactic representations by line segments lines, as in:

```
(1)       John            loves           Mary

           / \          /  |  |  \         / \

(1')   IND JOHN     LOVE A D  PRESENT    IND MARY
          \ T         R / /   /             \ T
           \|         |/ /   /               \|
            T         R1 /  /                 T
             \        |/   /                 /
              \       R2  /              /
               \      | /            /
                \     R2          /
                 \    |        /
                  \   |      /
                   \  |   /
                    \ |  /
                     \| /
                      \/
                       T
```

```
(5)   Something        loves            Mary

         / \          /  |  |  \          / \

(5') INDEF  T      LOVE A D  PRESENT    IND MARY
          \ |        R / /   /            \ T
           \|        |/ /   /              \|
            T        R1/   /                T
             \        |/   /               /
              \       R2  /             /
               \      | /             /
                \     R2            /
                 \    |          /
                  \   |        /
                   \  |      /
                    \ |    /
                     \|   /
                      \ /
                      T
```

```
(5') INDEF  T    LOVE A D  PRESENT    IND MARY
        \  /       R / /  /            \ T
         \/        |/ /  /              \|
          T        R1/  /                T
          \        |/  /                /
           \       R2 /               /
            \      |/               /
             \     R2              /
              \    |            /
               \   |         /
                \  |      /
                 \ |    /
                  \| /
                   T
```

6.3. General convention for exhibiting character strings with their associated syntactic representations.

We can state the relationship between natural language character strings and their syntactic representations as exhibited above, as follows: The associated syntactic representation of a sub-character-string w of (1) is defined as the largest sub-character string of (1′) that contains all and only those representational morphemes of (1′) that are connected by line segments to the characters (or character string parts) occurring in w. Thus the character string "John" in (1) has the syntactic representation:

```
IND JOHN
  \ |
   \|
    T
```

and the character string "loves" in (1) has the syntactic representation:

```
LOVE A D PRESENT
  R / /  /
  |/ /  /
  R1/  /
  |/  /
  R2 /
  |/
  R2
```

And the character string "Mary" in (1) has the syntactic representation:

```
IND Mary
  \ |
   \|
    T
```

Finally, the entire character string (1) has the syntactic representation (1’).

7. Ultimate purpose of study with reference to above examples. With reference to the particular examples discussed above, the further purpose of this study (not realized here[13]) is to develop semantic theories which enable us to assign semantic interpretations s((1’)), and s((5’)to the syntactic representations (1’) and (5’) respectively, so that the pairs <(1’), s((1’)> and <(5), s((5’)> constitute normal sentential interpretations of character strings (1) and (5) respectively, which are such that these sentential interpretations of (1) and (5) induce, in a precise and provable sense, that (1) deductively implies (5), (1) deductively implies (1), and (5) deductively implies (5). This latter means that the following pattern of deductive implication would be induced on the set {(1),(5)} consisting of the character strings (1) and (5):

{<{(1)},(1)}, <{(5)},(5)>, <{(1)},(5)>},

which we express as a relation from subsets of the set {(1), (5)} to members of this set. Note also that we include here the two trivial deductive implications that

(1) deductively implies (1) and that (5) deductively implies (5).

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