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Linguistic structure: A plausible theory

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Abstract. This paper is concerned with discovering the system that lies behind linguistic productions and is responsible for them. To be considered realistic, a theory of this system has to meet certain requirements of plausibility: (1) It must be able to be put into operation, for (i) speaking and otherwise producing linguistic texts and (ii) comprehending (to a greater or lesser extent) the linguistic productions of others; (2) it must be able to develop during childhood and to continue changing in later years; (3) it has to be compatible with what is known about brain structure, since that system resides in the brains of humans. Such a theory, while based on linguistic evidence, turns out to be not only compatible with what is known from neuroscience about the brain, it also contributes new understanding about how the brain operates in processing information.

Keywords: meaning, semantics, cognitive neuroscience, relational network, conceptual categories, prototypes, learning, brain, cerebral cortex, cortical column

1. Aims

Nowadays it is easier than ever to appreciate that there are many ways to study aspects of language, driven by different curiosities and having differing aims. The inquiry sketched here is just one of these pursuits, with its own aims and its own methods. It is concerned with linguistic structure considered as a real scientific object. It differs from most current enterprises in linguistic theory in that, although they often use the term 'linguistic structure', they are concerned mainly with the structures of *sentences and/or other linguistic productions* rather than with the structure of *the system that lies behind these and is responsible for them.* To have one's primary interest in sentences and other linguistic productions is natural for people interested in language and is nothing to be ashamed of or shy about; so to say that they are more interested in linguistic productions than in the system responsible for them is in no way intended as critical of these other theories. They have been providing useful and

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interesting information over the years, which satisfies various well-motivated curiosities about words and sentences and other linguistic structures.

To mention just one such descriptive theory, Systemic Functional Linguistics (SFL) aims to understand the structures of sentences and other texts by characterizing the set of choices available to a speaker in forming them (Halliday 2013, Fontaine, Bartlett, and O'Grady 2013, Webster 2015, and many other publications). The values of this approach are shown, for example, in Fontaine, Bartlett and O'Grady (2013) and in Halliday (2015). While the aims of SFL are not the same as those of the present investigation, they are compatible (cf. Gil 2013, Lamb 2013), and SFL therefore provides valuable data for use in devising a theory of *the system that lies behind* the texts and provides those choices to speakers. Similar things can be said, *mutatis mutandis*, in relation to various other descriptive linguistic theories.

In his *Prolegomena to a Theory of Language* (1943/61), Hjelmslev wrote, "A [linguistic production] is unimaginable—because it would be in an absolute and irrevocable sense inexplicable—without a system lying behind it". That system is unobservable in itself, but we know that it has to exist. The investigation described in this paper operates on the presumption that careful analysis of linguistic productions will reveal properties of the system that produced them. When we observe words in linguistic productions, we accept that there has to be a system that has produced them. Our task is to posit what must be present in the linguistic system to account for them. In Hjelmslev's terminology, this is a process of *CATALYSIS*. Catalysis begins with analysis of *observed* phenomena (texts and portions of texts), and proceeds to build an abstract structure consisting of elements *that are not observed.*

Most of linguistics, even that which claims to be studying 'linguistic structure', engages in *analysis and description* rather than in catalysis; it is occupied with analysing and describing and classifying linguistic productions. Again, to make this observation is in no way a criticism of analytical/descriptive approaches. Actually, most people, both ordinary people and linguistic scholars, have a greater interest in the outputs of the linguistic system than in the structure responsible for them. An account of 'linguistic structure' that contains rules or words or parts of words (prefixes, suffixes, stems, and the like), however interesting and valuable, cannot be an account of the underlying system, since that system could not *consist of* rules or words or parts of words. To claim otherwise would be akin to claiming that the human information system is a type of vending machine, in that what comes out of a speaking human is stuff that was inside. Rules too are linguistic productions, however formalized, but the system that produces them must have an altogether different form. It is that different form that we seek to encatalyze through the examination of words and parts of words and syntactic constructions and other linguistic productions.

Apparently there are some who believe that Chomskian Biolinguistics is a theory that shares the aims of the investigation described here. The erroneous thinking that has led to this belief has been described in detail by Adolfo García (2010).

It should be fairly obvious from the outset that whatever the linguistic system consists of, it does not *consist of* words or phonemes, and certainly not of written symbols. When a person speaks a word, he is not simply putting out an object that was in him, as a vending machine does. Rather, he has an internal system that activates, in proper sequence and combination, muscles of the mouth, tongue, larynx, and other parts of the speech-producing mechanism, including the lungs, so that the word *is produced on the spot*, an object that has not previously existed (see also Lamb 1999: 1–2, 6–7). The structure that produces words need not resemble them at all. Therefore, we can be sure right away that any theory that describes structures consisting of words or other symbolic material is *not* a theory of *linguistic structure* in the sense of that term used in this paper.

2. Evidence and plausibility

There are five easily identifiable areas of observation, relating to four kinds of real-world phenomena that are relevant to language and which therefore provide evidence for linguistic structure (see also Lamb 1999: 8–10).

The first type of evidence is easy and obvious. It relates to what Hjelmslev called *EXPRESSION SUBSTANCE* (1943/61). We have abundant knowledge from biology about the organs of speech production, which provide grounding for articulatory phonetics. So whatever a theory of linguistic structure has to say about phonology must be consistent with well-known facts of articulatory phonetics. Biology likewise provides knowledge of the inner ear and other structures related to hearing, which give solid ground to auditory phonetics. And acoustic phonetics is grounded by knowledge available from physics relating to frequencies and formants and so forth. Similarly we have plenty of scientific knowledge about the physical aspects of writing and reading and other kinds of expression substance.

The second body of evidence is the linguistic productions of people, the things they say and write, which are generally also things that people can comprehend (to varying degrees). For any such production I use the term *TEXT,* applying it to both spoken and written discourse. The term covers productions longer than sentences, and productions that under some criteria would not be considered well-formed, such as spoonerisms and other slips of the tongue, unintentional puns, and utterances of foreigners with their lexical, grammatical, and phonological infelicities. Such productions provide valuable evidence about the nature of linguistic systems (e.g., Dell 1980, Reich 1985, Lamb 1999: 190–193).

Third, as is obvious from cursory observation relating to the second body of evidence, people are indeed able to speak and write, and to comprehend texts (if often imperfectly). This obvious fact assures us that linguistic systems *are able to operate for producing and comprehending texts.* Therefore, a model of 'linguistic structure' cannot be considered realistic if it cannot be *put into operation* in a realistic way. This principle, the requirement of *OPERATIONAL PLAUSIBILITY,* has also been mentioned by Ray Jackendoff (2002).

Fourth, and also clear from cursory observation, real-life linguistic systems undergo changes, often on a day-to-day basis. Such changes are most obvious in children, whose linguistic systems undergo rapid development during the first few years, from essentially nothing at all at birth to huge capacity and fluent operation by age five. But adults also acquire new lexical items from time to time, in some cases quite often, as when they undertake learning some new body of knowledge. They also sometimes acquire new syntactic constructions. And so a model of linguistic structure, to be considered realistic, must incorporate the ability to develop and to acquire new capabilities of production and comprehension. This criterion may be called the requirement of *DEVELOPMENTAL PLAUSIBILITY*. It provides another easy way to distinguish a theory of linguistic structure from a theory of the outputs of linguistic structure. Valuable as they are for their own purposes, theories of the outputs, are in such a form that there is no plausible avenue that could lead to their development. This statement applies also to some network theories, such as the well-known connectionist theory of Rummelhart and McClellan (1986).

Finally, since we are attempting to be realistic, we cannot treat a linguistic structure as just some kind of abstract mathematical object. In keeping with the preceding paragraphs, we have to recognize that linguistic structures exist in the real world and that their loci are the brains of people. And so a theory of linguistic structure needs to be consistent with what is known about the structure and operation of the brain. This is the requirement of *NEUROLOGICAL PLAUSIBILITY*.

To summarize, our aim is to construct (encatalyze) a realistic theory of linguistic structure, recognizing that to be realistic means accounting for the fact that real linguistic systems (1) are able to produce texts and to understand them (however imperfectly), (2) are able to develop and the change themselves, and (3) have structures that are compatible with what is known about the brain.

3. Basic observations

The development of the theory sketched here has followed a crooked path over the past half-century, building on earlier work including that of Jan Baudouin de Courtenay, Adolf Noreen, Ferdinand de Saussure, Louis Hjelmslev, Benjamin Lee Whorf, Charles Hockett, and H.A. Gleason, Jr., with numerous cul-de-sacs along the way (cf. Lamb 1971). For this presentation the path is smoothed out. The earlier sections of this paper set forth in a straightened path the developments up to about the turn of the 21st century, most of which has previously been mentioned in scattered publications that appeared along the crooked path (including Lamb 1999, Lamb 2004a, 2004b, Lamb 2005; see also García 2012). Later sections concentrate on neurological plausibility, which I take as a central concern for a realistic theory of linguistic structure, and propose several findings that have not previously appeared in print, including some that are offered as contributions to cognitive neuroscience.

Since we can't do everything at once the path takes up one thing at a time, as with any exploratory enterprise. It best begins with easy stuff. Easy things are not only easier to work with in initial stages, they are likely to be basic and therefore to lay the foundation for further exploration. In focusing on the more obvious and easier to handle, we are not ignoring additional complications, just deferring their consideration until we have a basis for further investigation.

Perhaps the most obvious thing about linguistic productions is that they are combinations of various kinds: combinations of words, combinations of speech sounds, combinations of sentences, …

Another basic finding well known from the early days of language study is that which led to the distinction between *SUBSTANCE* and *FORM*. Speech sounds are endlessly variable, yet behind the variety is a much simpler structure. So for speech we have a set of *PHONEMES*, elements of *EXPRESSION FORM*, each of which is realized by any of a large variety of similar articulations and resulting sounds, belonging to *EXPRESSION SUBSTANCE*. For example, the phoneme /k/ of English is recognized as one and the same phoneme regardless of the exact location where the back of the tongue touches the palate and regardless of how much aspiration occurs at its release. Similar organization can be applied to marks on a surface vis-à-vis *GRAPHEMES*—consider the letter (*GRAPHEME*) ‘k’ and its many typographic variants, and with even greater variability in the case of handwriting. The key consideration is that the variability among different manifestations of a phoneme or grapheme is generally treated by language users as non-significant, and the non-significant variation is often outside the awareness of language users.

At the same time, we have to recognize that this distinction (between form and substance) cannot be taken as absolute. As pointed out by Lucas Van Buuren (in press), it applies mainly to what Halliday calls the ideational function of language, much less to other functions. For example, phonetic features that would be considered non-significant from the ideational point of view may be quite important from an interpersonal point of view, and, as Hjelmslev himself pointed out (1943/61), they may provide information about where the speaker grew up.

Another readily observed fact about language is that linguistic expressions generally have meanings or other functions. Here too we can use terms of Hjelmslev, and say that language relates meanings and other functions—*CONTENT*—to speech or other means of *EXPRESSION*. Typically, a given word or phrase can be interpreted differently by different comprehenders or in different contexts. Similarly, such meaning can usually be represented in a variety of different wordings.

Further, following Hjelmslev's usage, we need the distinction between *CONTENT FORM* and *CONTENT SUBSTANCE*. For example, a unit of content form like CUP, is represented in content substance by many different actual cups out there in the world, of different shapes and colors and made of different materials. For both content and expression we find more or less haphazard variability of actual *SUBSTANCE* and the much simpler structure of *FORM*. So for *CONTENT SUBSTANCE* we have the world, existing as what B. L. Whorf (1956) called a *kaleidoscopic flux*, which language represents as *CONTENT FORM*, a greatly simplified set of categories, varying from one language to another.

Although Hjelmslev made the distinction between form and substance without reference to the cognitive systems of human beings, we do so here, in keeping with the requirement of neurological plausibility. Also, we have to recognize that the distinction is not quite that simple, since substance, on both the expression and content sides, is actually multi-layered, and some of those layers are internal, represented in the brain. Considering articulatory phonetics, for example, there are multiple layers of structure between the distinctive articulatory features of expression form and the actual speech sounds (as they might be measured in acoustic phonetics), subserved in large part by subcortical structures of the brain, including the basal ganglia and the cerebellum and the brain stem, as well as by the musculature that operates the organs of speech.

A fourth basic observation is that texts have various functions, both social and private. The private functions are often overlooked, but thinking (to oneself) is a linguistic activity that for many people occupies more of their waking hours than social interaction through language. The social functions can be divided into various subtypes, such as schmoozing (Halliday’s *interpersonal function*), sharing observations, seeking information (“What is his wife’s name?”), and changing societal structure (“I now pronounce you man and wife”).

These and other commonplace observations, well known among linguists of different persuasions, will be taken for granted in what follows. On the other hand, there are some widespread beliefs that we want to avoid, since they do not stand up to scrutiny, such as the doctrine that the linguistic world is made up of a number of discrete objects called languages (Lamb 2004b).

Since the aim of this enterprise is to figure out the nature of linguistic structure, such observations require that we come up with a realistic hypothesis of what kind of structure might be responsible. And, to be realistic, the hypothesis must satisfy the requirements of plausibility described above.

4. Combinatory levels

Much of the structural linguistics of the twentieth century was hampered by failure to distinguish levels of different kinds. One type is *combinatory*: we can say that combinations are on a different combinatory level from their components. This type of difference is quite different from that between the level of concepts and that of phonological representations (content form and expression form). For example, a concept is in no way a combination of phonemes. So we need to distinguish what can be called *STRATA* from *COMBINATORY LEVELS* (Lamb 1966). We have to recognize at least three strata for spoken language, conceptual, lexico-grammatical, and phonological. (We shall see later that *conceptual* is not actually the right term, but it will do for now).

The first of the "basic observations" above, that both phonemes and graphemes occur in largely linear and largely recurrent combinations of different sizes, including words, is a matter of combinatory levels. It requires that we posit some kind of sequencing structure—a structural device that produces and recognizes linear combinations. The ordinary way of representing combinations of phonemes or graphemes is with combinations of symbols from ordinary language: "boy", "toy".

This simple notational practice, largely taken for granted, *avoids the issue*: It is just a notational convention, which *leaves the structure undescribed*, and thus renders such accounts lacking in operational and developmental plausibility. According to the convention, the left-to-right direction represents time. Such notation is very useful for many language-related studies, but it is not suitable for representing linguistic structure, for three important reasons. First, this notation uses symbols derived from language. But language is the object whose structure we are trying to discover. To use language as a notation for such exploration is akin to building a fireplace of wood. The second problem is that it leads us to overlook the essential fact that when we use the same symbols ("o", "y") in two or more different locations, as when we write "boy" and "toy", we are talking about the same objects ("o", "y"). The notational convention is failing to make explicit that "-oy" in "boy" and "-oy" in "toy" are just two *different notational occurrences of what is one and the same object.* The third problem is that simply writing the letters from left to right ("boy" and "toy") is taking the sequencing for granted, failing to indicate that there has to be a structure responsible for it.

In order to make such facts explicit, we can encatalyze the situation as in Figure 1, in which there is only one "-oy". Parts a, b, and c of the figure are alternative catalyses showing different degrees of detail. Focusing first on Figure 1a, the triangular node signifies that when it is activated from above both of the lower lines (e.g. to /t/ and to /-oy/) are activated, but in sequence, represented in this notation as left-to-right attachment of the lines to the bottom of the triangle. As this definition illustrates, the nodes of this network notation are defined

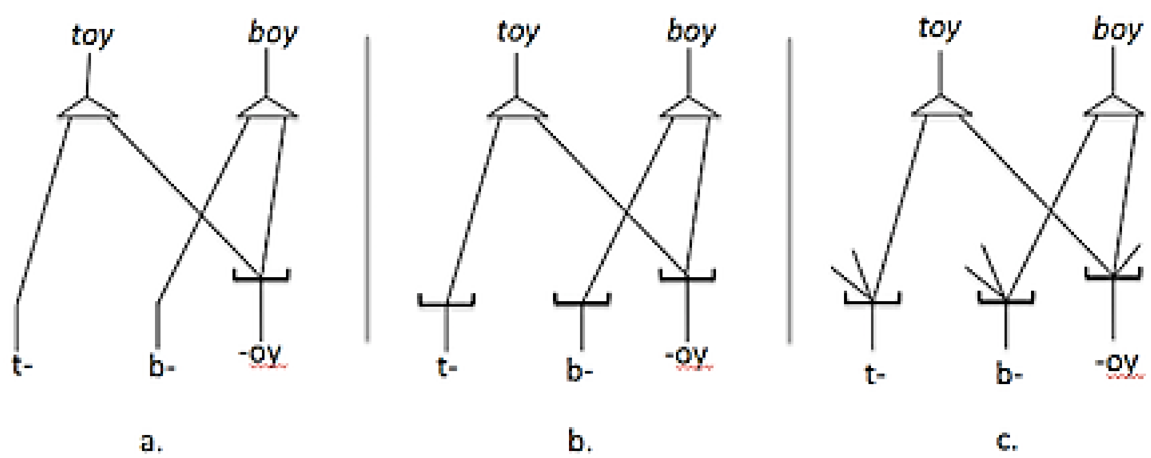


Figure 1. Relationship of toy and boy to their phonemic expressions

in terms of the passage of activation, and activation can be either downward—from content to expression—or upward—from expression to or toward content (i.e. function/meaning). So upward activation from /boy/ travels upward as /b-/ followed by /-oy/, and activation from both these lines connecting to the triangular node (called an AND node) satisfy it so that it sends activation on up to *boy*. On the other hand, activation from/-oy/ up to the AND node for *toy* is blocked by that node if /t-/ has not also been activated, since the AND condition will not have been satisfied. Notice that since the notation is defined in terms of operation, it concerns itself directly with the criterion of operational plausibility.

The other node, a square bracket rotated 90°, is called an OR node, since downward activation from *either* of its incoming lines passes through. On the other hand, upward activation to this node (i.e., coming up from /-oy/) goes to both (or all) outgoing lines. There is normally an either-or condition but not at the node itself. In the case that the input is /boy/, the AND node for *boy* is satisfied but that for *toy* is not (since there is no activation from /t-/), and so the overall effect is that only one succeeds, even though *locally*, at the OR node itself, both (or all) are tried. The situation can be seen as somewhat Darwinian (all are tried, only a few survive) if one cares to look at it that way.

Turning now from Figure 1a to 1b, a little more information is added, indicating that such an OR node is needed also for /t-/ and /b-/ since they also need connections upward to other AND nodes, such as those for *ten, tune, ben, boon,* and many others. This situation is indicated more explicitly in 1c, which shows that there are additional connections, without showing the other ends of them, as to do so would make the diagram harder to read, and such information would not be relevant to the point under discussion.

Now /-oy/ is generally recognized as a combination with its two components /o/ and /y/. But within the linguistic structure we *do not have such combinations; rather, they exist external to the structure itself.* Combinations outside of the structure are generated by (and recognized by) AND nodes. So to recognize that the (external) combination/oy/ is composed of /o/ and /y/, the structure needs an additional node as shown in Figure 2.

Notice that in this figure the symbol "-oy" is written at the side of a line. This symbol is not part of the structure; it is just a label, included to make the diagram easier to read, just like labels that are included on maps. When a highway map shows, say, "I-95" next to a line for a highway, it doesn't represent anything that will be found on the landscape at the location indicated. It is not part of the highway structure, just a label on the map that makes it easier to read. Note that this symbol "-oy" could be erased with no loss of information. Of course, a symbol could serve no function anyway as part of the structure, since the structure has no little eyes to read it, much less a visual perception system to interpret it. The structure consists only and entirely of nodes and their interconnections, represented as lines.

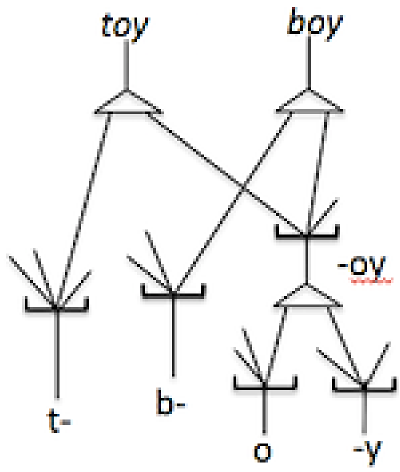
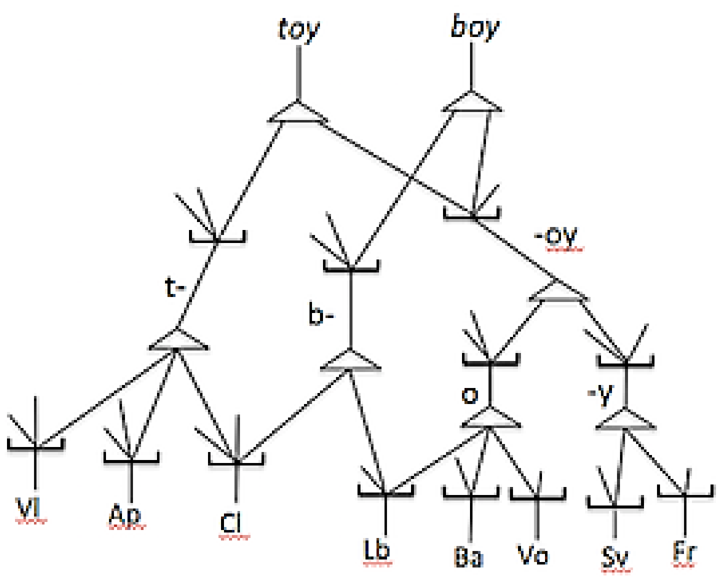


Figure 2. Relationship of *toy* and *boy* to their phonemic expressions, showing structure for combinatory levels in phonology

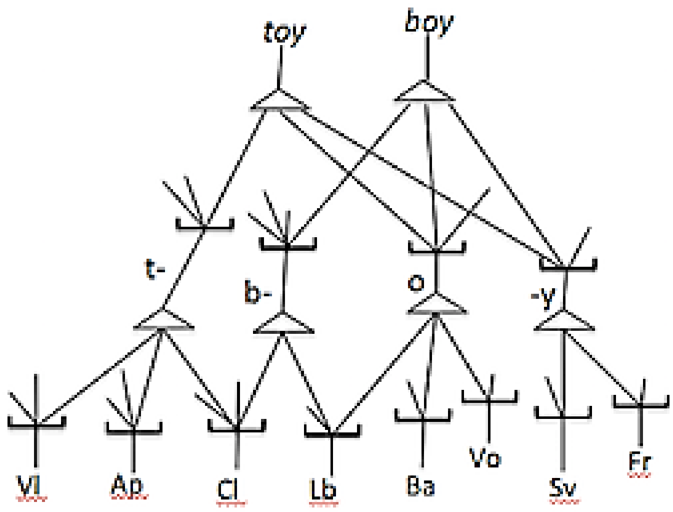
In Figure 3, we extend the "map" downward, to show phonemic components. Those shown here are articulatory components, and only the distinctive components are indicated at this level, on the assumption that the non-distinctive ones are supplied at lower articulatory levels. The same line of thinking applies to the sequencing of phonemes indicated at this level of structure. At lower articulatory levels, handled mainly or entirely by subcortical structures of the brain, timing is more complicated in that, for example, the mouth is put into the position for the vowel at about the same time the initial consonant is articulated rather than after articulation of that consonant.

Also left out of consideration, since it is not pertinent to the central argument, is the question of whether phonological components should be defined on an articulatory basis as opposed to an auditory basis. In fact, both bases have validity, as would have to be shown in a more detailed network diagram in which the two directions of processing would be represented by separate lines (see below, section 9).



Vl — Voiceless
Ap — Apical
Cl — Closed
Ap — Labial
Ba — Back
Vo — Vocalic
Sv — Semivocalic
Fr — Frontal

Figure 3. Expansion of Figure 2 showing phonemic components



Vl — Voiceless
Ap — Apical
Cl — Closed
Ap — Labial
Ba — Back
Vo — Vocalic
Sv — Semivocalic
Fr — Frontal

Figure 4. Alternative to Figure 3

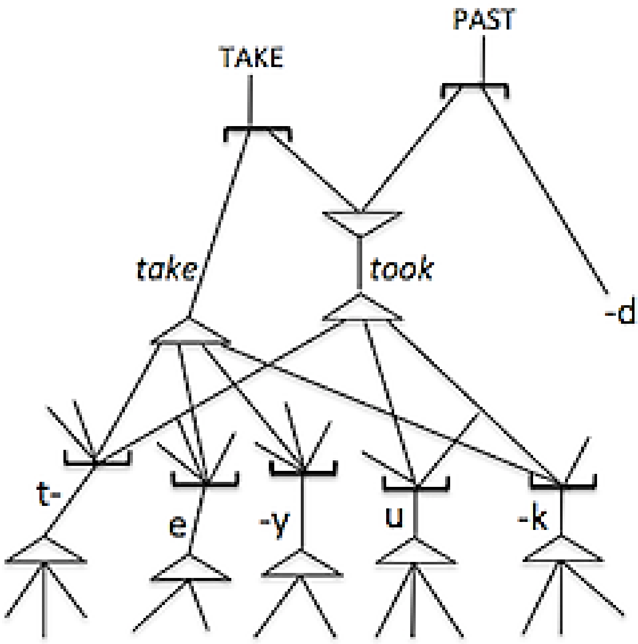
In Figure 3, the AND nodes connecting the phonemes to the phonological components are unordered—the lower lines all connect to the same point at the middle of the lower line of the triangle. So we have a distinction between *ordered* AND and unordered AND nodes.

Figure 4 shows an alternative structure for the same phenomena. Figure 3 and Figure 4 may be called alternative *CATALYSES*, that is, different structures posited to account for the same phenomena. There are arguments in favor of both, and I treat the situation here as unresolved, pending further study. On the one hand it can be argued that the syllable has two immediate constituents, as catalyzed in Figure 3. The catalysis of Figure 4, on the other hand, with its three-way ordered ANDs at the top, eliminates the need of a separate structure for /-oy/ and thereby has the advantage of shorter processing time, on the well-warranted presumption that it takes a certain amount of time for activation to pass through nodes.

5. Higher-level structure

The structures shown in these figures consist entirely of relations, forming networks. They suggest that perhaps the whole of linguistic structure is a relational network. As is mentioned above, there would be serious problems in defending a hypothesis that would also include symbols as part of linguistic structure, since symbols would entail some means of reading them and interpreting them, and the learning process would have to include some means of devising them (cf. Lamb 1999: 106–110). So the case in favor of relational networks, made up exclusively of nodes and their interconnections seems *prima facie* attractive.

The reasoning leading to this conclusion is presented in this paper in the third paragraph of the preceding section. It is only one of several quite different lines of reasoning that lead to the same conclusion. Others have been presented by Hudson (2007: viii, 1–2, 36–42), Lamb (1999: 51–62), and other investigators. But the exact form of the network varies from one investigator to another. For example, those of Hudson (2007) differ in some important respects from the *RELATIONAL NETWORKS* described in this paper, even though both ultimately derive from the systemic networks of Halliday. The relationships of relational networks to those of Halliday are described by Gil (2013) and Lamb (2013).



← *Ordered* OR *node:*

The line connecting off center takes precedence if conditions for its activation are present.

The line that goes straight through is the default line.

Figure 5. The irregular past tense

In the next several pages I look at various phenomena of grammatical and conceptual structure with the specific intent (not of describing them as such, but) of learning what additional properties are needed in relational networks to allow them to fulfill the goal of operational plausibility.

We may first take the case of PAST-TENSE, whose usual expression is the suffix *–ed*, but which has different representations in certain verbs: *went, saw, understood, took*… These are *ALTERNATIVE REALIZATIONS* of PAST-TENSE, and are therefore In an OR relationship to one another, as shown in Figure 5. But here, the alternative connections are on the lower side of the node. So we need to distinguish between *upward OR*, as in Figure 4 and the lower part of Figure 5, and *downward OR* as at the top of Figure 5. And that is not all. One of the realizations, *–d*, is the *default* form, used for most verbs, including those newly added to the system as part of the learning process. But when one of the other ("irregular") verbs is occurring, the other realization *takes precedence*, with the implication that the default realization must be blocked. This situation is represented in the network notation by the attachment of the lines at the bottom of the node. The default is the line that goes straight through while the line off to the side (either left or right of the default line just for considerations of readability) takes precedence. This type of OR node may be called a *precedence OR* (although in Lamb 1966 and most of the literature it is called *ordered OR*).

This figure also introduces the *upward AND* node, in this case for *took*. It is at this node that the conditions for taking the precedence lines from the two ordered ORs above it are either met or not met. That is, (considering the movement of downward activation) if the lines for TAKE and PAST are both activated, then the AND condition for *took* is met, and so the precedence lines are taken. Otherwise the activation proceeds along the default lines.

Clearly, there is some additional structure involved here when the network is operating that is not shown in this notation. The same can be said for the ordering of the ordered AND nodes, like those for *take* and *took*, and those in Figures 1–4. Thus we have the need for more

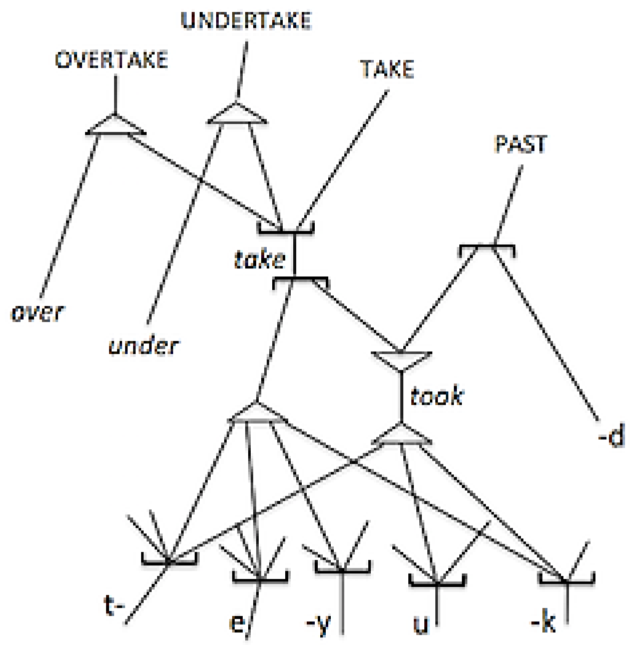


Figure 6. Present and past tense forms of three related verbs

refined modeling with a narrower notation system to specify such properties of the system (see below). The nodes of the relational network notation shown so far may be seen as abbreviations for such more detailed specification. Just as in chemistry, we have different notations showing different levels of detail.

Some analytical linguists might prefer to take account of the fact that both take and took begin with /t/ and end with /k/, so that the only difference between the present and past tense forms is the vowel or diphthong in the middle. That situation can also be represented, and in fact we can represent both catalyses within a single network diagram, as coexistent catalyses that can operate together, as shown in Lamb 1999 (pp. 235–236). But the catalysis shown in Figure 5 may be considered to represent the one that operates most for ordinary people, since learning mechanisms (see below) will assure that these forms will have become very well entrenched fairly early in the lives of typical speakers of English.

Figure 6 extends the view upwards to show the structure responsible for the fact that the past tense forms of *overtake* and *undertake* are *overtook* and *undertook* respectively, even though the meanings of these two verbs do not have any conceptual suggestion of TAKE.

6. Lexemes of different sizes and their meanings

It is often said that words have meanings, but *have* is not the correct term here, nor is *word*. Many lexical items are longer than words. This is why we need a more accurate term, and the term *LEXEME* (coined by B. L. Whorf in the 1930's) is less clumsy than *lexical item*. Also, some lexemes are shorter than words, for example, the prefix *re-*, which can productively be applied to verbs, as in *rethink, retry, renegotiate, refalsify, rehack, regoogle.*

Another thing to notice in Figure 6 is that, although *overtake* as an object occurring in a text is larger than *take*, it is *no larger in the linguistic system.* As an object in a text, *overtake* is a combination consisting of two parts, *over* and *take*, but in the linguistic system there is only a node and lines below it, connecting to structures for *over* and *take.* This is just another illustration of the fact that the linguistic system is a relational network and as such *does not contain lexemes or any objects at all.* Rather it is a system that *can produce and receive such objects.* Those objects are external to the system, not within it.

Using the term *lexeme* for the external object, we can say that lexemes (lexical items) come in different sizes. The larger ones, like *undertake* and *understand*, are represented in the system by nodes *above* and connected to those for their components. Such larger lexemes

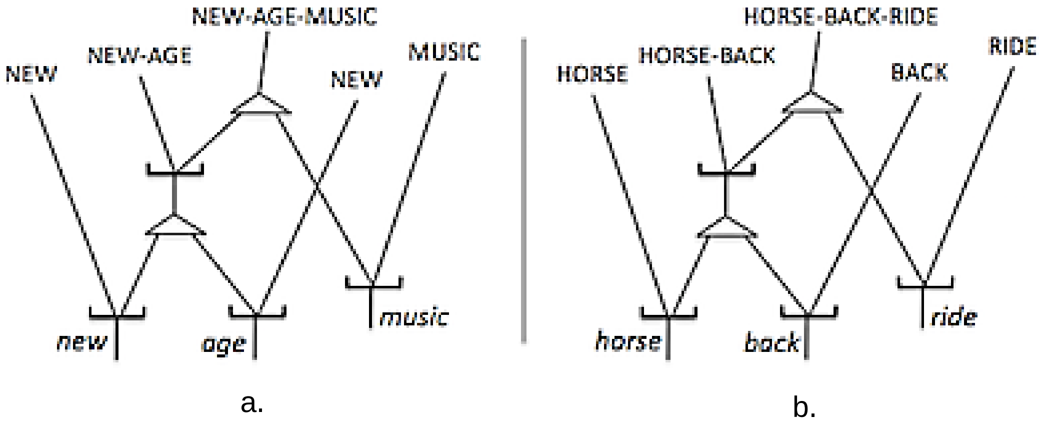


Figure 7. Linked hierarchies of lexical structure

may be called COMPLEX LEXEMES, and we should observe that they are very numerous, more so than may meet the eye of the casual observer. A few examples: *Rice University, The White House, give me a break, it's not rocket science, all you need to do is, comparing apples and oranges, connect the dots.*

We can also observe that the meaning of a complex lexeme may (*bluebird, White House*) or may not (*understand, cold turkey*) be related to those of its components. Those that are not may be called IDIOMS. Those that are may be called *transparent*, and transparency comes in degrees. But even if they are very transparent they still qualify as complex lexemes if they have been incorporated as units within the system of the language user. And they will have been incorporated if they have occurred frequently enough, according to the learning hypothesis described below. Thus idiomaticity comes in degrees. (Some people use a different definition of *idiom* that makes it roughly equivalent to what is here called a *complex lexeme*).

Also, as Figure 7 illustrates, we find lexical hierarchies. While the output *horseback ride* is larger than *horse*, each of them is represented within the structure by a single AND node. And notice that although the lexemes whose structures are shown in 7a and 7b are altogether different in both expression and content, their network structures are identical. The difference between them is not in their structures but in the fact that they have differing connections above (to content) and below (to expression).

Lexemes can have simple or more complicated relationships to their meanings. If they were all simple one-to-one relationships, there would be no need to distinguish a stratum of meaning from that of lexical structure; but they are not. For example, *soft* has two clearly distinct meanings, represent as UN-HARD and UN-LOUD. This is an example of *polysemy*. Similarly, *hard* can representable either DIFFICULT or HARD (as opposed to SOFT), while DIFFICULT can be represented by

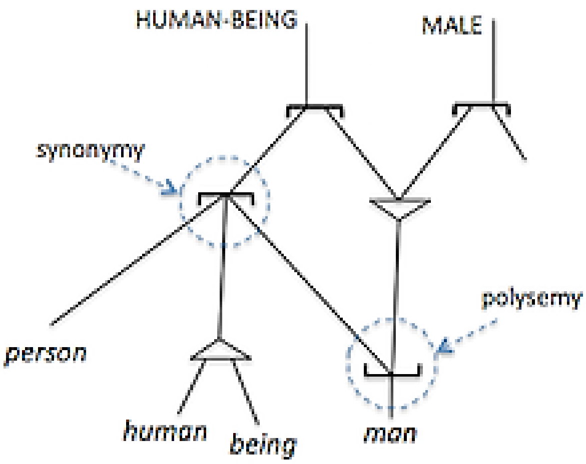


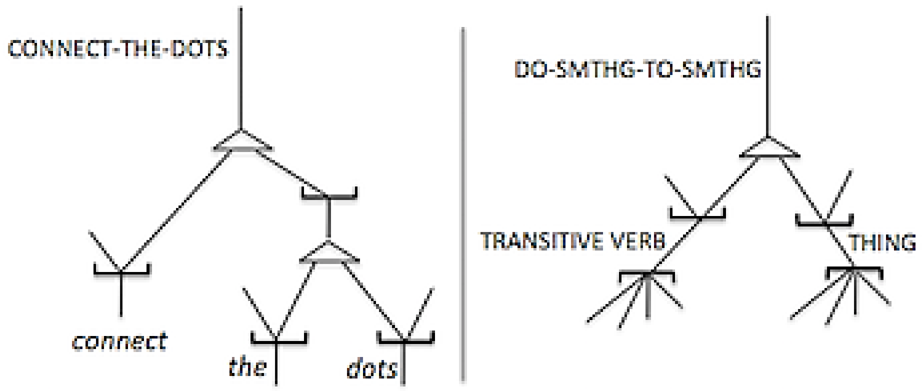
Figure 8. Example showing structure for synonymy, polysemy, and a lexeme longer than a word

either *difficult* or *hard* (synonymy). Similarly, *man* can represent either a human being or a male human being (Figure 8).

7. Syntax—Variable complex lexemes

In analytical approaches to language, those that focus on analyzing and describing texts rather than encatalyzing the system that lies behind them, syntax is often viewed as a large batch of information describable by rules. For a realistic structural linguistics (that is, an approach that takes seriously the criterion of operational plausibility) the objective is to encatalyze a reasonable hypothesis of the structure responsible for such phenomena.

We can view this information as made up of individual units of network structure added one by one to the system during the language development process, just as lexical information is added one unit at a time. These individual units of network structure correspond to the *constructions* of descriptive approaches. They are very much like the structural units for complex lexemes, the difference being that on the expression side there are multiple possibilities, such as a whole set of noun phrases, rather than just one (Figure 9).



a. *Fixed expression* b. *Variable expression*

Figure 9. Structures for a complex lexeme (left) and a construction (variable lexeme)

Another traditional term that is pertinent here is *linguistic sign*. The sign is pairing of a unit of content—the *signified*—with an expression—the *signifier*. Since it appears that at least most syntactic constructions are meaningful, we can view constructions as signs along with lexemes, and we can then say that the linguistic system as a whole is a structure that produces and interprets linguistic signs; that signs can have either fixed or variable expression; and that the process of language development consists of incorporating the structures for signs into the system, one by one. The structure in the linguistic system that corresponds to a sign may be called a *SIGN RELATION*. Using this term, we may say that the learning process consists of incorporating sign relations into the system, one by one.

To illustrate a little more relational syntax, we can expand on Figure 9b by adding other types of predicator, resulting in Figure 10, which shows the structure of Figure 9b along with two other types of predicator added at the left.

Meaning can also be expressed by the ordering of constituents. In English, we have the passive construction, the yes-no question, and the marked theme. Following the analysis of Halliday, we can say that the yes-no question is marked by expressing the finiteness element

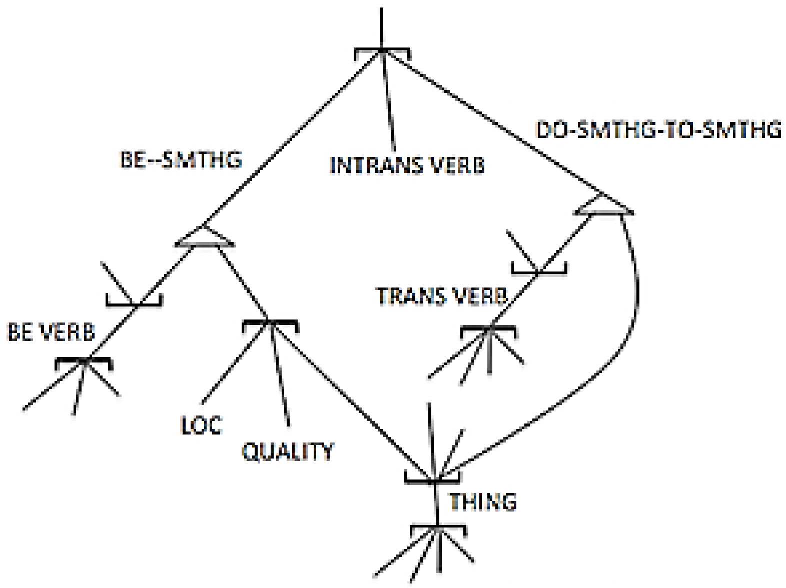


Figure 10. Some additional syntactic connections

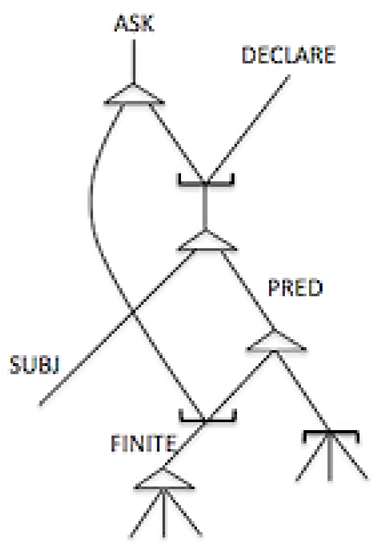
(e.g., modal auxiliary) before the subject rather than after it as in the unmarked situation (Figure 11). Similarly, the THEME-RHEME construction puts the theme first in the clause. *Subject* is the unmarked theme, but something else, like LOCATION, can be the marked theme, coming before the rest of the clause. For example, *At the lecture he dozed off.*

8. Meaning—Conceptual, perceptual and other cognitive structures

Network diagrams as shown so far have a vertical orientation such that downward is toward expression while upward is toward content (function/meaning). The ultimate bottom for the linguistic system, in the case of speaking, is the mechanisms of speech production, while for the input side of spoken language it is the cochlea and other structures of the ears, along with auditory processing structures of the midbrain. These interfaces constitute boundaries between two different kinds of structure, appropriately called *expression form,* a *relational network,* and *expression substance.* The study of expression substance, which is of course very complex, is left to other sciences.

Turning now to the upward direction, we can ask: how far does it go, does it end somewhere? Surely the system cannot keep extending upward forever. It may seem that somehow the top of the system is the locus of meanings and other communicative functions. It might also appear at first glance that meanings can be called concepts, but the situation is not that simple. To proceed, we have to take a look at some of the kinds of meanings we find.

Surveying various lexemes we see that only some of them have concepts as their meanings, including both concrete (e.g. DOG, DOCTOR) and abstract (CONFLICT, PEACE). Other lexemes have



Examples:
DECLARE: *Timmy can see it.*
ASK: *Can Timmy see it?*

Figure 11. The Yes-No question, expressed by ordering

meanings that are perceptual rather than conceptual, and others are of still other kinds, as indicated in Table 1. Far from giving a complete account, the table is intended only to be suggestive. The three-way distinction shown under Material Processes is likewise merely suggestive, as the actual situation is considerably more complex (Halliday and Matheissen 2004).

Table 1. Some kinds of meaning

Conceptual		
		Concrete—CAT, CUP
		Abstract—CONFLICT, PEACE, ABILITY
		Qualities/Properties—HELPFUL, SHY
Perceptual		
		Visual—BLUE, BRIGHT
		Auditory—LOUD, TINCKLY
		Tactile—ROUGH, SHARP
		Emotional—SCARY, WARM
Processes		
	Material	
		Low-Level—STEP, HOLD, BLINK, SEE
		Mid-Level—EAT, TALK, DANCE
		High-Level—NEGOTIATE, EXPLORE, ENTERTAIN
	Mental	
		THINK, REMEMBER, DECIDE
Relations		
		Locational—IN, ABOVE
		Abstract—ABOUT, WITH-RESPECT-TO

The difference between concepts and percepts is that percepts involve a single perceptual modality, such as vision, whereas concepts involve more than one; they thus occupy a higher level. Taking the concept DOG as an example, it has connections to percepts of multiple modalities, as the meaning DOG includes what dogs look like (visual), what a dog's bark sounds like (auditory), what a dog's fur feels like (tactile). It also includes memories of experiences with dogs within the cognitive system of the individual, and they of course differ from one individual to the next.

All these kinds of meaning are cognitive—engaging structural elements within the cognitive system—as opposed to referential, which covers all those dogs in the world outside of the mind. The latter may be said to belong to *content substance*, while the cognitive aspects of meaning belong to *content form*.

A distinction similar to that between concepts and percepts, not shown in the table, applies to processes. Considering processes of the kind performed by humans, like those mentioned in Table 1, the low level ones involve just a few relatively contiguous muscle groups while higher level processes involve multiple organs operating in coordination, both serially and in parallel. Accordingly it would be possible to draw a distinction like that between concepts and percepts: Using the stem *-funct* (as in function), we would have *confuncts* (complex processes involving multiple organs) and *perfuncts* (low-level, parallel to percepts). But in the interest of avoiding pedantry, I shall refrain from using such terms.

We can hypothesize that for both perception-conception and for motor activity we have multiple strata, as with language narrowly defined, such that each perceptual and motor modality has its own network structure, with the downward direction leading to an interface with substance while the upward direction leads to upper-level cognitive structure that, as upper level structure, integrates systems of different modalities.

As Table 1 demonstrates, the term *conceptual* is inadequate as a general term for the realm of meaning, since concepts constitute only one of several kinds of meaning. A more general term is *SEMEME*, first proposed by Adolph Noreen (1903–18) in the early days of structural linguistics, and adopted by Leonard Bloomfield (1933). Based on this term, we can use the term *SEMOLOGY* for the whole system of meaning structure.

The number of strata in different semological systems evidently varies. Vision, for one, appears to be far more complex than speech perception. It needs not only more strata but also different systems at its lower levels for different kinds of visual features, including color, shape, and motion.

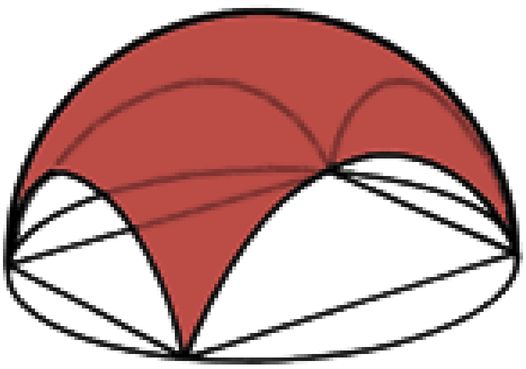
We can visualize an approximation to the situation as a *cognitive dome*, somewhat like than shown in Figure 12, in which semological structure is the large area at and near the top, while the four leg-like portions represent (1) speech input, (2) speech output, (3) extra-linguistic perception, (4) extra-linguistic motor activity. It is only a rough aid to visualizing the actual situation, since what we really have is a separate leg for each perceptual modality, and several to many legs for motor structures, depending on how we choose to count.

As the figure suggests, the numerosity of distinguishable features is greater at higher strata than at lower. For example, in spoken language we have only about a dozen articulatory features, two to three dozen phonemes, a few thousand morphemes, tens of thousands of lexemes, and hundreds of thousands of sememes. The same type of relationship evidently exists for the other systems.

The conclusion of this line of reasoning is that meaning structures are not simply *above* lexicogrammatical structures, in the same way that lexicogrammatical structures are above phonological structures. Rather, they are *all over the cognitive system*: Some, including concepts, are above, while others, including percepts, are not.

At this point we encounter the question of how far linguistic structure extends. We could take the position that these other systems are not part of linguistic structure and therefore don't have to be included in the investigation. That proposal would lead to an impoverished understanding. Conceptual structure and perceptual structure and the rest are so intimately tied up with the rest of linguistic structure that the latter cannot be understood without including the former. There are two major reasons for this conclusion: (1) the semological categories are highly relevant to syntax; (2) semological structure is largely organized as a hierarchical system of categories, and this categorical structure, along with the thinking that depends on it, varies from language to language and is largely learned through language (cf. Whorf 1956, Boroditsky 2009, 2011, 2013, Lamb 2000, Lai & Boroditsky 2013).

Moreover, the boundaries between conceptual structure on the one hand and perceptual and motor structures on the other are also at best very fuzzy, so there seems to be no clear



The four legs can be construed as (1) speech input, (2) speech output, (3) extra-linguistic perception, (4) extra-linguistic motor activity.

(figure from Wikipedia: http://en.wikipedia.org/wiki/Dome)

Figure 12. The cognitive dome

boundary anywhere within the cognitive dome. And so the quest for boundaries for language comes up empty: *There is no discernable boundary anywhere within the cognitive system*. We conclude that the investigation of linguistic structure takes us to a way of understanding cognition in general, including the structures that support perception and motor activity.

Unless and until we encounter evidence to the contrary, it is reasonable to continue with the hypothesis that conceptual structure and other cognitive structures consist of relations forming a network. But we need to be prepared for differences of network structure, and to adjust the relational network notation as needed.

9. Narrow Notation

The relational network notation as described up to this point operates in two directions. This bidirectionality suggests that there are actually separate structures for the two directions that are not shown in the notation as described thus far. There are also additional structural features so far left unspecified, including the temporal ordering implied in the ORDERED AND node and the precedence implied in the PRECEDENCE OR (ORDERED OR). To make such details explicit we need a more refined notation. It can be called *NARROW NOTATION*. In narrow notation all lines have direction (i.e., they are *directed*), it generally has two lines of opposite direction corresponding to each line of *ABSTRACT NOTATION*. Similarly, every node of abstract notation (also known as *COMPACT NOTATION*) corresponds to two (or more) nodes of narrow notation, as illustrated in Figures 13 and 14 (for details, see Lamb 1999: 77–83). The two levels of notational delicacy are like different scales in maps. In a more abstract map, divided highways are shown as single lines, while maps drawn to a narrower scale show them as two separate lines; and if narrow enough, the structures of the interchanges are shown.

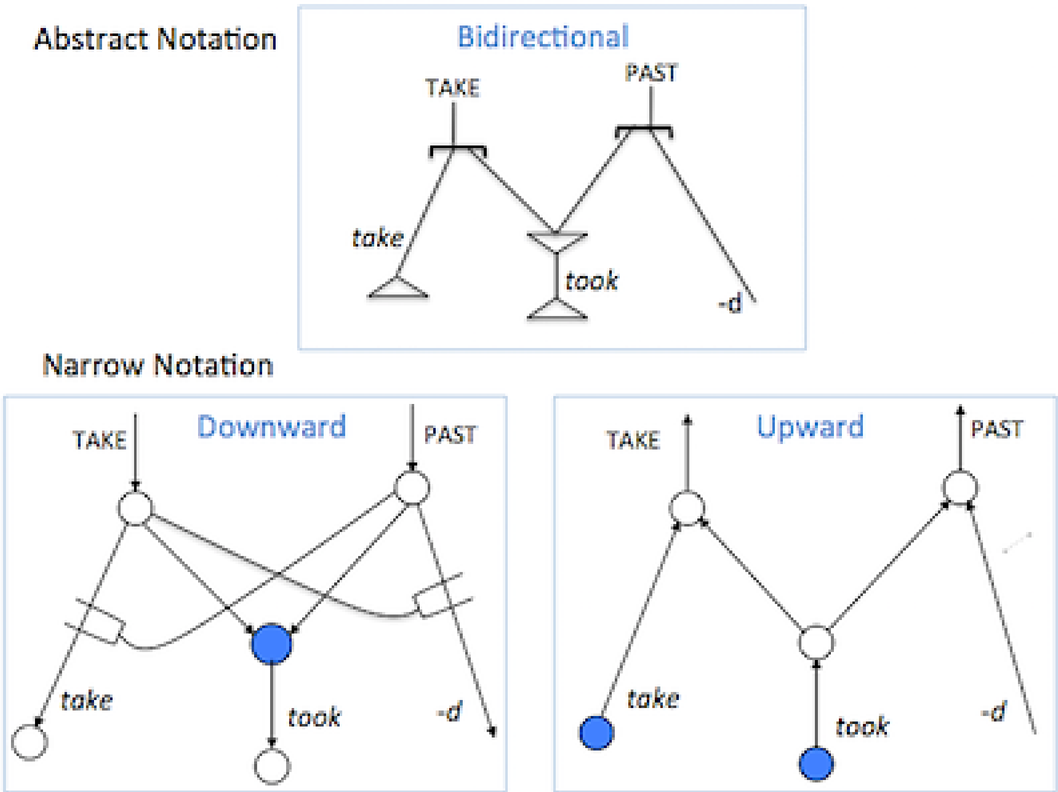


Figure 13. Abstract and Narrow Notation: the ORDERED OR

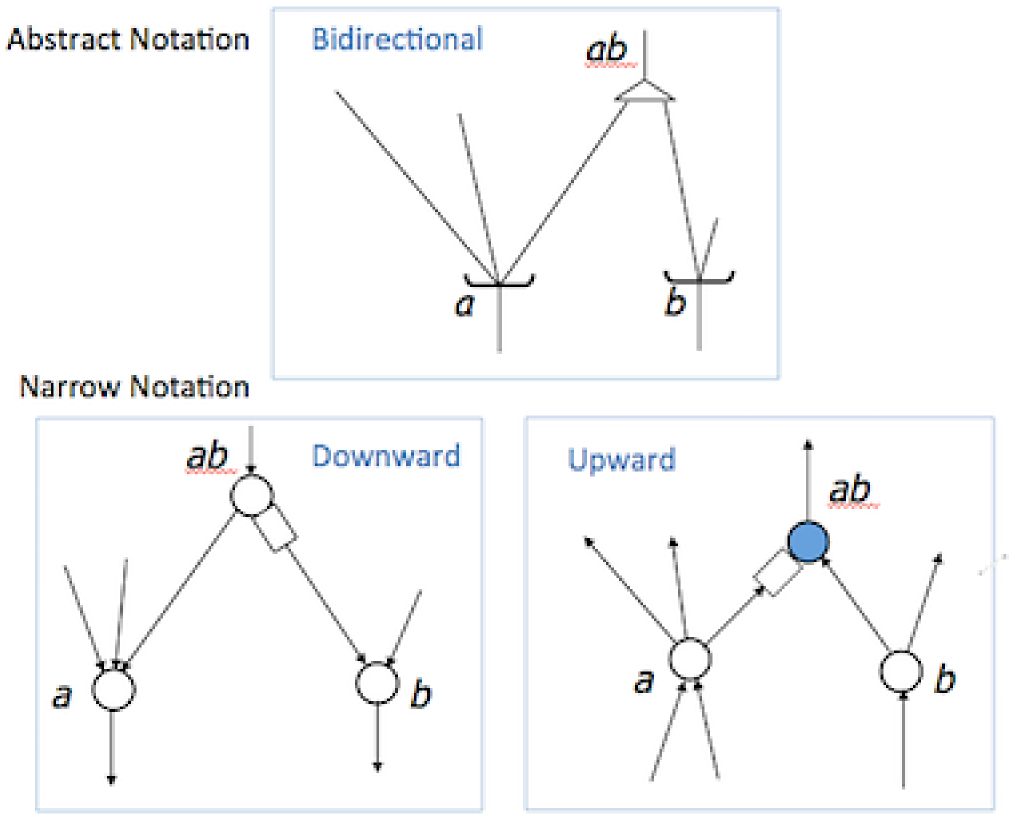


Figure 14. Abstract and Narrow Notation: the ORDERED AND

In narrow notation every node is drawn as a little circle, and the difference between AND and OR is recognized as a difference in threshold of activation: The AND requires both (or all) of its incoming lines to be activated to satisfy its threshold of activation, indicated by a filled-in circle, while the OR node needs only one incoming line to be active. A notational alternative is to write a little number inside the circle indicating the number of incoming lines that need to be active for the node to send activation onward, 1 for OR, 2 for AND.

For the PRECEDENCE OR, illustrated in Figure 5 above, further specification is needed to show the structure responsible for precedence. In abstract notation the line connected off to the side takes precedence. Therefore there must be a means of blocking the other line, the default representation. So in Figure 13 we have, in the downward direction, a *blocking element* from the node for TAKE to the line leading to the default realization of the past tense element, and a *blocking element* from the node for the past tense element to the line leading to the default realization *take*. The blocking element blocks any activation that might be traveling along the line it connects to.

Figure 14 shows the structure needed to make the ORDERED AND work. The little rectangle in the narrow notation is the *WAIT ELEMENT*. When the node ***ab*** is activated in the downward direction, the activation proceeds to both of the output lines, but the connection leading to ***b*** goes first through the WAIT element since ***b*** has to be activated *after* ***a***.

Clearly, this WAIT element likewise requires further specification. The amount of waiting time evidently varies from one type of structure to another, suggesting that there are different varieties of WAIT element. In phonology the amount of delay from, say, one segment to the next is small and relatively fixed, so the timing might be specified by the regular "ticking" of a "clock". In terms of brain structures such "ticking" may be provided by the thalamus, which sends signals throughout the cortex at fixed short intervals. For a wait element in syntax, on the other hand, the amount of delay is variable. In the case of the construction providing for a *subject* followed by a *predicate* (Figure 11), the activation for the predicate proceeds only after that for the subject, which can be as short as one syllable or long enough to include a relative clause. In such cases the timing seems to require feedback control; that is, the waiting of the wait element continues until a feedback signal is received (from 'f'), as indicated in Figure 15. Notice that the little loop keeps the activation alive until the feedback arrives, and that the feedback activation goes not only to the high-threshold node so that it can proceed to ***b***, but also turns off the little loop. (For details, see Lamb 1999: 98–102 and http://www.langbrain.org/Ordered-and).

10. Variation of thresholds and connection strengths

The study of conceptual and perceptual systems soon makes it apparent that there is much more to the question of the threshold than the simple distinction between AND and OR that seems to work so well in phonology and grammar. I say "seems to" in the preceding sentence because a closer look just at these levels suggests that we need refinement there as well. In a noisy room, for example, a hearer doesn't have to have every AND node fully satisfied in order to understand the words being received.

What we evidently need are thresholds of intermediate value, *between* AND and OR. A simple case of *intermediate threshold* would be a node with three incoming lines any two of which can activate the node; or we might have one with any three out of four, and so forth. Such intermediate thresholds can be indicated by little numbers written inside the circle, or more roughly by degrees of shading of the fill, solid fill for high threshold, intermediate degrees of shading for intermediate thresholds. For reasons given below, such rough indication, while not very accurate, is nevertheless quite useful, since accurate portrayal of thresholds in a simple notation is not practical.

Nodes of intermediate threshold turn out to be essential in accounting for conceptual and perceptual structure, since most concepts and percepts do not have a fixed number of defining properties. For example, within the category of drinking vessels, an object will generally be recognized as a CUP rather than a GLASS or a MUG if it has just two or three significant properties like SHORT, HAS-HANDLE, NOT-MADE OF-GLASS, ACCOMPANIED-BY-SAUCER, TAPERED (top larger than bottom) (Labov 1973). But that is only a first approximation, since there are many other properties albeit of lesser—but not neg-

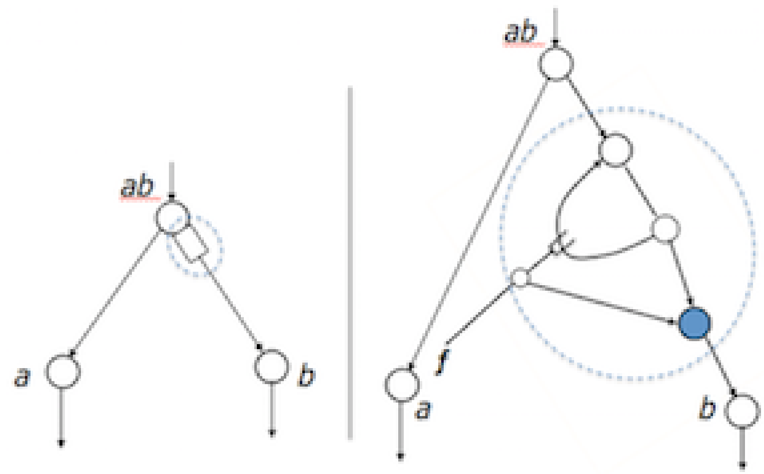


Figure 15. The Wait Element (with feedback control), abbreviated and detailed notations
(For animation see: http://www.langbrain.org/wait-anim-fb.html)

ligible—importance (Labov 1973, Wierzbicka 1984). Their lesser importance may be accounted for if we posit that nodes for different properties have different strengths of connection to the concept node. Strengths of connection can be roughly indicated in graphs by the thickness of lines. The node will be activated by *any of many different combinations* of properties.

The situation is roughly depicted in Figure 16, in which the lines have varying thickness and the nodes are shown with varying degrees of shading, indicating intermediate thresholds of differing value, such that if *enough of* the incoming connections are active, the threshold is satisfied. The key word is *enough*—it takes *enough* activation from *enough* properties to satisfy the threshold.

Since the property MADE-OF-GLASS is a negative indicator—a vessel is more likely to be a cup if it is *not* made of glass—its connection to the CUP node has to be inhibitory. And so we need to have both *excitatory connections*, which if active contribute to satisfaction of the node's threshold of activation, and *inhibitory connections*, which if active *detract from* satisfaction of the threshold. The inhibitory connection is indicated with a tiny circle (Figure 16). This is actually the second of two types of inhibitory connections needed in relational networks. The first, seen in Figures 13 and 15 above, attaches to a line rather than to a node.

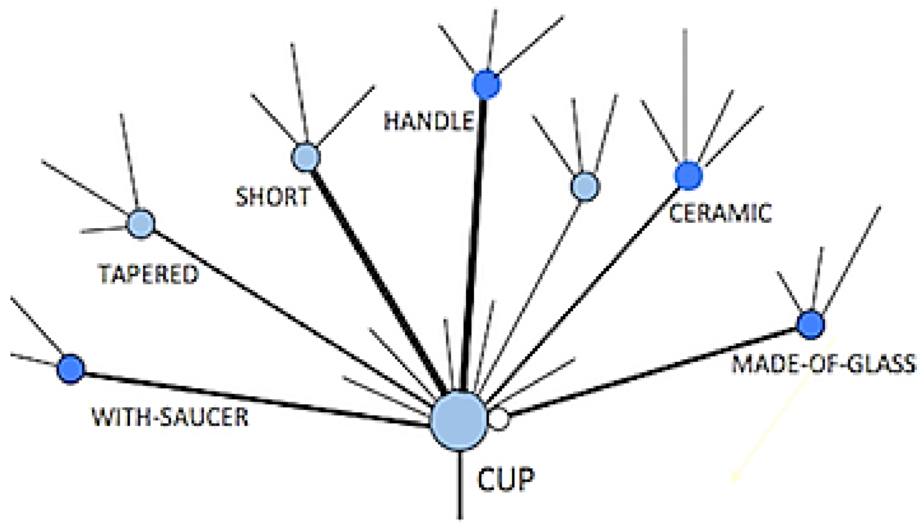


Figure 16. A concept node of intermediate threshold with connections of varying strength (higher is *not* more abstract, as this structure is near the top of the cognitive dome)

And there is yet more to the story. The structure shown in Figure 16 guarantees that a node like that for CUP will be activated *to different degrees* by different combinations of properties. For example, more activation will enter the node for prototypical cups than for peripheral members of the category, since the prototypical ones are those that provide activation from stronger connections and from more connections. Therefore the threshold of the node is not only satisfied, it is *strongly* satisfied for a prototypical cup.

Prototypicality effects have been *described* in numerous publications beginning with those of Eleanor Rosch in the 1970's, but that literature does not provide an account of the structure that *explains* the phenomena.

From the foregoing it is apparent that threshold satisfaction is a matter of degree. It seems reasonable to hypothesize that a higher degree of incoming activation causes a higher degree of activation along the output connection(s) of that node. Thus if the CUP node is strongly activated, as in the case of a prototypical cup, it sends out stronger activation than if it is weakly activated, as would be the case for a vessel that is short, has no handle, and is made of glass; in such a case the node might just barely be activated. Stronger activation would contribute, for example, to faster recognition. So prototypical exemplars provide stronger and more rapid activation.

And so threshold is not specifiable by a simple number. Rather we must assume that every node has a *threshold function*, such that (1) weak incoming activation produces little or no outgoing activation, (2) a moderate amount of incoming activation produces a moderate amount of outgoing activation, (3) a high degree of incoming activation results in a high degree of outgoing activation. Thus outgoing activation is a function of incoming activation, but the relationship is doubtless more complex than a simple linear proportion (that would be graphed as a straight line). It is far more likely that any node has a maximum level of activation that is approached asymptotically beyond some high level of incoming activation. Such considerations lead to the assumption of a sigmoid function, as illustrated in Figure 17 (see also Lamb 1999: 206–212).

To summarize this group of hypotheses, we have to recognize three kinds of variability:

(1) Connections (shown in graphs by lines) differ from one another in strength. A stronger connection transmits more activation than a weaker one, if both are receiving the same amount of activation.

(2) Nodes have threshold functions, so that outgoing activation varies with amount of incoming activation; and different nodes have different threshold functions.

(3) A connection of a given strength can carry varying degrees of activation from one moment to the next, since each node is sending out varying degrees of activation in accordance with property 2.

Further observation of language and linguistic processing requires the catalysis of additional properties in narrow relational networks (Lamb 2013: 157–160). Of particular importance, we have to recognize that the downward and upward structures (as in Figures 13 and 14) need not be contiguous or even close to each other.

11. Neurological plausibility

We now turn to the question of how relational networks (RN) are related to neural networks (NN). Relational networks were devised to account for linguistic structure; their properties, as sketched above, depend on properties of language. Evidence for these properties comes from language, not from the brain. But we know that the brain is the locus of linguistic structure and that it is a network of neurons. And so *we may view every property of narrow RN notation as a hypothesis about brain structure and function.*

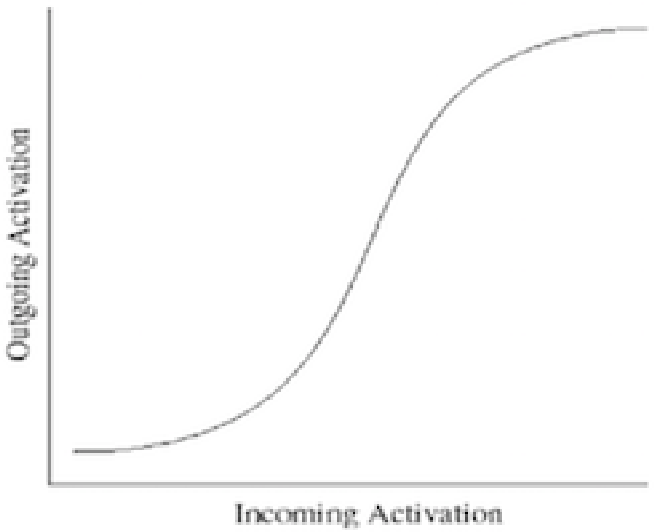


Figure 17. A threshold function: greater incoming activation produces greater outgoing activation (different slopes for different nodes)

Relevant properties of brain structure are known partly from neuroanatomy and partly from experimental evidence. Let us begin with properties of RN structure that can be tested against neuroanatomical findings. First, RN and NN are both connectional structures. Neurons do not store symbolic information. Rather, they operate by emitting activation to other neurons to which they connect via synapses. This activation is proportionate to activation being received from other neurons via synapses. Therefore, a neuron does what it does by virtue of its connections to other neurons.

In relational networks, connections are indicated by lines, while in NN, connections consist of neural fibers and synapses. The fibers of NN are of two kinds, *axonal* and d*endritic*. A neuron has an *axon*, typically with many branches, carrying electrical output from the cell body, and (typically) many *dendrites*, bringing electrical activity into the cell body. Dendrites allow the surface area for receiving inputs from other neurons to be very much larger than the cell body alone could provide for. This property is not present in RN but some corresponding notational device would be needed if diagrams were drawn to reflect the complexity of connectivity more accurately. For example, the actual number of connections to the concept node for CUP is considerably larger than what is shown in the simple representation of Figure 16, in which the surface area needed for showing incoming lines has been made large enough simply by increasing the size of the node. To show hundreds of incoming connections would require a greatly expanded circle for the CUP node—too awkward and inelegant—or else (and preferably) a new notational device that would correspond to dendritic fibers.

As Table 2 shows, there is a remarkable degree of correspondence between RN and NN, especially considering that the properties of RN structure come just from examination of language; that is, relational networks were constructed *without using neurological evidence*. So the old saying that language is a window to the mind turns out to have unexpected validity. On the other hand, this correspondence should not really come as a surprise. *The brain is where linguistic structure forms. If cortex had a different structure, then linguistic structure would not be the same.*

Table 2. Properties of connections in relational networks (RN) and neural networks (NN)

Properties of RN Connections	Properties of NN Connections
Lines have direction (they are one-way)	Nerve fibers carry activation in just one direction
Connections are either excitatory or inhibitory	Connections are either excitatory or inhibitory (from two different types of neurons, with different neurotransmitters)
Inhibitory connections are of two kinds: Type 1: Connects to a node (Figure 16) Type 2: Connects to a line (Figures 13, 15)	Inhibitory connections are of two kinds: Type 1: Connects to a cell body ("axosomatic") Type 2: Connects to an axon ("axoaxonal")
Connections come in different strengths	Connections come in different strengths—stronger connections are implemented as larger numbers of connecting fibers, hence larger numbers of synapses
A connection of a given strength can carry varying amounts of activation	A nerve fiber (especially an axon) can carry varying amounts of activation—stronger activation is implemented as higher frequency of nerve impulses ("spikes")
Nodes have threshold functions such that amount of outgoing activation is a function of incoming activation	Neuron cell bodies have threshold functions such that amount of outgoing activation is a function of incoming activation

Types of cortical neurons

Cells with excitatory output connections
- Pyramidal cells (about 70% of all cortical neurons)
- Spiny stellate cells (in layer IV)

Cells with inhibitory output connections (differing in axonal branching structure)
- Large basket cells (two subtypes)
- Columnar basket cells
- Double bouquet cells
- Chandelier cells
- Other

There is great variation in length of axon fibers
- Short ones—less than one millimeter
- Long ones—several centimeters
- Only the pyramidal cells have such long axon fibers

See also:
www.langbrain.org/Neurons.html
http://www.ruf.rice.edu/~lngbrain/Sidhya/#Types of Cells

More on the varying degrees of activation: A neuron receives activation from other neurons via synapses located on dendrites and on the cell body. Summation of the incoming activation takes place at the *axon hillock*, from which the axon extends. The summation consists of adding together all of the currently incoming excitatory activation and subtracting the inhibitory activation. The result of summation determines the amount of activation sent out along the axon and to its branches. The amount of activation varies from roughly 1 to 100 pulses per second. Each axon branch ends in a presynaptic terminal. A synapse consists of the presynaptic terminal plus a postsynaptic terminal located on the cell body or a dendrite of another neuron, together with an intervening synaptic cleft, typically about 20 nanometers across. When activation reaches a synapse, it sends neurotransmitter molecules into the synaptic gap, and their quantity is proportional to the amount of electrical activation arriving at the presynaptic terminal (see animation by Jokerwe at https://youtu.be/HXx9qlJetSU).

Excitatory and inhibitory activation use different neurotransmitters, produced by two different kinds of neurons; that is, every neuron is either excitatory or inhibitory in nature. Figures 13 and 15 above show both excitatory and inhibitory connections coming from the same node, a property which might seem at first glance to be a discrepancy; but it is not, since the node of RN corresponds to a group of neurons, not to just one (see below).

Having observed close correspondences between RN and NN with respect to connectivity and activation, we come to the next question: What kind of neurological unit corresponds to the node of (narrow) RN notation? For several reasons, the possibility that a node of RN could correspond to a neuron has to be ruled out. To mention two of them, a single neuron (1) is rather unreliable in its firing patterns—it can occasionally fire even when not receiving any incoming activation, and (2) is quite fragile. So to operate reliably a system needs to have the redundancy that is provided by groups of neurons working together.

At this point, examination of language is of no further help so we turn to neuroscience, not for confirmation as above but for new information. The findings that are most pertinent come from the work of Vernon Mountcastle (1918–2015) and several of his colleagues, including in particular David Hubel (1926–2013) and Torsten Wiesel (1924—). From their voluminous experimental findings, summarized recently (Mountcastle 1998), it is clear that, as Mountcastle says (1998: 192), "[T]he effective unit of operation…is not the single neuron and its axon, but bundles or groups of cells and their axons with similar functional properties and anatomical connections". More precisely, these bundles are *columns* of neurons, called *cortical columns*, in which cell bodies are stacked vertically. Mountcastle discovered and characterized the columnar organization of the cerebral cortex in the 1950s. Many in

Some properties of the (mini)column

Roughly cylindrical in shape

Contains cell bodies of 70 to 110 neurons (typically 75–80), about 70% of which are pyramidal, while the rest include other excitatory neurons and several kinds of inhibitory neurons

Diameter is about 30–50 µm, slightly larger than the diameter of a single pyramidal cell body

Two to five mm in length, extends thru the six cortical layers

If expanded by a factor of 100, the dimensions would correspond to a tube with diameter of ⅛ inch and length of one foot

The entire thickness of the cortex (the grey matter) is accounted for by the columns

(Based on Mountcastle 1998)

neuroscience did not accept his findings (and some still do not accept them), but for others the discovery was considered a turning point in investigations of the cerebral cortex. David Hubel in his Nobel Prize acceptance speech said Mountcastle's "discovery of columns in the somatosensory cortex was surely the single most important contribution to the understandding of cerebral cortex since Cajal".

A typical cortical minicolumn is about 3 mm tall (the thickness of the cortex) and contains 70–100 neuronal cell bodies. Larger columns consisting of bundles of adjacent minicolumns also have functional importance (see below). All of the cell bodies of a minicolumn have the same response properties; that is (as numerous experiments have shown) when one cell in a column is activated all of them are.

In a typical experiment, a microelectrode, tiny enough to detect activation in a single neuron, is inserted into the paw area of a cat's sensory cortex (Mountcastle 1998). It detects electrical activity in response to stimulation of one precise point on the cat's paw. As the electrode is gradually inserted further, to vertically adjacent neurons, it detects activity in response to stimulation *of the same point*; and so forth, for every neuron in the column. Of course, the neuronal cell bodies are very small and adjacent columns are tightly packed, so it is easy for the electrode to detect a cell of a neighboring column upon deeper penetration, instead of one in the same column. In this case, the electrode responds to stimulation of *an adjacent point* on the cat's paw.

Experiments of this kind have been done also for visual cortex and auditory cortex of cats and monkeys, with corresponding results. As Mountcastle writes (1998: 181), "Every cellular study of the auditory cortex in cat and monkey has provided direct evidence for its columnar organization". He further points out that the columnar theory is confirmed by detailed studies of visual perception in living cat and monkey brains, and that this same columnar structure is found in all mammals that have been investigated. They establish as a general property that the neurons of a cortical minicolumn have the same response properties, indicating that the minicolumn functions as a unit. Accordingly, he concluded that the column is the fundamental module of perceptual systems, and probably also of motor systems.

In addition to the cell bodies, a cortical column contains axonal and dendritic fibers, including axonal fibers from distant cortical locations, which extend to the top layer of the cortex, where they have liberal branching providing connections to columns in the vicinity. Every pyramidal cell—the most common type in any column—has an *apical dendrite* extending upward to the top layer of the cortex, with many branches extending up to a few millimeters into the territory of neighboring columns. They are especially copious at the top layer, where they are available to receive activation from any of the many axonal fibers from more or less distant cortical regions. There are additional dendrites extending outward from the cell body. The axon of a pyramidal cell extends downward from the bottom of the cell body. It is typically very long, extending into the white matter and to a more or less distant location, up to several centimeters away. The axon also has numerous branches, not only at those distant locations but also quite close to its point of origin at the cell body. These *collateral* branches extend upward, as do axonal fibers from *spiny stellate cells*, activating other pyramidal cells in the same column, thus guaranteeing their activation.

Some cortical quantities

The cortex accounts for 60–65% of the volume of the brain, but has only a minority of the total neurons of the human brain
Surface of the cortex: about 2600 sq cm (about 400 sq inches)
Weight of brain: 1,130–1,610 grams, average: 1,370 grams
Thickness of cortex: 1.4–4.0 mm, average: 2.87 mm
Number of neurons in cortex (avg.): ca. 27.4 billion
Number of minicolumns in cortex: ca. 350 million (i.e., 27,400,000,000 / (75–80))
Neurons beneath 1 mm^2 of surface: 113,000
Minicolumns beneath 1 mm^2 of surface: 1,400–1,500 (i.e., 113,000 / (75–80))
Minicolumns beneath 1 cm^2 of surface: 140,000–150,000
Approximate number of minicolumns in Wernicke's area (est. 20 cm^2): 2.8–3 million
(Based on Mountcastle 1998)

These excitatory connections from cells in a cortical column to other cells of the same column provide neurological confirmation for the hypothesized WAIT element of RN used for sequencing (Figures 14 and 15 above). The vertical connections of pyramidal and spiny stellate cells activate other cells in the column, and reciprocal vertical connections between upper and lower layers keep the activation alive while the column awaits further input. The blocking element needed for turning off the WAIT element is provided by one or more inhibitory neurons within the column such as the chandelier cell, whose vertical axon terminates with inhibitory synapses on axons of pyramidal cells within the same column.

Since the columns extend from bottom to top of the cortex, they account entirely for what is called the *GREY MATTER*. The *WHITE MATTER* consists of *cortico-cortical connections* (connections from one part of the cortex to another), which are *axons* of *pyramidal neurons*, each of them surrounded by a *myelin sheath*. It is called white matter because that is the color of the myelin. The myelin greatly enhances the speed of transmission of the neural impulse, to the extent that an impulse can travel along a myelinated axon up to 100 times faster than (unmyelinated) axons traveling through grey matter. The myelin also provides insulation, which is needed since different axons are generally closely contiguous to one another in bundles.

A column also has several kinds of inhibitory neurons, with some axon branches connecting to other points within the same column, while others extend horizontally within the grey matter from a minicolumn to neighboring minicolumns. These axons are generally very short, up to one or two millimeters.

In the middle of each column (layer IV) are spiny stellate cells, which receive activation at regular intervals from the *thalamus*, centrally located under the cortex. A wondrous organ with fibers reaching out to cortical columns throughout the cortex, it sends activation sweeping across the cortex at varying rates of speed depending on the state of consciousness, up to 40 times per second. Like the conductor of a vast orchestra, it provides the timing coordination needed for mental activity. It is available to provide the clock timing mentioned above in connection the WAIT element. It is also vitally important for other situations requiring timing coordination. Consider, for example, a person receiving speech input at the rate of around 3 syllables per second. While one syllable is being processed phonologically, the next is already entering the system. And when activation from the phonological layer is reaching lexicogrammatical portions of the network, new phonological input is simultaneously being received. For the management of this extremely complex and little understood processing we have to be grateful to the thalamus, a truly marvelous neural structure.

12. Learning—Developmental plausibility

Since all of the information in a relational network structure is in its connectivity, learning would seem to be a matter of building connections. But that is not the only possibility: The alternative is to assume that all or most of the connections that will be needed for representing the information that will be learned during a lifetime are *already there in a latent form* and that the learning process consists of *strengthening these LATENT CONNECTIONS* and *activating LATENT NODES*. This assumption, which may be called the *ABUNDANCE HYPOTHESIS*, while presumptuous, confers the great advantage of allowing us to treat entrenchment and development as basically the same process.

The process of *ENTRENCHMENT,* which goes on throughout life, or up to limits imposed by senility, is accounted for in a relational network model as strengthening of established connections as a result of repeated use. Lexical items as well as syntactic constructions (variable lexemes) vary widely from one another with respect to how often they have been used. So for example we can say that for most people *strange* is more heavily entrenched than *bizarre*, and that the 'respectively' construction, as in *Jimmy and Tommy dated Jane and JoAnn respectively*, is not at all entrenched in most English speakers other than mathematicians, and not even established at all in many.

So we need to ask, how does a connection get stronger? We have already observed (Section 10) that different links have different strengths, crudely representable in diagrams by different line thicknesses. Stronger links represent more heavily entrenched information. The answer to the question is simple: A connection gets stronger through repeated successful use, just as a pathway through a field becomes more worn and therefore easier to walk on as a result of repeated use. That notion can be defined more precisely as follows: (1) *Links get stronger when they are successfully used*; (2) *successful use* means that activation of the link in question has contributed to satisfaction of the threshold of the target node; that will be the case if one or more other connections to same node is simultaneously active such that the node's threshold is satisfied. A typical simple scenario is illustrated in Figure 18, in which latent links and a latent node at left (initially with very low threshold) become dedicated (right). This hypothesis is similar to one proposed by the psychologist Donald Hebb (1949), or it can be seen as a formal specification of the hypothesis proposed by Hebb in a vague form.

A third part of the specification concerns the threshold of the activated node: As a result of successful activation, the threshold of the node is raised. The adjustment (moving the curve of Figure 17 to the right and possibly altering the slope) is needed since the increased strength of the incoming links would otherwise allow the threshold to be too easily "satisfied" in the future.

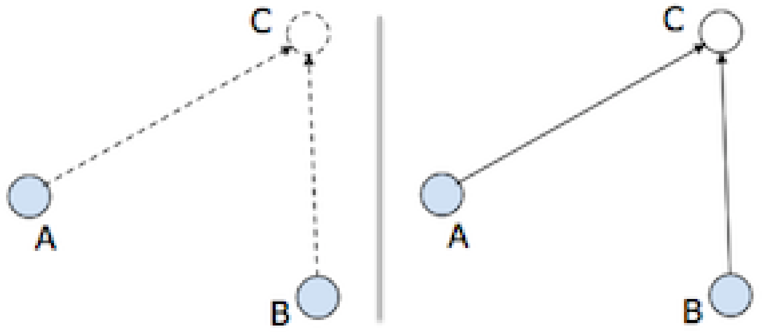


Figure 18. Basic learning process: If connections AC and BC are active at the same time, and if their joint activation is strong enough to activate C, they both get strengthened and the threshold of C is adjusted

This simple hypothesis, along with the *ABUNDANCE HYPOTHESIS* proposed above, provides an answer to the basic question of relational network formation: How does the system get those seemingly hardwired connections that are seen in linguistic network diagrams? How can it 'know' how to build the precise connections that it must build for linguistic performance, during the process of language learning? The answer is that it doesn't need to know at all; it just *proliferates possibilities beforehand* (the abundance hypothesis), and the *learning process is one of selection*. It is a Darwinian process, analogous to that which leads to the origin of species and to complex biological structures (compare Edelman 1987). At each of many steps in the process it proliferates possibilities, and those that succeed pass their genetic material to the next generation.

In the application of this principle to learning, what corresponds to the next generation is the next higher layer of network structure. This scenario is consistent with bottom-up learning: Lower levels are generally established (to some extent) before higher levels. This property of the learning process is easily observed in the progress of children acquiring their linguistic and other skills and is confirmed by neuroanatomy in that the growth of myelin sheaths around axons of pyramidal neurons spreads from lower to higher levels during early childhood.

As mentioned, the process of new learning (for example, of a new lexical item) is the same as that for entrenchment of already established information. In the case of new learning, previously *LATENT* links and nodes become *ESTABLISHED* or *DEDICATED*. In the case of entrenchment, established connections become stronger.

Two aspects of this hypothesis need to be checked for neurological plausibility: (1) mechanisms of connection strengthening, (2) the abundance hypothesis. Both appear to be supported by the neurological evidence.

The processes of strengthening of neural connections have been under active investigation for years in neuroscience. They include biochemical changes at synapses, formation of new synapses, and growth of dendritic spines (increasing the receptive area of a dendrite).

The abundance hypothesis, a prerequisite for this view of learning, is that there must be enough latent nodes and links available throughout the system to support a lifetime of learning. Note that this requirement, while presumptuous, is not as outrageous as it may appear at first glance. We are *not* requiring that there be enough latent nodes and links to learn anything at all. Our human brains, while marvelous, are limited. We can *not* in fact learn anything at all. The great preponderance of information we are bombarded with every second passes by unretained; in fact, most of it is simply unnoticed. Another factor is that learning takes time and our time on Earth is limited. This quantitative question is explored further elsewhere (Lamb 1999: 341–343, Lamb 2005), along with considerably more discussion of learning (Lamb 1999: Chapters 10 and 12).

Extent of neuronal fibers in the cortex

Estimated average 10 cm of fibers per neuron (a conservative estimate)
Avg. cortex has about 27 billion neurons
27 billion × 10 cm = 2.7 billion meters
Or 2.7 million kilometers
– About 1.68 million miles
– Enough to encircle the world 68 times
– 7 times the distance to the moon

Number of synapses in cortex

40,000 synapses per neuron (4×10^{4})
And 27 billion neurons (27×10^{9})
$4\times10^{4} \times 27\times10^{9} = 108\times10^{13}$
or about 1.1×10^{15} (over 1 quadrillion)

The abundance hypothesis implies that most of the thousands of fibers connecting one neuron to others along with their associated synapses are very weak—that is, latent, available to be called upon if needed—and as such are not actively functioning in information processing, but are available for new learning. It thus asserts that the number of connecting fibers of the typical cortical neuron is very large just for the purpose of providing for flexibility of learning—to enable (the neurological bases of) latent nodes to be available to assume any of a very large number of functions, which, especially at higher levels of the cognitive dome (corresponding neurologically to higher cortical levels), could not have been foreseen in advance and could not have been specifically prepared for by processes of evolution in any way other than the development of mental flexibility. Thus there is no other way than through development of extreme cognitive flexibility that humans could have evolved to be able to fly aircraft and spacecraft, design and program computers, go skydiving, write plays, compose operas, etc.

In support of the abundance hypothesis, with its apparent gross redundancy, it can first be noted that abundance *cum* inefficiency is a very widespread property of biological systems and one that goes along with Darwinian processes generally. Take for example the thousands of acorns that fall from an oak tree, or the thousands of eggs laid by a sea turtle, only a few of which will lead to viable offspring. Like these other biological processes, learning works by a process of trial and error: Thousands of connection possibilities are available (the abundance hypothesis), and those few that succeed are strengthened and become available for the next steps—in this case, for the next layer of learning. Gerald Edelman (1987, 1989) calls this process *neural Darwinism.* He also writes (1987), "… if one explores the microscopic network of synapses with electrodes, the majority of them are not expressed, that is, they show no detectable activity. They are what have been called silent synapses".

A typical pyramidal neuron has thousands of incoming synapses from other neurons connecting to its dendrites and its cell body, and thousands of output synapses at the many branches of its axon. But only a very few of these are ever recruited for specific functions. The typical lexical node, for example, has perhaps only a few dozen links, and a typical conceptual node has maybe up to a few hundred. These vast numerical discrepancies between (1) number of available connections and (2) number of dedicated connections are multiplied when we consider that the effective unit of operation, corresponding to the node of RN, is the column, a unit containing many pyramidal neurons. And so we safely conclude that by far the great preponderance of the available links are indeed latent.

13. Inter-nodal proximity

I conclude this sketch of linguistic structure and cortical structure—from which, as we see, it can't be separated—with a look at the importance of locations of nodes in the network. Much of this section consists of proposals that are new to neuroscience and thus are offered as contributions from the study of linguistic structure to cognitive neuroscience. Whether they will be accepted remains to be seen.

The starting point is a property of relational networks and cortical networks that may be called *FUNCTIONAL SPECIFICITY*. It is implicit in all of the RN diagrams of the figures above but has not yet been explicitly discussed. *FUNCTIONAL SPECIFICITY* is a property of every node of an RN (and every column of an NN): *Every node has a specific local function.* For example, the node for CUP in Figure 16 has a specific conceptual value, suggested by the label CUP. We can't say exactly what that value is, of course, not even for one person, although we can be quite sure that it varies from one individual to the next, depending on each one's previous experience with cup-like objects, for that experience will have resulted in connections of definite but varying strengths from each of a large number of other nodes representing properties, along with a connection to and from a node representing the lexical item *cup*.

To appreciate the feature of functional specificity of RN, we have to be clear that while the cup node is specifically dedicated to a particular concept, *it does not on its own represent any of the multitudinous facts and impressions of cups.* Hardly. It is just a node in a network, connected to other nodes. As such it gets activated when it receives sufficient activation from incoming connections, and passes it on. Those multitudinous items of information relating to cups are captured *not in the cup node itself but in the network consisting of thousands of nodes that are connected to it.* In other words, *there is a CUP node and there is also a CUP network.* What I am calling the CUP node at the "center" of the network, may be called the *CARDINAL NODE*.

Moreover, in accordance with this same principle of functional specificity, each of those other nodes in the CUP network likewise has a specific property, since the principle of local specificity applies throughout the system, to every node. The CUP node is at the top of a very complex hierarchical network, and it is this network as a whole that represents all the information about cups that a given individual has. The property labeled WITH-SAUCER, for example, is itself at the top of a complex hierarchy of network structure. And so forth, all the way down to elementary perceptual properties connected to the sense organs. And each of those properties also has a specific function.

And so what we have in relational networks is *both local representation and distributed representation* (cf. Lamb 1999: 329–341). It is *local representation* in that there is one local node exclusively dedicated to, say, the concept, existing at the top of the hierarchy (e.g., the CUP node); and it is *distributed representation* in that what represents the concept CUP (for example) is a large network, consisting of perhaps thousands of nodes, connected in many layers to that node at the top. This important feature of relational networks and evidently also of actual neural networks has yet to be recognized by most cognitive neuroscientists, who instead believe that the issue is a choice between local representation and distributed representation, and who generally opt for the latter and reject the former.

Evidence for functional specificity comes from several directions. First, it provides a direct simple solution to the basic problem of communication in networks, a solution that is implicit in all of the RN diagrams above. The problem (which remains unresolved in neuroscience) can be illustrated by an example: How does the network provide for connecting a specific lexical item, say *cup,* with a specific concept, say CUP? For relational networks, the answer is simple and obvious: by means of a direct connection from the one node to the other (Lamb 1999: 366–369). *This method works because each of these two nodes conforms to the property of functional specificity*: Such a direct connection is possible only if there is a node specifically dedicated to the lexical function *cup* and another specifically dedicated to the conceptual function CUP. I have a challenge for any reader who does not like this solution: Come up with another.

As a second piece of evidence, functional specificity follows automatically from the learning process described above. In Figure 18, for example, the newly recruited node C has the specific function *A and B—whatever A and B may be, a new node has been recruited to represent their combination.*

A third item of evidence is provided indirectly by the discovery of what are (misleadingly) called mirror neurons. The so-called (and widely misunderstood) mirror neurons are just ordinary high-level motor neurons. They are in (columns of) motor cortex representing nodes at the top of a hierarchy for, say, GRASPING-AT. There is a column specifically dedicated to that process. In the distributed hierarchical network to which it connects are both the lower level motor processes needed for grasping at an item, and also, over in the visual area of the cognitive dome, the network representing what it looks like to see someone grasping at an item. Such sensory associations for activities will naturally have been built up during a long learning process consisting of multiple steps of the simple procedure described above. Notice that the communication in this case between visual cortex and motor cortex is another example of direct connection from one node to another, made possible by functional specificity.

Now, in the context of a scientific approach, we would like to have some direct experimental evidence to support the principle of functional specificity. Well, we have such evidence, and it has already been described. It is the many experiments of Mountcastle, Hubel and Wiesel, and others, all of which have revealed that perceptual functions are very highly localized in the cortex such that *every column has a very specific local function*. For example, in the paw area of a cat's sensory cortex, each column represents a specific point of the cat's paw; in auditory cortex, each column represents a specific frequency; in visual cortex, there are individual columns for specific orientations of short lines and individual columns for specific directions of motion (Mountcastle 1998).

To be sure, these investigators have not performed such experiments for human language or human conceptual structure. The reason is that they are deemed too invasive. But neuroanatomy tells us that the structure of the cortex is (1) quite uniform across mammalian species and also that it is (2) uniform across different cortical regions. Therefore it seems fairly safe to assume that the findings of Mountcastle and others for perceptual cortices of cats, monkeys and rats apply also (1) to humans and (2) to other cortical areas. This extrapolation of the experimental findings has not previously been proposed in cognitive neuroscience.

The next property, closely related to functional specificity, may be called *FUNCTIONAL ADJACENCY*: *Adjacent network locations have adjacent functions.* Again we have neurological evidence from the experiments of Mountcastle and others, described for example by Mountcastle (1998), demonstrating that adjacent cortical locations respond to properties that are functionally adjacent. For example, adjacent locations in the cat's paw are represented by adjacent cortical locations. Similarly, adjacent columns of auditory cortex respond to neighboring sound frequencies, and adjacent columns of visual cortex respond to slightly different orientations of line segments; and in the motion detection area of visual cortex, adjacent cortical locations respond to slightly different directions of motion.

Extending this principle to language (a step justified by the uniformity of structure across cortical areas and across mammalian species) we can posit that nodes for recognizing /p/ and /k/, for example, are adjacent, since /p/ and /k/ are auditorily very similar; and we can likewise posit that the nodes for CUP and MUG are adjacent.

The advantage of adjacent positioning of functionally adjacent nodes is apparent when we consider that similar functions are necessarily in competition: When we hear someone say *pick*, especially if the speech volume is low or there is noise, it may sound a lot like *kick*. To aid in the correct perception it is altogether likely that the node for /p/ sends an inhibitory signal to that for /k/, and vice versa, as in Figure 19, which shows three competing nodes. (The figure is a bit misleading in showing the nodes as merely close to each other rather than adjacent). Such mutual inhibition enhances the contrast between such otherwise functionally close neighbors. And experiments have indeed shown that perception of contrasting phonological pairs is binary; that is, an experimental subject who hears a computer-generated sound intermediate between the sounds of two competitors generally hears it as one or the other rather than as the intermediate sound that it actually is. Such enhancement of contrast has also been confirmed by experiments in visual perception, for example of edges. Similarly, we can posit that the nodes for CUP, MUG, and GLASS have mutually inhibitory connections, as in Figure 19.

The neurological plausibility of Figure 19 is supported by consideration of the connectivety of cortical minicolumns. They send out inhibitory connections horizontally to adjacent columns, as depicted in Figure 20, which also shows that all distant connections are excitatory (all are myelinated axons of pyramidal neurons). According to Mountcastle (1998), *columnar specificity is maintained by pericolumnar inhibition* (p. 190), and *activity in one column can suppress that in its immediate neighbors* (p. 191). It is also the case that inhibitory cells can inhibit other inhibitory cells (p. 193), and that large basket cells send myelinated projections as far as 1–2 mm horizontally (p. 193), implying that a column can inhibit not only immediately adjacent columns but also those that are merely nearby.

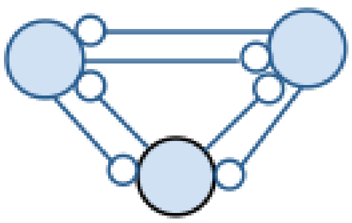


Figure 19. Nodes of related function, hence in competition: competition is enhanced by mutual inhibition

A further property that is implicit in the above discussion is that, in general, members of the same category, whether it is phonological or visual or conceptual or whatever, will be in same area. Why? Well, they are in the same category because they have similar functions. In other words, they share many functions and differ in relatively few. They will thus be in the same area as a consequence of how learning works (Lamb 1999: 218),

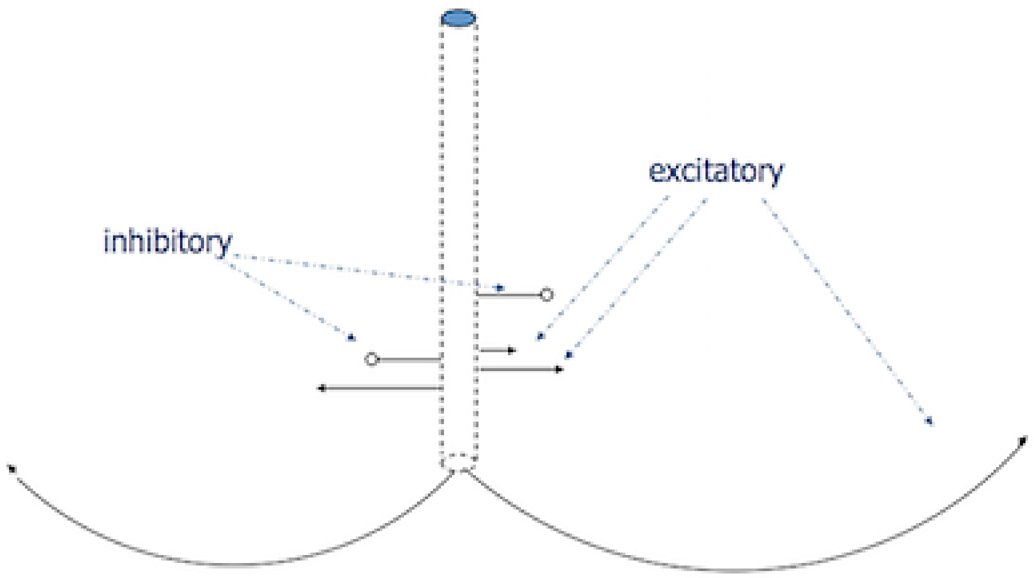


Figure 20. Model of cortical minicolumn showing types of connections: proximate connections are inhibitory and excitatory, distal connections excitatory only

and as competitors. We can also put it the other way around: Neighbors in the same area of a network can be expected to have some shared general function along with additional differentiating functions, and they are in mutual competition with respect to these differentiating features. Such a group of neighboring nodes of related function may be viewed as a cluster of nodes. As an example, the nodes for CUP, MUG, and GLASS may be expected to be together in such a cluster along with other nearby nodes for other types of drinking vessels, and also, fairly nearby, soup bowls, etc.

We thus come to clusters of contiguous nodes (RN) or contiguous columns (NN). And here is where we see why Mountcastle uses the term *minicolumn*. It is because minicolumns come in clusters, that is, larger columns. The *MAXICOLUMN* is a bundle of about 100 continuous minicolumns. It has a diameter of 300–500 microns (thousandths of a millimeter). Still larger modules also exist—up to 1 mm in diameter. The minicolumns within a maxicolumn respond to a common set of features, and differ from one another with respect to additional features. So *they represent subcategories of a category*. We are talking here about what Hudson (2007) and others call the “isa” function, but with a different means of network representation from that used by Hudson (2007) and in earlier versions of relational networks.

The properties of functional specificity and functional adjacency also apply to such larger columns. According to Mountcastle (1998: 165), “The neurons of a [maxi]column have certain sets of static and dynamic properties in common, upon which others that may differ are superimposed”. These others that differ are the features that distinguish the subcategories from one another.

We may use the term *FUNCTIONAL COLUMN* as a general designation for bundles of columns of varying sizes, including bundles intermediate in size between minicolumns and maxicolumns. So we can say that different functional columns within a larger column are distinct because of non-shared additional features. Similarly, all columns of a larger module may have similar response features, upon which others that differ may be superimposed, resulting in maxicolumns sharing certain basic features while differing with respect to others

(Mountcastle 1998: 189). Such maxicolumns may be further subdivided into functional columns on the basis of yet additional features.

And so as a more general statement, we can say that functional columns of different sizes within a very large column represent hierarchical category structures: categories, subcategories, sub-subcategories, etc. In other words, *columnar structure directly maps categories and subcategories.* By the extrapolation mentioned above, this is a property that can be applied to conceptual categories, representing another contribution from the study of linguistic structure to cognitive neuroscience.

Many or most of the nodes of relational networks doubtless correspond not to minicolumns but to larger functional columns.

The size of a given functional column is determined by experience/learning. In initial stages, a node recruited for a function, as in Figure 18, will normally represent a bundle of minicolumns, perhaps a fairly large bundle in the case of a child in the early stages of learning conceptual categories. Such functional columns will be subdivided with the learning of finer distinctions.

As a consequence of these processes and structural principles of cortical organization, closely related cortical functions tend to be in adjacent areas. This principle, which applies quite generally, not just to conceptual categories, may be called the *PROXIMITY PRINCIPLE* (Lamb 1999: 217–219, 322–327, 352–362). According to it, for example, we can expect that the area for phonological recognition ought to be close to the primary auditory area and that the area for phonological production should be close to the portion of the primary motor area that controls the organs of speech production. If such expectations are taken as predictions from theory, we find that they too are confirmed, in this case by findings from aphasiology. They also provide a good example of the principle that in converting from abstract notation to narrow notation (section 10 above), there is no reason to suppose that the lines and nodes for the downward direction are adjacent, or even close, to those for the upward direction (cf. Lamb 2013: 157–158).

Further evidence for the hypothesis of local organization of conceptual categories comes from studies of people who have suffered brain damage. If it is indeed the case that related concepts are represented in contiguous areas, then we would expect that if damage affects a conceptual node of a given category, then other nodes of the same category should also be affected. Just this situation has been found in numerous cases of brain damage. As an example, two such cases are discussed by Rapp and Caramazza (2001: 905b–906a). The temporal lobes of both had been affected by herpes simplex encephalitis. They could not define animate objects, such as ostrich, snail, wasp, duck, holly, but were much better at defining inanimate objects, including tent, briefcase, compass, wheelbarrow, submarine, umbrella. Another study describes three patients with damage in different portions of the left inferior temporal (IT) lobe (Damasio et al. 1996). One of them, with damage to the posterior IT, had a deficit in retrieval of words for tools; another, with damage to anterior IT, had a deficit in retrieval of animals; while the third, with damage to the most anterior section of IT, had a deficit in retrieving names of persons.

14. Concluding remarks

The foregoing account is replete with evidence that linguistic structure, viewed realistically, is a network. Yet the recognition of this finding can be misleading to those whose acquaintance with networks is limited. They are likely not to realize that many different kinds of networks have been proposed, with quite different structural properties, even among those whose declared interest is in brain structure. Relational networks (RN), as described in this paper, are in fact rather unusual among the range of networks that have been promulgated, such as those of Rumelhart and McClelland (1986). Ironically, although some such other networks have been claimed to offer insights into brain operation and have been called "neural networks", they lack neurological plausibility (Lamb 1999: 61–62, 329–336).

There is a long-standing debate about local representation vs. distributed representation, based on the (unstated and unwarranted) assumption that it has to be one or the other. But as shown above, with direct support from neurological evidence, representation is *both local and distributed.*

Why are there such wide differences between different kinds of networks, and how are we to choose among them? The simple answer is that most of them have been based on false assumptions and faulty reasoning, such as the assumption that representation of information has to be either local or distributed and the assumption that the cerebral cortex works like a computer (Churchland and Sejnowski 1992). Relational networks acquired their particular form solely from linguistic evidence, as I have endeavored to show in this paper. Every feature, from the first steps of their construction, is motivated by linguistic evidence.

To review, the relationship of RN to neural networks (NN) was brought into question (section 12) only after the basic structural properties of RN were developed based on linguistic evidence. These properties were then checked against NN properties known from neuroanatomy, and the checking showed a (surprisingly?) high degree of correspondence. Then, for the question of what kind of grouping of neurons corresponds to the node of narrow RN, we turned to the evidence from neuroscience, specifically that provided by the research of Mountcastle (1998) and his colleagues. To repeat: this was the first step at which neurological evidence was used to enhance the understanding of network structure rather than to confirm hypotheses already formed on the basis of linguistic evidence. This step represents a contribution from neuroscience to structural linguistics. Finally, we see that bringing additional evidence from language into play we can offer contributions to neuroscience.

And so we end up with a series of steps from linguistic structure to cortical structure, each with its appropriate notation (cf. Lamb 2013). At an abstract level (yet not as abstract as Halliday's systemic networks) we have RN in its original form, the abstract RN notation. For greater precision, we have the narrow RN notation; it comes in varying degrees of narrowness (Lamb 2013). Then at a still more refined level we have representation of various details in terms of cortical columns (e.g., Figure 20 above); and still more detailed representation would show the actual neurons within the cortical column.

This exploratory sketch has taken us to distant shores, and yet we haven't left the subject matter that we started with: linguistic structure. When we take a realistic view of language structure we reject a narrow definition that would not include concern with meaning. And the range of meaning covers every aspect of cognition, so we find no boundary to separate linguistic structure from the human information system as a whole. And neurologic structures also are inseparable from linguistic structure. So it seems that while the brain looms large in this account, we haven't left the subject of the title.

Back in earlier days of structural linguistics the criterion of neurological plausibility would have had little force, since not enough was known about the brain. Hjelmslev did not consider the brain and chose to treat language in and of itself. Yet he too found that the study of linguistic structure, even considered on its own, led to a breathtaking vista because of its relationship to semiotic structure as he defined it. He concludes his *Prolegomena to a Theory of Language* (1943/61) with these words:

> Accordingly, we find … no object that is not illuminated from the key position of linguistic theory. Semiotic structure is revealed as a stand from which all scientific objects may be viewed.
> … In a higher sense than in linguistics till now, language has again become a key-position [sic] in knowledge. … Linguistic theory is led by an inner necessity to recognize not merely the linguistic system…but also man and society behind language, and all man's sphere of knowledge through language.

By bringing neurological structure into the picture we are able to find still greater justification for this view of the centrality of language.

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About the author

Sydney Lamb graduated from Yale University with a B.A. in Economics and earned his Ph.D. in Linguistics from the University of California, Berkeley, where his dissertation was a description of a California Indian language. He taught linguistics at the University of California, Berkeley, at Yale University, and, after spending some time with an electronics start-up in California, at Rice University, where he became the Agnes Cullen Arnold Professor of Linguistics. He is best known as the father of the relational network theory of language, known in its early versions as ‘stratificational theory’.

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Comments on 'Linguistic structure: A plausible theory'

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Abstract. This comment on Sydney Lamb's article "Language structure: A plausible theory" explores the similarities and differences between Lamb's theory and my own theory called Word Grammar, which was inspired by Lamb's work in the 1960s. The two theories share Lamb's view that language is a symbolic network, just like the rest of our knowledge. The note explains this claim, then picks out a number of differences between the theories, all of which centre on the distinction between types and tokens. In Word Grammar, tokens are represented as temporary nodes added to the permanent network, and allow the theory to use dependency structure rather than phrase structure, to include mental referents, to recognise the messiness of spreading activation and to include a monotonic theory of default inheritance.

Keywords: dependency, Word Grammar, spreading activation, default inheritance, tokens, network

Sydney Lamb's ideas about networks inspired me in the 1960s, and provided the foundations for my own network-based theory, called 'Word Grammar' (Hudson 1984, 1990, 2007, 2010). So it's perhaps not surprising that we agree on the most important issues:

1. Language is a network in which the nodes are just unstructured atoms and the labels are redundant.
2. This network is a symbolic network (Lamb's 'relational network') in which each node corresponds to a separate mental unit (in my terms, to a concept).
3. There are no boundaries between this network and the rest of the network for general cognition.

For example, here's the core of a network entry for the lexical item DOG. It uses Word-Grammar notation, but conceptually it could come from either theory.

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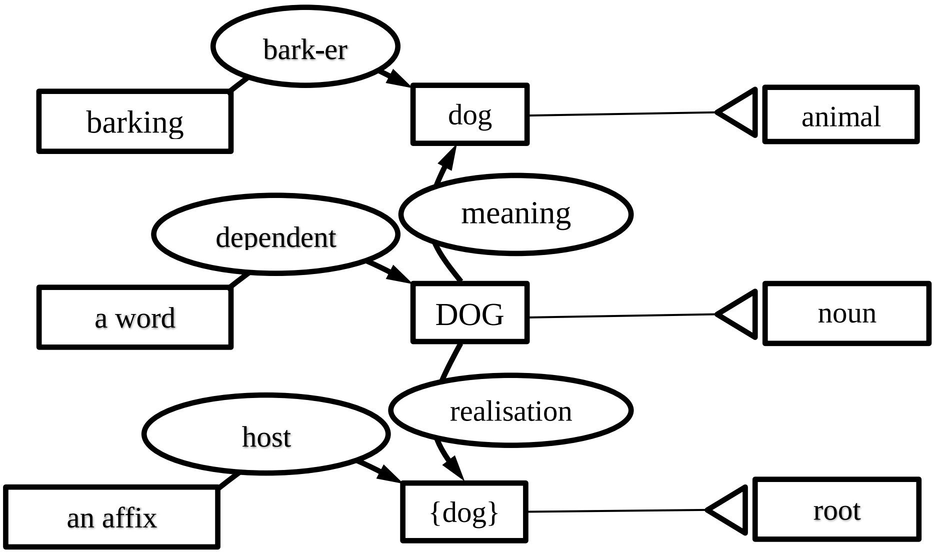

Figure 1. A conceptual network

In words, Figure 1 asserts that the lexeme DOG is a noun (the small triangle denotes the 'isa' relation), which means 'dog' (the general concept of a typical dog), which is an animal and which barks. DOG is typically dependent on another word, and is realised by the root morpheme {dog}, which may be the host for an affix. The horizontal arcs denote Lamb's tactic patterns (how things combine with one another), the lines with triangles denote his unordered downward links, while the vertical arcs denote his other upward and downward links. The labels are redundant because each node has a unique position in the total network, and the only way to invoke a node is by linking directly to it; so a label such as 'DOG' never appears anywhere else in the network. The nodes are symbolic because each identifies a single concept, which is in turn only represented by that node. And there are no boundaries in the network between the 'linguistic nodes' in the bottom half of the network and the 'non-linguistic nodes' of ordinary cognition in the top half.

Claims #2 (symbolic network) and #3 (no boundaries) link us to the Cognitive Linguistics movement, which of course Lamb's early work predated by a couple of decades. Maybe #1 (nothing but networks) distinguishes us from all other contemporary theories covering the whole of language; but we should both be pleased to note that our views are shared by an important theory of morphology, Network Morphology (Brown and Hippisley 2012). And, of course, Head-driven Phrase Structure Grammar presents a somewhat similar view of language as a rather limited kind of network, a Directed Acyclic Graph (Pollard and Sag 1994).

These general claims are easy to justify in terms of cognitive psychology, and Lamb (2016) offers a much better bridge to neuroscience than I could ever do. Lamb also makes the important point that the claims are easy to justify with evidence from linguistics, and that this evidence is an important contribution by linguistics to the general science of the mind. It is odd how reluctant other linguists are to make this point, especially given the importance of language in experimental cognitive psychology.

But having established these general claims, we then needed to work through their consequences for a detailed theory of language structure, the traditional target of linguistics. This is a project to which we have both dedicated most of our working lives, but working independently, so it is perhaps unsurprising that we have reached different conclusions in various places. All the points of disagreement are issues for research rather than simply matters of personal taste, so we must hope that those who are attracted by the idea of 'network linguistics' will also engage in serious exploration of these questions.

To kick-start this process, here is a short list of points on which we at least appear to disagree. I offer it while recognising that it is all too easy to misunderstand a theory, so I may well have simply misunderstood.

Tokens. Word Grammar claims that token-concepts play an important part because we create a new node (and therefore a new concept) for every linguistic item that we process—for every word, sound segment, letter or whatever. The type-token distinction is of course a standard part of linguistic theory (Wetzel 2006), and figures outside linguistics in the 'type-token ratio' which is standardly used to measure the breadth of vocabulary in a text (Malvern et al. 2004); in terms of this distinction, the sentence *The cat sat on the mat* contains six tokens of five types (because the type *the* occurs twice). However, the conventional wisdom assigns types and tokens to two quite separate areas of theory, 'competence' for types and 'performance' for tokens. This theoretical contrast used to be supported by a similar contrast in cognitive psychology between long-term memory (competence) and short-term (or working) memory (performance), but many cognitive psychologists now reject this contrast in favour of a unified theory in which working memory is simply the part of long-term memory which is currently active (Ericsson and Kintsch 1995). Similarly, a network model of language treats the tokens of performance as temporary additions to the permanent network of types.

The claim in Word Grammar is both that we create temporary token nodes whether we are receiving a communication (as listeners or readers) or producing one, and that the same is true throughout cognition. Consequently, Word Grammar recognises the process of node-creation as one of a few very general mental operations. The structure of an utterance must be entirely composed of tokens, and not merely of activated stored types, because otherwise it would be impossible to recognise two tokens of the same type. In contrast, although I believe that Lamb's intention is to model production and perception, I don't see how token nodes can be created in his system.

Dependencies. One of the consequences of distinguishing token nodes from the types on which they are based is that a token word shows the influence of the words that depend on it. So in *French house*, the token word *house* is not simply a copy of the stored lexical item HOUSE, since its meaning is affected by the accompanying *French* so that this particular token of HOUSE actually means 'French house'. The Word-Grammar structure for an example phrase, *typical French houses,* is shown in Figure 2. The word tokens are labelled in italics, and the effect of 'modifying' a word by adding a dependent is shown by the '+' signs to distinguish one token from another. This example answers one of the most telling criticisms of dependency theory, that if each word has just one token node there is no node with the meaning 'French house' to which the other dependent, *typical*, applies (Dahl 1980).

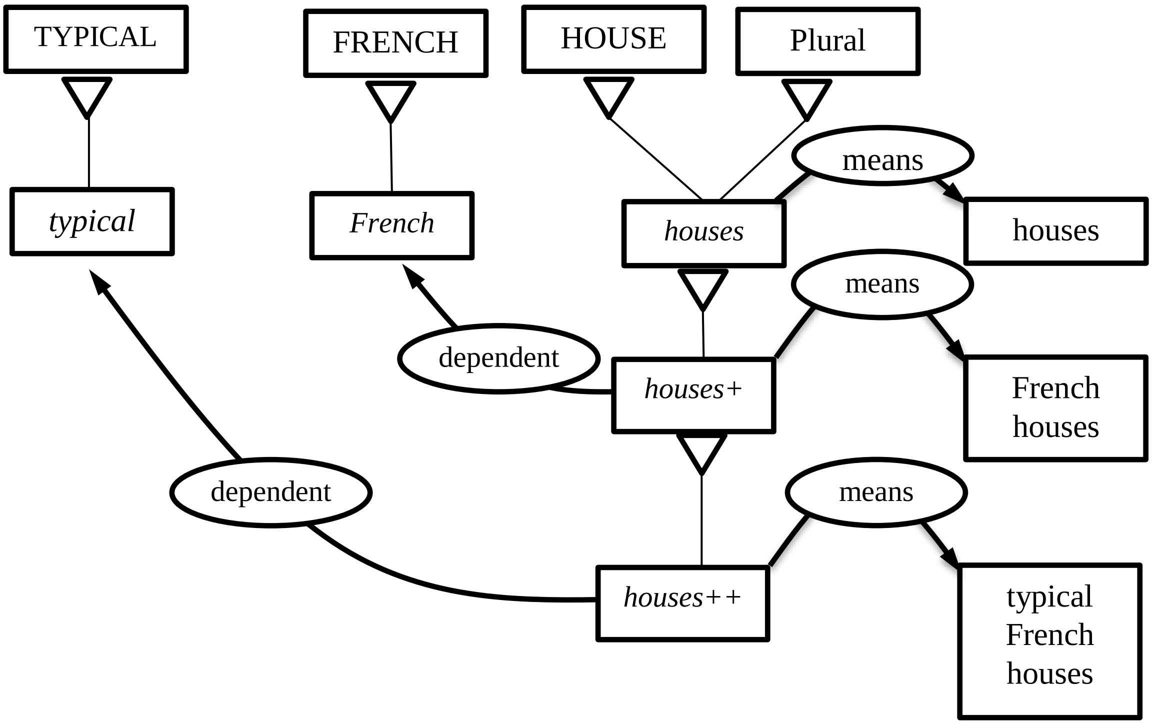

Figure 2. Dependency structure and meaning

The idea that a dependent creates a new token node removes the main motivation for phrase structure, and supports the much simpler approach of dependency structure in which the only units of syntax are single words; and one word may 'govern' another directly (e.g. the verb RELY selects the preposition ON, rather than a preposition-phrase headed by ON). However, Lamb's mechanism for combining words appears to rely on the phrase-structure idea of a mother node which contains both the combined units as its parts; it doesn't seem to allow for direct links between co-occurring units.

Referents. Another consequence of the earlier disagreement over tokens is that Word Grammar allows mental representations for experiences and objects in the world, just like the ones we have for tokens of words and other linguistic items; for instance, we can not only classify some bit of experience as a dog, but we can also represent this dog mentally by creating a temporary 'token' node for it. These item-bound, ad hoc and temporary concepts contrast both with the things in the world and with the stored categories to which we assign them. In contrast, Lamb (2016, 15) seems to say that there are no mental representations for objects in the world; but this means that we cannot identify one object as the same as another. For instance, if we hear a dog barking at 11 o'clock, we can classify it as a barking dog but we can't recognise it as the same dog that we heard at 10 o'clock. This is a general weakness for any cognitive theory, but a critical weakness for a theory of language because it seems to rule out any theory of anaphora such as the one needed to explain the identity-of-reference anaphora in *It is barking again.*

Activation. Some of the strongest evidence for a network view of language comes from spreading activation (which Lamb 2016 doesn't mention, although I'm sure he's aware of it). This is responsible both for the priming effects found in experiments and for the speech errors we are all prone to; and in both cases the causal chain involves activation spilling over in an uncontrolled and unintended way from a target node onto its neighbours. A standard example of priming is that we can retrieve the target word *nurse* more quickly shortly after hearing a related word such as *doctor*, *nursing* or *curse* than after hearing an unrelated word such as LORRY (Reisberg 2007, 257–59). Similarly in speech errors, the target word may be replaced by a related one (as when we mean 'black' but say *white*, or mean 'eradicate' but say *educate*) or by one which is already active in our planning (as when the famous Dr Spooner accused a student of tasting the whole worm when he meant 'wasting the whole term') (Harley 2006) Lamb's much more orderly account of activation doesn't seem to allow for activation spreading in this messy way if, as Lamb (2016, 7) says, activation is blocked where not all conditions are satisfied.

Exceptions. Both of us distinguish defaults from exceptions, but we do so in different ways. To make the discussion more concrete, suppose we are distinguishing the default pattern for English past-tense verbs (such as *baked*) from the exceptional form of an irregular verb such as *took*. How do we guarantee that the exception takes priority over the default? This is important because exceptions introduce serious uncertainty into any model of processing: if the processor can inherit the default property before the exceptional one, every property that's predicted ('inherited') is just provisional because it may turn out later to be overridden; so for example if you're generating the past tense of TAKE, and you first apply the default rule to produce *taked*, this will have to be revised when you find the exceptional rule for this particular verb. Because of this uncertainty, logicians often reject 'default inheritance' as 'non-monotonic' and unworkable, but it all depends on how we think default inheritance works, and Lamb and I both offer workable suggestions.

What Lamb (2016, 18) suggests is that exceptions actively block the default; so for example, the past tense of TAKE not only has the value *took*, but also has a blocking link to the default *-ed*. This is similar to a view I once espoused (Fraser and Hudson 1992), but I now think there is a better alternative, which once again involves the treatment of token nodes. In Word Grammar, default inheritance is part of the process of creating new token nodes, and only applies as part of this process; and as explained above, node-creation attaches the new node to an existing 'type' by means of an 'isa' link—the normal classification link shown by a small triangle in the figures. This means that the new token node sits at the very foot of an 'isa hierarchy' which links more particular concepts to more general concepts; for instance, in Figure 2 the token *houses++* (meaning 'typical French houses') isa *houses+* which isa *houses* which isa the types HOUSE and Plural, which in turn isa even more general concepts such as Common Noun, Noun and Word (not shown in the diagram). Now if the default inheritance mechanism always starts with the nearest 'isa' link and works cyclically up the isa hierarchy, it will automatically reach the exceptional value before the default value, so all we need is a general principle giving priority to any value which has already been inherited.

These research questions are really important because, as Lamb says, the study of language gives us an especially clear window into the human mind, so we linguists have the opportunity, and responsibility, to share our insights with our colleagues in other disciplines.

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Dependency networks: A discussion note about Lamb's theory of linguistic structure

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Abstract. Sydney Lamb (2016) presents a theory of linguistic structure that reaches through all levels of linguistic organization (semantics, syntax, morphology, phonology). The network architecture of Lamb's system is analogous to the network of neurons in the brain. Lamb's theory organizes linguistic units in part in terms of *constituencies*. This discussion note explores the possibility of recasting Lamb's theory entirely in terms of *dependencies*. An approach that relies more on dependency as the principle organizing the units of linguistic structure would result in simpler networks, increasing plausibility and thus being more consistent with the network of neurons in the brain.

Keywords: constituency, dependency, dependency grammar, constituency grammar, network, neural network

In his article *Linguistic structure: A plausible theory*, Sydney Lamb (2016) presents an account of linguistic structure that strives to "discover the system that lies behind linguistic productions and is responsible for them". The system Lamb introduces is intended to satisfy three requirements on the theory of linguistic structure: it must be productive, learnable, and consistent with what we know about the brain. Concerning the third requirement, Lamb takes his theory to be analogous to the network of neurons in the brain. The network architecture Lamb advocates regards linguistic units organized at least in part in terms of *constituency*. The purpose of this discussion note is to suggest that a network architecture based entirely on *dependency* would be simpler and thus perhaps more plausible and consistent with the neural network of the brain.

The distinction between dependency and constituency is most prominent in the field of syntax. Lucien Tesnière (1893–1954) is widely viewed as the father of modern dependency

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grammar, whereas constituency grammar (phrase structure grammar) is associated above all with the works of Noam Chomsky (1928–). Tesnière's oeuvre *Elements of Structural Syntax* appeared posthumously in 1959, just two years after Chomsky's first prominent publication *Syntactic Structures* in 1957. While the dependency vs. constituency distinction is well-established in the field of syntax (see e.g. Matthews 1981:71–95; Mel'čuk 1988:12–7; Schubert 1987:17–20; Jung 1995:15–27; Heringer 1996:27–9; Uzonyi 2003; Hudson 2010:147–150), it is less known in other fields of linguistics. The point developed here now, however, is that the dependency vs. constituency distinction is applicable to the organization of units at all levels of linguistic structure (semantics, phonology, morphology), and it is hence possible to recast Lamb's theory of linguistic structure entirely in terms of dependency.

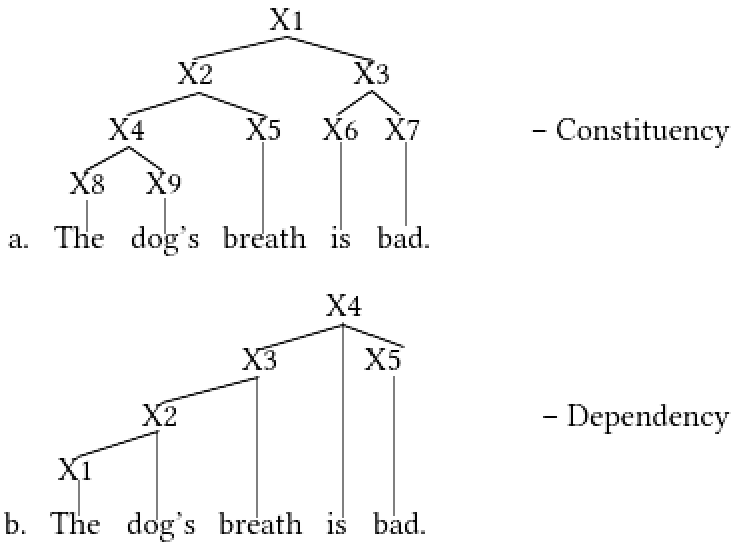
Dependency and constituency are competing principles of organization. The units of linguistic structure can be organized in terms of the one or the other, or both are possible at the same time, which means the structures are hybrid. Constituency *combines* units in such a way that a greater unit is created, whereas dependency *attaches* a unit to another unit in such a way that a greater unit is created. To illustrate:

(1)

The constituency structure (1a) shows that the atomic units A and B combine to create the greater unit AB; three nodes are present. The dependency structures in (1b), in contrast, show that A attaches to B, or B attaches to A, in such a manner that the two together are connected and thus joined into a greater structure. Crucially, the number of nodes present matches the number of atomic units, two each time.

The proponents of dependency as a principle of organizing linguistic units point to the parsimony of dependency in comparison to constituency (e.g. Engel 1994:23, 26; Anderson 2006:48; Hudson 2007:117, 2016). This parsimony is illustrated next by comparing the analyses of a more complex example:

(2)

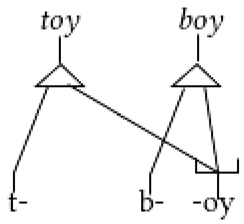


The constituency analysis shows how the units (words and phrases) *combine* to create larger units (phrases and clause); there are five words presents, yet there are nine nodes assumed. The dependency structure, in contrast, contains just five nodes, one for each word present.

The dependency structures above differ crucially from the constituency structures insofar as they see the relationship that obtains between two linked atomic units as necessarily *directed*. This directedness involves taking one of the atomic units as more prominent than the other in one sense or another. Directedness is usually reflected in the diagram in terms of the vertical ordering dimension. More prominent units are positioned above less prominent ones. In (2b), *is* X4 is the most prominent word, *breath* X3 is more prominent than *The* X1 and *dog's* X2, and *dog's* X2 is more prominent than *The* X1. In comparison, the manner in which constituency allows the units to combine does not necessitate the presence of this directedness. The diagram in (2a) does not reveal whether *The* X8 is more prominent than *dog's* X9, or whether *The dog's* X4 is more prominent than *breath* X5, etc. The traditional terminology that captures this distinction is that of *endo-* and *exocentric* structures. The dependency structures (1b, 2b) are entirely endocentric (headed), whereas the constituency structures (1a, 2a) are entirely exocentric (headless). Labeling conventions can render constituency structures endocentric, such as when heads are identified in terms of the labels VP (verb phrase), NP (noun phrase), etc. For instance, the label NP in the position of X4 above the phrase *The dog's* in (2a) would identify the noun *dog's* as the head of the phrase *The dog's*.[1]

Turning to Lamb's theory of linguistic structure, one sees that it is at least in part conceived of in terms of constituencies, a fact that is visible in the diagrams he produces by the presence of the and nodes, which Lamb gives as small triangles. The first of Lamb's (2016) diagrams shows the phonemic structure of the lexical items *toy* and *boy*. That diagram is reproduced here next:

(3)

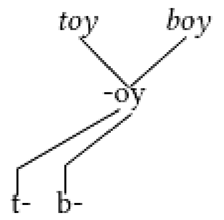


The nodes at the top given as *toy* and *boy* represent the semantic content. Below these nodes, though, we see the triangle nodes, each of which is interpreted as marking the combination of the consonant *t-* or *b-* and the syllable nucleus *-oy*. These two combinations are manifestations of constituency.

One can reinterpret those two combinations, i.e. *t-* and *-oy* and *b-* and *-oy*, in terms of dependency by granting one of the two sounds in each pair a more prominent status than the other. In these cases, one would certainly choose to position the syllable nucleus *-oy* as the more prominent sound each time. Thus, removing these and nodes and putting the *-oy* in their position, one arrives at the following entirely dependency-based diagram:

[1] To avoid unnecessary complication of analysis, the status of the clitic *'s* of possession as an independent node in the syntax has been suppressed in this discussion and in the example trees (2a) and (2b). Note as well the nominal groups are deemed here to be noun phrases (NPs) instead of determiner phrases (DP).

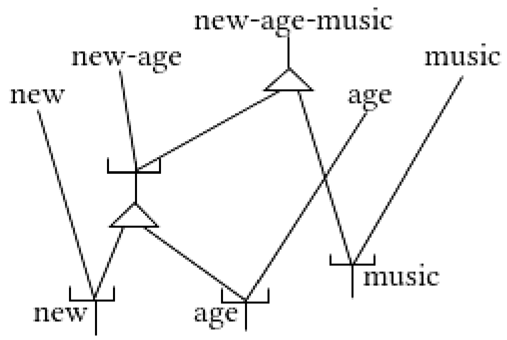
(4)



Counting the number of atomic units and nodes reveals that the number of nodes matches the number of atomic units here; there are five units shown and five nodes in the structure. In contrast, the same five atomic units are assumed in the diagram in (3), yet there are seven nodes posited. The extra two nodes in (3) are manifestations of constituency. Note that the or node in (3), the bracket rotated 90◦, is not necessary in (4) because the intermediate position of *-oy* in the hierarchy allows for no ambiguity as to whether the *-oy* of *toy* or the *-oy* of *boy* is chosen.

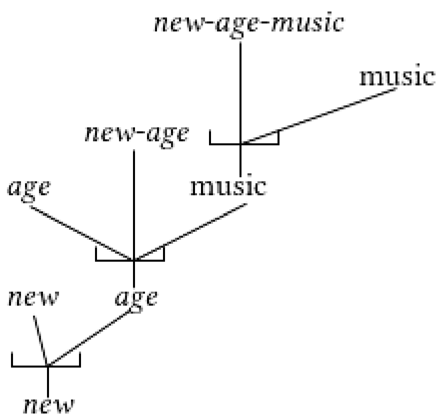
Lamb provides the following diagram to illustrate the linguistic structure of the complex lexeme *new age music*:

(5)



Rendering (5) entirely in terms of dependency results in the following diagram:

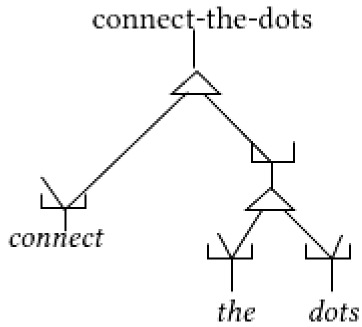
(6)



The and nodes removed, there are two fewer nodes in (6) than in (5). The removal of the two and nodes involves construing *age* as more prominent than *new* in the compound *new age*, and *music* as more prominent than *age* in the compound *new age music*. Note that the or indicators are necessary here in order to distinguish between the literal meanings of *new* and *age* and their figurative appearance in *new age music*. The figurative meaning of *new age music* as a whole is accommodated in the diagram insofar as there is a path extending down from *new-age-music* through the figurative nodes for *music*, *age*, and *new*.

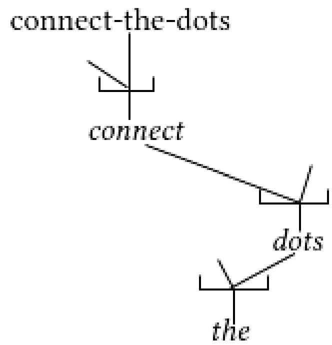
Lamb gives the following diagram for the idiom *connect the dots*:

(7)



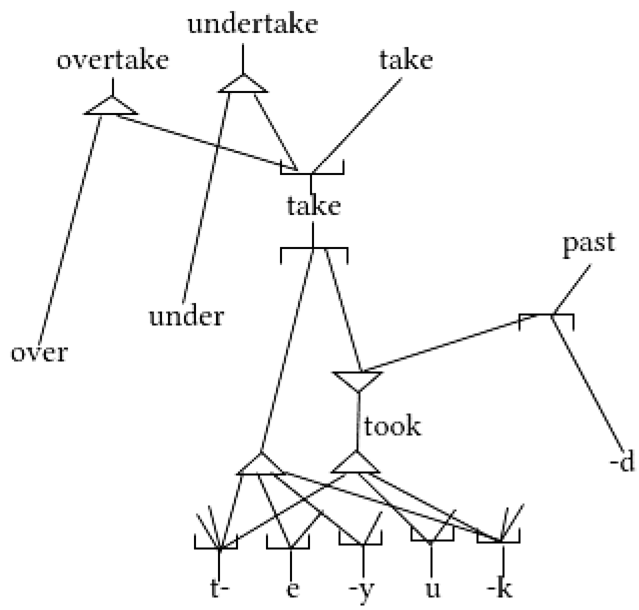
Removing the and nodes in order to render the structure entirely in terms of dependency, one arrives at the following diagram:

(8)



Changing from (7) to (8) involves viewing *dots* as more prominent than *the* in *the dots*, and *connect* as more prominent than *dots* in *connect the dots*. The number of nodes present is reduced from six to four. The idiomatic meaning of the whole *connect the dots* is again accommodated by the fact that there is a path down from *connect-the-dots* through the figurative nodes corresponding to the non-literal meanings of *connect*, *dots*, and *the*.

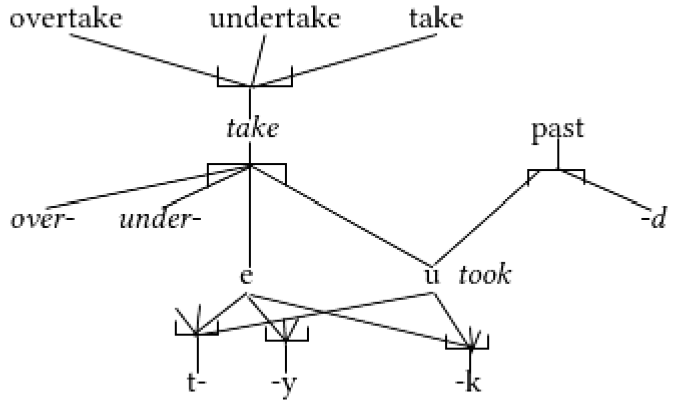
(9)



The next example (9) reproduced from Lamb's article is more complex. It reaches from the lexico-morphological level down fully into the phonemic level of structure. It shows the manner in which the past tense of the lexical items *overtake*, *undertake*, and *take* relate to the default past tense *-d* and the idiosyncratic past tense form *took*.

The presence of the triangles bears witness to constituency. Rendering this diagram completely in terms of dependency requires the removal of the triangles and the promotion of one of the lower nodes below each triangle into the position of the triangle:

(10)



At the phonemic level, the sounds *e* and *u* have been 'promoted' into the dominate position over *t-*, *-y*, and *-k*, and at the lexical-morphological level, *-take* has been 'promoted' into the dominate position over *over-* and *under-*. The result is that diagram (10) is simpler than (9) because it contains four fewer nodes.

In conclusion, the relevant question of course concerns the (in)ability of the entirely dependency-based networks above to convey the same information as Lamb's networks, which include a measure of constituency. In the field of syntax, some who do dependency syntax, myself included (cf. Osborne 2005; Osborne et al. 2011; Osborne and Groß 2012, 2016), have argued that constituency is in fact not necessary, the simpler dependency structures accomplish everything that is needed for a coherent and principled theory of syntax, and that constituency actually gets in the way of transparent theory construction.[2] In any event, many grammarians will agree that the dependency vs. constituency distinction reaches through all strata of linguistic structure and that dependency structures are minimal compared to constituency structures.

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Is linguistic structure an illusion?

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Abstract. The article notes some valuable contributions in Sydney Lamb's article, "Linguistic structure: A plausible theory" and welcomes his raising some key issues, but points out some epistemological and ontological difficulties. It is suggested that linguistic structure involves explanatory constructs in conceptual frameworks which address only a limited number of aspects of linguistic phenomena. The apparent order of linguistic structure arises from the human tendency to systematise and classify. When the complexity of multiple interacting factors as well as the diversity of linguistic associations are taken into account, the orderliness of linguistic structure is illusory, and a more dynamic multifactorial account of language is needed.

Keywords: applicability, empirical validity, ontological commitment, analogy, anomaly, linguistic associations, dynamism

1.0 Introduction

In his recent contribution to *Language under Discussion*, Sidney Lamb (2016) proposes that 'linguistic structure' is a 'plausible hypothesis'. He does not define the term 'structure', but seems to mean that any linguistic organisation or 'relational network' is a 'structure'. Again, he appears to be both defending the idea of linguistic structure as 'plausible' (in the first part of the paper) and specifically proposing his stratificational view of linguistic structure as plausible, although the bulk of the paper is devoted to the latter. The second part of the question clearly depends on more general attitudes to the first.

I think Lamb has made some valuable points in the course of his paper. In particular, he is right (in my view) to emphasise that linguistic theories and analyses must be consistent with the findings of other sciences—neuroscience being one of them (although I think linguistics, and neuroscience too, must look in several directions: towards experimental psychology, sociology, ordinary language philosophy, and anthropology as well, for example). ‘Consistency’ is not the same as ‘being identical with’ any particular scientific view, although Lamb’s hypothesised systems and entities are clearly intended to coincide with neurological ones. Lamb is right to note the separate contributions of linguistics and neuroscience with a view to their ultimate synthesis. He rightly emphasises too the need for a dynamic view of language in the context of the flexibility and plasticity of the human brain, although I think he underestimates the numerous disposing and interacting factors in verbal communication. His position is clearly ‘monist’ (i.e. it rejects a ‘mind-body’ dualism in line with most modern thinking in philosophy and neuroscience), advocating an ‘internal system’ (p. 2) activating all brain and physical mechanisms. His account of the ‘strengthening of connections through repeated use’ (p. 26) is clearly consistent with the ideas of ‘positive feedback’ in biological systems and ‘memetic’ behaviour (on those points, see also Rastall, 2000, and, for biological systems, Dawkins, 2004). He is right also to point out that languages are not discrete, and that linguistic entities must be seen in multiple dimensions (p. 6). However, he does not make clear whether he regards linguistic systems as discrete from other communication systems or how non-verbal and verbal communication can be integrated in his approach. In his relational networks, we still have the centrality of phonological, grammatical, and lexemic structures relatively unconnected to social or wider discoursal determinants and patterns. However, he rightly points out that the boundaries between perception and language, if they exist at all, are fuzzy. Also, it is not clear whether the multiple associations of linguistic entities (such as are found in his example of *cup*) are consistent with the idea of a ‘system’ (see below).

Despite those areas of agreement, I think there are serious epistemological issues that need to be addressed in connection with Lamb’s proposals (or any other structural account with a strong ontological claim). We should be grateful to Lamb for providing a basis for such a discussion. The first issue is a matter of what Quine (1953: 1 *ff*) calls ‘ontological commitment’. To what extent, if any, are we committed to asserting the objective existence of linguistic entities and structures, and, if so, what sort of existence do they have? ‘Existence’ is, of course, not the same as ‘reality’. There are many sorts of reality, and one of them—an example of a constructed reality—is the reality of structures in our *conception* of language, languages, and verbal interaction. ‘Our’ conception may be that of a linguist’s analysis or a speaker’s private conception of his or her language, which are well known to differ considerably. There is also the question of the different meanings of ‘language’. Saussure (1972: 27 *ff*) placed structural/systemic reality in the minds of speakers as a component of the ‘speech circuit’, but also spoke of its existence as a supra-individual reality in the ‘collectivity’[1] (1972: 38–9). In the first case, he seemed to attribute actual existence to linguistic systems as mental entities. The second seems to be more of an explanatory construct or social property. One can also see ‘language’ as the intension of the class of languages—the properties shared by all languages by definition (in a theory) or by induction (from observed languages or language behaviours), or as a set of social events or interactions,

[1] Saussure’s idea has been much criticised. It is ‘mumbo-jumbo’ according to Roy Harris (1973: 158). However, Saussure’s ideas come to us through the prism of his students’ notes (an unenviable fate). We could take Saussure to mean that a language is the defining property of a speech community in its totality. While this interpretation may not allow an ontological commitment to the existence of a language, it would provide us with a conception of a language, in all its varieties, as the property which binds speech communities and gives linguistic identity.

for example. The various meanings are clearly not identical. Another issue raised by Lamb is intimately connected to our understanding of the role of language in the construction of reality, and how verbally constructed reality comes about.

To take the ontological issue first, Lamb's position is clearly stated. He says (p. 4), 'linguistic structures exist in the real world, and their loci are the brains of speakers'. Many linguists (including Lamb, 1999) have taken the view that linguistic structures are mental, or cognitive, realities with existence in each speaker's brain. There have been doubting voices (e.g. Hjelmslev (1953)[2] and Mulder (1993)). Those linguists regard our conception of languages and linguistic structures as a function of our methods of analysis and general theoretical framework, which contains many 'arbitrary but appropriate' choices on the part of the linguist. For them, there is no justification for attributing the linguist's structure to the speaker. It is just a tool for our understanding of selected aspects of phenomena. That is clearly in the tradition of Kant and the view that our conception of the world depends on our sense organs and ways of organising our understanding. The above choice can be expressed tendentiously as one between 'god's truth' and 'hocus-pocus'—in Householder's formulation (1952: 260). That is, are linguistic structures as we conceive them 'real' in any objective sense or is structure (to paraphrase Schopenhauer) my representation of it? (Other linguists, notably Harris, 1982, have denied the validity of 'language' as an entity at all.)

There are at least three considerations in this question of ontological commitment. In the first place, it should be clear that linguistic units and relations are not simply naturally occurring, i.e. we cannot 'observe words in linguistic productions', as Lamb puts it (p. 9). They are constructs, and as such are heavily 'theory-laden'. You may say there are 45 phonemes in southern standard British English, but I may agree with Mulder and Hurren (1968) that there are 25. You may say *are* is a word, but I may say it is an allomorph. You may say *butcher* is a morphological complex, but I may say it is morphologically simple (a 'pseudo-composite'). You may say *video-recorder* is a compound word, but I may say it is a syntagm. You may say *John loves Mary* is an instance of **subject-predicate**, but I may say it is a case of **diverse determination of the nuclear verb**. The disagreements are not matters of factual observation (*quid facti*?), but a matter of different theories with different methodologies leading to different constructs (as in the (in)famous case of whether *blackbird* is a simple or complex entity). My phoneme or word may not be your phoneme or word. Given the arbitrary theoretical content of any construct, how can we claim exact correspondence of a construct with an essentially unknowable real-world entity? As Lamb says (p. 9), 'the exact form of the network varies from one investigator to another'. It does so because their approaches are theoretically and methodologically different, leading to different constructs or views of different aspects of phenomena.

Secondly, linguistic constructs are class properties. The phoneme /t/ in English is a class of allophones, each of which is a class of phonetic realisations, i.e. it is a class of classes of classes or the property which is common to all members of the class of allophones. Here the question of ontological commitment arises, i.e. do we admit the existence of class properties as real-world entities? Lamb's solution is to take class concepts like /t/ and place them in the relational hierarchy as entities (and *mutatis mutandis* for other units of analysis), but that

[2] I am not sure how Lamb interprets Hjelmslev's explicit rejection of an 'existence postulate'.

looks very much like a platonic hypostatisation. We would not normally want to assert the existence of 'the blue tit' because we have a real-world class of birds grouped together by similar properties, although we will want to consider the properties shared by blue tits—and the same goes for /t/ and other linguistic units.

Thirdly, there is a further class-member issue. Saussure struggled to reconcile the difference between the individual's language and the language of the community. The problem is the same for Lamb (or any other linguist). His relational network is in the individual brain (like Saussure's system), but we still need the concept of a shared community language to explain mutual communication and the sense of shared linguistic identity, where each individual's relational network is *different* (in varying degrees depending on many social and varietal factors). We thus end up with a linguist's analysis referring to a *class* of relational networks abstracting from the differences between individuals—the linguist works mainly with what is *typical* for a speech community; but a class of relational networks is not a relational network any more than a class of horses is a horse, and the abstracted generalised system runs into all the problems noted above. Again, we face the problem of ontological commitment to a class property, but in this case we have a huge collection of constructs of constructs, and they must be projected onto different individual brains.

I would like to suggest there is a third possibility, which is connected to our wider understanding of language. It is that our sense of linguistic structure or system arises from our partial and imperfect understanding of the complexity of verbal communication, and that what is needed is a deeper point of view which accounts for, *and includes*, our sense of regularity in verbal communication. The physicist, Carlo Rovelli, has suggested (2015: 42) that our sense of the space-time order of the physical world comes from our 'blurred vision' due to the limited and partial interactions we are capable of with our limited senses and intellects. The order of the apparently regularly rising sun, its movement through the sky and setting at night, or the sense of the earth below and the sky above us, are illusions arising from our limited perspectives and our need to make sense of our everyday level of experience. Our confusion and difficulty in understanding the quantum world arises, he says, because we can only deal in a small number of perspectives on it, whereas quantum phenomena involve many interacting forces. Rovelli's view is clearly in the tradition of Kant (without the commitment to fixed forms of the understanding), Schopenhauer, and Nietzsche (and Zen Buddhists), who took the view that we only glimpse selected aspects of the world through our limited perceptions and intellect.

I would like to suggest that Rovelli's point can be extended to the world of social communication. We see ordered structure in our understanding of verbal communication because we look at it (and for it) from a limited number of perspectives—not least from a natural human propensity to seek ordered classification and system in all things. When we allow for the multiplicity of potential associations in verbal behaviour and interactions, we arrive at an enormously complex verbal world whose totality we have difficulty in understanding, and in which regularity or structure is less apparent and only a small part of the totality. Indeed, our sense of reality, insofar as it is verbally constructed, involves vast numbers of interacting factors and is constantly changing; and our linguistic means of communication are constantly changing too, as we learn from studies in the 'synchronic dynamics' of languages. 'Structure' is a convenient illusion for *some aspects* of macro-level understanding. I think Lamb's position is actually not too far from this. He too points out the many disposing factors in verbal communication. His example of the semantic associations of *cup* (p. 20 *ff*) clearly shows the complexity. But it also shows that each linguistic sign's associations are idiosyncratic—there is little that is systematic about them. The apparent clustering of associated signs—*cup, mug*, etc.—reflects the clusters of experiences and real things, not a linguistic ordering.

To make progress, we must make an epistemological detour, revive an ancient debate, consider some evidence, and suggest some wider perspectives.

2.0 Some epistemological points

A hypothesis is a kind of *statement* (or set of connected statements). Each hypothesis is a statement whose truth or falsehood is contingent on facts. Its key feature must be its testability in confrontation with real-world states of affairs (see, among many possible references, Hempel, 1952: 36 *ff*). I am sure Lamb will agree with that. Followers of Popper would say the key characteristic of a hypothesis is its potential falsifiability. We do not have to follow Popper's 'criterion of demarcation' (1972a: 34 *ff*) between empirical science and 'metaphysics' in all its details, but the potential for falsification is a key feature of testability. One cannot have a hypothesis which can never—even in principle—be false, so there must be some way of testing a hypothesis to destruction.

Any hypothesis can be launched regardless of its plausibility. Boltzmann's (correct) hypothesis that heat is transferred from hot to cold things and not *vice versa* because that direction is more *probable* was regarded as highly *im*plausible at first (Rovelli, 2015: 49 *ff*). Similarly, many must have doubted Einstein's (correct) prediction that light would be bent by the sun. On the other hand, Lamarck's (false) views on the hereditability of acquired characteristics and Heyerdahl's hypothesis of a South American origin of Polynesian people were regarded as plausible in their day. Thus, plausibility is neither necessary nor sufficient for *launching* a hypothesis. As only the facts decide on a hypothesis, plausibility is neither necessary nor sufficient for *accepting* a hypothesis too. Who (before Einstein) would have imagined that light from a distant object originating millions of light years away could be bent by a curve in space-time, or until recently that Neanderthal or Denisovan DNA is found in the genomes of various human populations?

A hypothesis can only be tested. It must, therefore, be very precise (as indeed Lamb's specific hypotheses about particular structures are), and contain both a subject and a predicate in such a way that we can identify instances of the subject and instances of characteristics in the real world. 'Structuralism', 'structure', and 'linguistic structure' are *not* hypotheses (and neither are the phoneme /t/ or the structure **subject-predicate**). They are naming expressions, and hence shorthand for the statements relating to the entities being named and their claimed properties. Of course, they could be components in statements, such as 'structures exist', 'structuralism is our best explanatory framework in linguistics', or '/tš/ is a phoneme of English'. It is not clear that the first two statements would be *testable* hypotheses. How could they be refuted or even empirically tested? The third is refutable in principle, but only in the terms of the theory and methods which give meaning to the term, 'phoneme'. The resolution of the 'one or two phonemes?' problem (do we have a single phoneme, /tš/, or a combination of /t + š/ for example?) hangs on the phoneme theory you adopt, as in the above cases of different solutions.

If the naming expression, 'linguistic structure', does *not* correspond to (or name) a real world entity or set of entities, then the claim that 'linguistic structures exist' is automatically false. If they do demonstrably exist, then the statement, 'linguistic structures exist' is at best otiose—no *hypothesis* is then needed; it would be a fact. The problem is, of course, that we do not know whether the expression, 'linguistic structures' has real-world reference or not. The further problem is that we need to be able to test the claim, 'linguistic structures exist', independently of any classification into linguistic structures. Otherwise, we would end up with a clear *petitio principii*.

For example, it is possible to set up a theory for phonological description based around the notion, phoneme, in which phoneme constituency is described in terms of distinctive features, and the distribution of phonemes is described by modelling the construction of groups of phonemes in phonotagms. Lamb's phonology gives a dynamic representation of such an approach. Similarly, one can set up a 'scale and category' grammar with a 'rank scale' of the usual sort. Those theories for the phonological and grammatical description of languages can then be used in the description of specific languages. It is what Martinet (1956) and Mulder (1968) did in phonology[3] (followed by many others) and Cook (1971), among many others (e.g. Berry, 1977, Chalker and Weiner, 1998, Halliday, 2004), did in grammar (tagmemic or systemic). The description of (aspects of) languages using a given approach demonstrates the *applicability* of the method—what Lamb (p. 1) describes as operability. It does not demonstrate the empirical *validity* of the description. For that, one would need some triangulation with other methods to test whether structures exist *in the way linguists set them up*[4]. (A successful application of a method is necessary but not sufficient for empirical validity.) To claim that a structural description demonstrated the empirical validity or existence of linguistic structures would be a clear *petitio principii* because the linguistic method itself presupposes a structural viewpoint—the 'proof' presupposes what was to be demonstrated. Phonemes, distinctive feature analysis, phonotagms, the scale and category approach, and many other approaches plainly contain a presupposition of structure. You cannot use a structural description to show the empirical validity of a structural approach[5]. Lamb's numerous examples are both clearly set out and interesting analyses, but they do not show the *existence* of the structures in the real world. Thus, his claim (p. 3) that:

> People are indeed able to speak and write, and to comprehend texts (if often imperfectly). This obvious fact assures us that linguistic systems are able to operate for producing and comprehending texts.

either begs the question, or means that *any* organisation or process is trivially a 'system'—the claim that linguistic structures exist would become irrefutable in principle.

[3] Both explicitly presented theory first and then *applied* it in the description of Franco-Provençal and Chinese respectively.

[4] I am tempted to say such a thing is inherently improbable, but have excluded plausibility arguments.

[5] Possibly, that was Pike's error when he stated that 'phonemes exist' (1971: 61).

Lamb's claim for plausibility (his triangulation), however, rests on a comparison between the features of his (in itself interesting) stratificational approach[6] and a number of facts of neuroscience. However, whereas the linguistic analyses are very detailed, the facts of neuroscience (at least insofar as specific linguistic entities are concerned) are at a much more general level. As has been often observed, neuroscience has made great strides at a cellular level and at the level of macro-level functions. The problem is the gap between the two levels, but that is precisely where Lamb's theory fits (along with those of other linguists). The problem is clear even in the work of the neurolinguist, Pulvemüller (2005: 273), who says:

> A closer look at the actual empirical data so far indicates that a clear correlation between language phenomena and patterns of electrical activity [in the brain] are not easy to find.

In short, the many hypotheses grouped in his theory are not (currently) testable for empirical validity, but broad comparability (plausibility) is not a strong argument—it is a type of 'subjective conviction' (Popper, 1972a: 44).

I think Hjelmslev was aware of that set of problems when he put forward *his* hypothesis of linguistic structure; that for every *process* there is a *system* to analyse and describe it using a limited number of premises (1953: 9). While it was a statement, it was a point of view which was not empirically testable in relation to naturally occurring phenomena. Of course, Hjelmslev's conception of empiricism differed from that of other linguists (as many commentators have pointed out). He was more concerned with the coherence of descriptions than with correspondence to fact. For Hjelmslev, I think[7], empiricism included the *coherence* of a description with observables. Since Hjelmslev rejected the idea of an 'existence postulate'—the claim that a linguistic description represents some ultimate real-world entity (linguistic 'substance')-, coherence with observables in a logical framework of ideas would be the test of the hypothesis of linguistic structure 'underlying' phenomena. He thus avoided circularity at the expense of not making any claim for correspondence with the external world. Unfortunately, he also immunised his hypothesis against refutation, since it is always possible to find *some* way of making a coherent description, if only by constantly adjusting it or absorbing diversity by some additional component (as Popper pointed out, 1972b:30). There may be some justification for the view that we can never get beyond ever more complex explanatory constructions of experience, but it could not include hypotheses in the usually accepted sense, and one could not arrive at 'empirical truth' in the usual sense of correspondence with reality external to descriptive statements. Hjelmslev's strategy would not suit Lamb, although it would suit those who regard linguistic analyses as explanatory constructs.

3.0 Questioning structural views

So, we must ask—are there any reasons for questioning structural views of language and languages? Apart from the serious epistemological problems above (including Rovelli's idea of our 'blurred vision'), it seems to me that there are at least three sources of doubt.

[6] I would like to mention the work of Sotavalta (1936) which has some remarkable similarities to Lamb's stratificational grammar. Sotavalta's theory is a connected hierarchy of constants and variables on several levels.

[7] But there are many different views on the meaning of Hjelmslev's work.

3.1 Diversity of communicational means

Firstly, by comparison with macro-level structural generalisations, there are significant amounts of anomaly of detail and variations in structure in all languages. Of course, verbal phenomena can be considered 'anomalous' only in relation to structures which are regarded as 'normal'. There is diversity, rather than 'anomaly', if structures are *not* regarded as classificatory norms. If we look at 'case languages' such as Russian, for example, it is clear that a macro-level structure such as **noun = [prefix] + root + case + number** covers a very large diversity of combinations, and is actually false in the case of 'indeclinables'. In fact, there is considerable 'amalgamation' in Russian, which makes it difficult to specify the forms of roots, cases, and number (those categories are projected onto phenomena as forms of classificatory explanation), and the functions of cases are very diverse, as any standard grammar will show (e.g. Unbegaun, 1957, or Offord, 1994). The macro-level generalisation lumps together many different features of form and meaning, and imposes a structural analysis on them. In English, the macro-level structure **subject—predicate** for the 'simple sentence' covers a wide diversity of subject (and predicate) functions, and is false for so-called 'minor sentence types' (extensively listed by Cook[8], 1971, and discussed in Rastall, 1995).

3.1.1Examples of grammatical variation

In languages like Russian, it is particularly important to allow for impersonal expressions (such as *mn'e xolodno*—lit. 'to me is cold', 'I'm cold'; *jemu n'ekuda idt'i*—lit 'to him nowhere to go', 'he has nowhere to go') as well as **subject-predicate** structures as separate linguistic strategies to achieve communicational ends. Impersonal expressions have largely disappeared from English except in fossilised expressions such as *methinks*, although they existed in Early Modern English (*me thinketh, him liketh it*). However, even in English, it is important to see that **subject-predicate** structures are by no means all of one type. Copulatives (e.g. *Fred is a good worker*) differ in structure and function from non-copulatives, which—as we know—must be divided into transitives, di-transtives, and intransitives, and those in turn must be distinguished from 'middle voice' structures (*the shirt cleaned well*, etc.). Furthermore, the internal structure of the predicate and its relation to the 'subject' clearly differ. The array of possibilities (ignoring adverbial complements) includes those listed in Table 1.

In addition to the above types, we should note the many 'predicates' which are, in fact, fixed phrases, where the predicate appears to consist of a verb with a direct object (or other complement), but where the meaning of the whole is not a function of its parts and the predicate is not grammatically analysable. Such expressions are generally of metaphorical origin—e.g. *x bit the bullet/bore fruit/came a cropper/hit the sack/showed a leg*, etc. Another subset of verbs with a fixed and meaningless direct object is the class of 'fixed reflexives' (usually of romance origin) in which the reflexive pronoun is contextually required, but does not commute with nouns or personal pronouns—*avail oneself (of), behave oneself, concern oneself (with), enjoy oneself,* etc. (as opposed to 'genuine reflexives'—*cut oneself, see oneself in*

[8] Curiously, neither Cook nor other scale-and-category grammarians consider the many 'minor sentence types' to be refutations of the claim that all simple sentences are analysable as **subject-predicate** structures. They are treated as 'exceptions'.

Table 1. Varieties of subject-predicate structure

Subject	Copulative verb	Noun phrase	*John is a drummer*
		Adjectival	*John is big*
		Adverbial	*John is here*
		Prepositional phrase	*John is in the garden*
		Past participle*	*John is loved*
	Intransitive verb A		*John sleeps*
	Intransitive verb B (Middle)		*The carpet washes (well)*
	Transitive verb	Direct object	*John sees the cat*
	Di-transitive verb A	Direct object + Indirect object	*John gives the cat its dinner*
	Di-transitive verb B	Direct object + Complement	*John considers Mary the ideal woman*

* I regard the 'passive' as an orientation towards the subject expressed by a **participle + complement** structure (along with a number of earlier linguists such as Fries, 1957

a mirror). Some 'fixed reflexives' are of the middle voice type—*the situation resolved itself, the boat righted itself*. Other 'middle voice' expressions are probably derived as fossils from the old passive in *–ing* (such as *the tea was serving* = *was being served*, still found in early 19th Century English), e.g. *the kettle is boiling, the chicken is cooking*[9], whereas others are more recent 'middle voice' expressions, *the book is launching, clouds are forming*, etc. Another possibility is that of 'verbs of general meaning' (Guiraud, 1970: 24–6)[10], where the predicate is grammatically analysable, but where the verb makes very little, or no, semantic contribution, and the relation of the subject to predicate is variable (*John had trouble, John made trouble*).

We can add that there are a number of restrictions in the verb structures related to the type of predicate, e.g. we can have *John is being good, John is being a cowboy* (e.g. in describing a child's behaviour or play) but not *John is being big, John is being here, John is being in the garden*, etc. *John is being a bartender* suggests a temporary occupation (as opposed to *John is a bartender*). That is, the above **copulative + complement** structures hide micro-level diversity. It should be obvious from the examples that the relation of the predicate to the subject varies considerably and includes the identification, classification, description, location, and attributes of the subject in the case of copulatives, and the naming of real-world actions, processes connected with the subject or the effects of the subject on other parts of the world or attitudes to it in non-copulatives. What we are saying is, of course, not that such phenomena cannot be accommodated in a stratificational or other structural approach, but that a structure such as **subject-predicate** is a generalisation of several generalisations to the point of meaninglessness, and that we can only achieve deeper understanding by a consideration of micro-level strategies for communication, which have broad similarities . Familiarity with the **subject-predicate** structure can blind us to the anomalies and

[9] Another interesting aspect of linguistic diversity is the existence of expressions from earlier stages of a language, whose grammatical form is not consistent with synchronic 'norms'—*waste not, want not; gather ye rosebuds, while ye may*; or President Kennedy's '[A]sk not what your country can do for you,...' with its biblical overtones.

[10] Often put in the ill-defined ragbag of so-called 'light verbs'.

variations. It is even less meaningful to start top-down with a presupposed **subject-predicate** structure and fit all utterances, however diverse, to it.

As a further example, it should be very clear that negation and interrogation in English each contain two separate structures—one for the verb *to be* (post-negation and inversion respectively) and one for other verbs (involving '*do*-support')[11]. Even then, there is some overlap where '*do*-support' is found with *to be* (*Little Johnny does be good sometimes, Do you always be kind to animals?*), and certain verbs (e.g. *have* and *dare*) are found with or without '*do*-support' (*I haven't a clue/I don't have a clue*, *He daren't go there/He doesn't dare go there*) in some contexts. Macro-level structures obscure that diversity and the disposing factors involved in the variation.

3.1.2 Examples of phonological variation

In phonology, it is well known that macro-level phonemic systems are built up from a mass of very varied and overlapping (but not identical) micro-level commutations in fixed contexts. Twaddell (1935) first made that clear, and Mulder (1968) devised a method for generalising from micro-level contexts to macro-level entities and structures. The distribution of phonemes in phonotactic combinations can be described in broad macro-level generalisations for English (e.g. CVC, CCVC, etc.), but the occurrence of phonemes in such structures is highly *un*systematic. (Lamb allows for that in his representation of phonological processes, but the point here is that phonological systems are highly unsystematic—and that is hidden by his representation.) The following table illustrates the points clearly.

One way of representing the great diversity of phonotactic combinations is given in Rastall (2006). There a table of the combinations of phonemes in the pattern CVC for any given English short vowel is set up. It shows the very variable 'deployment' of phonemes in the formation of the forms of allomorphs, as well as the considerable differences in the frequency and distribution of phonemes and contexts. Obviously, one can use the same method for more complex groups, but the variability will be the same. Here we use the same method for a restricted number of consonants (occlusives and fricatives[12]) and the 'long' vowels[13] in broad phonemic transcription, /a:/ and /u:/ (i.e, the vowels in forms of words such as *part, dark, booth, coot*, etc.). The first +/- refers to /a:/ and the second to /u:/ in each cell. Thus, in the columns we have /a:/ and /u:/ + Consonant and in the rows we have Consonant + /a:/ and /u:/ (+ C). The initial consonant is in the column and the final consonant is in the row. Only 'canonical' words of the form Consonant-Vowel-Consonant are considered[14]. The restricted sample is for convenience of presentation only. Increased complexity reduces the ratio of attested forms to possible forms, as one can easily test for oneself using contexts such as /bl-/, /spr-/ or /-lk/.

Table 2 shows a number of significant features. (It allows for a number of marginal words (e.g. *sahib, sars, souk, sooth*) and slightly non-standard expressions (e.g. *barf, goof*)—all found

[11] Of course, there are other ways of asking questions and denying as well.

[12] Other phonemes could be considered, but the table is for illustrative purposes, so complications relating to distribution (/h/, /ŋ/) and phonemic status (/r/, /j/, /w/) are avoided. The fundamental points would not be affected.

[13] Phonetically, the vowels in question are often diphtongised.

[14] I.e. excluding past tenses and plurals, such as *sued, booed, zoos*, etc. and personal names.

Table 2. Attested CVC combinations of English occlusives and fricatives with /a:/ and /u:/[15]

	-p	-b	-f	-v	-t	-d	-θ	-ð	-s	-z	-k	-g
p	-/+	-/-	-/+	-/-	+/-	-/+	+/-	-/-	+/-	-/-	+/-	-/-
b	-/-	+/+	+/-	-/-	-/+	+/	+/+	-/-	-/-	-/+	+/-	-/-
f	-/-	-/-	-/-	-/-	+/-	-/+	-/-	-/-	+/-	-/-	-/-	-/-
v	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	+/-	-/-	-/-
t	+/-	-/-	-/-	-/-	+/+	-/-	-/+	-/-	-/-	-/-	-/-	-/-
d	-/-	-/-	-/-	-/-	+/-	-/+	-/-	-/-	-/-	-/-	+/-	-/-
θ	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
ð	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
s	-/+	+/-	-/-	-/-	-/+	-/-	-/+	-/+	-/-	+/-	-/+	-/-
z	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-
k	+/+	+/-	+/-	+/-	+/+	+/-	-/+	-/-	-/-	-/-	-/+	-/-
g	-/-	-/-	-/+	-/-	-/-	+/-	+/-	-/-	-/+	-/-	-/-	-/-

in standard dictionaries. The results would be slightly different if polysyllabic words or words with a more complex consonantal structure were considered (e.g. *booster*, *bouffon, sloop*), but then the number of possible combinations would also rise.

Overall, there are 12×12×2 possible combinations i.e. 288 possible forms, of which only 48 are attested. 26 forms contain /a:/ and 22 contain /u:/. Reading across, the phonemes /θ, ð, v, z/ do not occur initially in these combinations. They have no functions in these contexts. The phoneme /k/ occurs the most (10 out of 24 possible forms) followed by /b/ (9), /s/ (7), /p/ (7), /t/ (4), /g/ (4), /d/ (3), and /f/ (3). There are relatively few minimal pairs (*tarp/carp, poop/coop*, etc.). Most of the minimal pairs reading downwards occur in the context /-Vt/. In the contexts /-Vð, v, s/, there are no minimal pairs.

Reading down, we see that there are no combinations in the context /CVg/. At least, in these contexts /g/ has no function. /v/ has only one attestation, and hence only a marginal functional load in these contexts.

It should be clear that only a small proportion of possible combinations are actually attested (slightly more than 21%), and some phonemes and some combinations are far more commonly found than others. (The figures for combinations with short vowels (Rastall, 2006) show around 48% of attested forms, so short and long vowels behave differently.) In the above table, /k/ is more frequent than its minimal pair, /g/. The context /a:t/ is more common than /a:d/, etc. Some phonemes have no function at all in these contexts, but appear in the overall phonological structure because they have functions attested elsewhere. While some combinations do not occur at all, others (e.g. /pa:k/) are used in more than one sign (*park* in different senses). If we compare with the neatness of the phoneme matrix or the phonotactic structure CVC, we can see that there is little that is systematic in the phonotactic system. The overall picture conceals many anomalies and a great deal of variation. In this example, of course, the number of combinations is affected by the fact that /u:/ does not occur in all contexts and we find /u/ instead (*book*, etc.), but that is merely part of the overall variation.

[15] Checking the pluses and minuses is very simple. Take an initial combination such as /su:/ and identify the monosyllabic words ending in a single consonant from the list that can be formed: *soup, sooth, soothe, soon, souk.*

The structure CVC can be used to account for the occurrence of actual groups and the potentiality of others, but it does not determine the distribution of phonemes.

Any micro-level analysis will provide similar findings (of course, there are many possible contexts). Usually, the many unattested forms are regarded as 'accidental gaps' (such as /ga:k/, /pu:g/, etc.) Perhaps, in view of the statistics one should speak of 'accidental fills' for attested forms instead.

That is, from the micro-level (or 'bottom-up') point of view of the individual unit, the 'top-down' macro-level analysis is very misleading (unless supplemented by a clear linkage between macro—and micro-level entities and functions such as Mulder (1968) provides), and probably proceeds from the general human propensity to classify and systematise. However, there are many other areas of 'anomaly' in all phonological systems. Consider the (functionalist) phoneme table for English in Table 3:

Table 3. Partial phoneme table for standard English consonants

Series/Order	**Occlusive**		**Fricative**		**Nasal**
	Voiced	**Voiceless**	**Voiced**	**Voiceless**	
Labial	b	p	v	f	m
Apical	d	t	ð	θ	n
Hissing			z	s	
Hushing			ž	š	
Affricate			dž	tš	
Velar	g	k			ŋ

Again it was Mulder (1978) who pointed out that standard phoneme tables for English (such as the one above) put together phonemes with three dimensions of distinctive feature constituency (e.g. /p, b, t, d/) with two-dimensional phonemes (e.g. /s, z, m, n/), and in the overall set of consonants we must even allow for /h/ and /l/ which cannot be analysed into component (*functional*, not *phonetic*) distinctive features at all. Furthermore, it is clear that the function of a feature such as /fricative/ has no value in the context of /dorsal/ since there is no /dorsal, fricative/ combination in English. This means that /voiced/ has different values in the contexts /labial/ and /apical/ from the context /dorsal/. In the first case, /voiced/ is mutually exclusive with /voiceless/ and /fricative/, but in the context of /dorsal/, only /voiced/ and /voiceless/ are in opposition. Rastall (1993) offers a way of modelling the combinability of distinctive features and phonemes working 'bottom-up' from the associations of individual features.

4. Multiple perspectives

The *second* source of doubt about structure, again from the point of view of the individual linguistic unit, is the set of associations (Saussure's 'rapports associatifs', 1972: 173 *ff*) of any entity cuts across structural classifications (I think Lamb agrees here). A phoneme such as /ð/ in English, from a macro-level point of view, enters correlations with the order of apicals /d, t, θ, n/ and with the series of fricatives/continuants /v, z, ž, dž/, and thus takes its place in a phonematic table of consonants, such as the one above. It occupies the first and second consonant positions in the structure CVC.

However, it is obvious that the phoneme /ð/ has a low frequency in terms of its distribution in phonotactic combinations. It enters relatively few minimal-pair commutations, certainly far fewer than its minimal pair /θ/, which also has a different phonotactic distribution. /θ/ occurs in CCVC—*thrash, thwack*—and CVCC—*wealth, length*, for example. The symmetry of the phoneme table is misleading—minimally paired phonemes have different phonotactic distributions—wouldn't we expect a system to be more systematic? Furthermore, /ð/ is nevertheless relatively frequent in terms of its occurrence in texts. It is a redundant feature signalling the identity of a number of words with important grammatical roles—*the, this, that, there, then,* etc. /ð/ also occurs in the non-meaningful formant, /-ðr-/ again as a redundant signal of sign identification—*wither, bother, dither, slither, blether*—often in verbs with a specific descriptive meaning used in relatively informal contexts, and occurs in the important kinship terms (*mother, father, brother*). Another non-phonological function of /ð/ is its role as a component of certain plurals in alternation with /θ/—*booth/booths, truth/truths*—and in certain adjectives—*south/southern, north/northern.* Any description of /ð/ would be incomplete without these intersecting non-phonological and aesthetic functions. Similar remarks can be made about the phonemes, /v, z/, and phonemes such as /t/, /s/, /n/ also have a number of non-phonological functions.

Individual signs too have associations in numerous, idiosyncratic, dimensions. The sign, *string*, taken at random for example, has a range of interpretations as a noun—type of material (twine, cord), instance of that material used for tying, catgut used in musical instruments, linearly linked group of objects or events (*string of people, string of horses, string of misfortunes*) among other possibilities. It enters a number of common collocations—*bowstring, violin string, apron string, string of pearls, string theory*—and metaphors—*two strings to one's bow, be tied to x's apron strings, pull the strings, like a puppet on a string*[16], etc. It enters morphological combinations such as *stringy, stringer.* As a verb it is found in *string a bow, string beads*, and metaphors such as *string x along, string x up.* Of course, many more associations of *string* could be added (such as the field, *string, rope, hawser, cable,…*) but the point is that *string*, like most other signs, enters a mass of different associations, morphological, syntactic, semantic, metaphorical, and collocational in a number of aesthetic registers. From a 'bottom-up' point of view, the identification of *string* as a noun or verb is a function of its use in a range of contexts. It shares some of those contexts with other signs and thus the generalisation, 'noun' or 'verb', arises from those similarities, but is relatively unhelpful in understanding the sign, *string*, and its position in the 'linguistic space' of multiple associations or the disposing factors in its instantiation in utterances.

4.1 A further example of multiple complexity—nouns in −er in English

English nouns may be formed with the suffix *−er*. The class of nouns in *−er* shows the same diversity and complexity as in other morphological combinations (such as verbs in *−en*). Some of those nouns are clearly morphologically complex from a functional point of view, i.e. both the root and the suffix have a recurrent form and meaning, and the meaning of the whole is a function of the component signs—*writer, runner* (i.e. 'one who runs' as opposed to the

[16] For older British speakers almost inevitably associated with Miss Sandie Shaw's Eurovision song contest performance—an example of an idiosyncratic experiential association. Other speakers will wonder what on earth I'm talking about… that's part of the point.

various other meanings), *employer*, etc. Some nouns in *−er* do not meet these criteria. They are 'pseudo-composites', i.e. they appear to be genuine combinations, but the meaning is not a function of the parts because the apparent analysis is incomplete. *Butcher, carpenter, lever*, etc. are of that type. Those signs have a final syllable in *−er* and are thus only formally associated with the other *−er* nouns. Some nouns end in *−er*, as it were, 'accidentally'—e.g. *badger.* Some pseudo-composites are not synchronically analysable, but may have been so historically—e.g. *joiner* (except as a neologism from *join —she isn't a great joiner of clubs*) whereas others—*butcher, carpenter*—are derived from borrowings. The *−er* nouns are an example of a class in which functional, natural, and formal criteria overlap.

In the case of genuinely (synchronically) composite *−er* nouns, *−er* is strongly associated with naming the one who performs an action—*maker, swimmer, employer, plasterer*, etc., although not all nouns in *−er* are formed from verbs (*footballer, (an) upper, (a) downer*). However, *−er* has more than one recurrent meaning (it is a class of homonyms). Other meanings include:

– Inhabitant of a place—*Londoner, Berliner*, ...
– Object/instrument used to perform an action—*drier, cooker, cleanser*, ...
– Occupation name—*cricketer, drummer, driver, cleaner* (overlapping with performer of an action),..
– Example or instance of an item (especially involving numbers)—*fiver* ('five pound note'), *tenner* ('ten pound note'), *sixer* ('a score of six runs in cricket', *three-pointer* ('score of three points in rugby'), but also *goer* ('a suggestion or idea with real potential'), *non-starter* ('idea or suggestion which is immediately rejected', *no-brainer* ('question whose answer requires no thought'). Note also the register effects of these expressions.
– Place where an action is performed—*diner, boozer.*

There are frequent cases of homonymy involving the different categories (and pseudo-composites), which are usually easily disambiguated contextually. For example, *(football) player/(CD) player, a boozer (*person*)/at a boozer* (place), *sleeper (railway sleeper, sleeper in an underground organisation), reader (in a library)/(card) reader* among other meanings, *eater* (person)*/(a good) eater* (apple), *steamer* (pan for steaming)/*steamer* (ship), *(crowd) pleaser* ('one who pleases/action which pleases a crowd'), *racer* ('one who races', 'bike used for racing').

Some examples involve metaphorical uses—*loosener, gnashers* (= teeth), *sucker* (on a rose plant)/*sucker* ('person who can be duped'). In other cases, the reference may be restricted to particular contexts (e.g. *carer* ('person with responsibility for caring for another', not 'anyone who cares'). Or there may be multiple homonymy: a *starter* may be 'one who starts a race' (i.e. either a competitor or an official), 'a first course', 'an initial question', etc. An *opener* may be 'one who bats first in an innings in cricket', 'an instrument for opening a can', 'an initial statement, suggestion', 'first game in a series', etc.

Like other signs, nouns in −er also have their collocational associations—*for starters*, *spin drier*, *rotary drier*, *clothes drier*, *seed drier*, *egg timer*, *on a timer*, etc.

While we can easily see that nouns can be put in classes when they form similar sets of semantic associations, it should also be clear that there are many variations and intersecting associations with the result that each noun in *−er* has its own distinctive set of associations differing from other nouns in *−er*. Thus, *player* and *reader* share at least two semantic parameters (performer of an action and instrument used for an action), but the collocational associations of the two signs are quite different—as in, for example *card player* as opposed to *card reader*. *Employer* shares the parameter of 'performer of an action', but not 'instrument used for an action'. With *cleanser* it is the reverse (instrument not actor). The associations of *eater, steamer, starter*, etc. are—as we have seen—even more complex and idiosyncratic. Furthermore, there is no 'rule' for formation of nouns in *−er* with a particular function. A *cooker* is not a *cook*, and we find *farmer* along with *shepherd, swimmer* along with *gymnast*, etc.

Consequently, we can see that the overall (macro-level) pattern for the formation of nouns in *−er*, while having some use as a generalisation, covers up an enormous diversity. In fact, on a micro-level, each sign has a different set of functions and associations, which partially overlaps with the associations of other signs—hence the possibility of some overlapping classifications. Thus, while a top-down classification by genus and species is useful for exposition, one may conclude that a classification is actually formed from a mass of overlapping (and idiosyncratic) individual similarities in different parameters. Most important here is the sheer range of diverse association types and ways of looking at the 'same' phenomena. Of course, one can produce a more refined set of '*−er*' structures, but that would be to miss the point that structure is only one way of looking at verbal phenomena. As noted above, one cannot demonstrate the empirical validity of linguistic structure by simply adducing more structures.

5.0 'Aesthetic' scales

The *third* point about structure is a development of the second. Linguistic units and constructions enter scales that are broadly aesthetic—i.e. based on their social and attitudinal or emotive values. Thus, *hang* and *string up* both refer to a form of execution, but are used in different contexts and with different emotional overtones. We can all understand a scale such as, *please go away, leave me alone, take a hike, sling your hook, get lost, bugger off*, or *make worse, worsen, deteriorate; make weaker, weaken, debilitate.* In other cases, there is a mixture of stylistic and contextual/situational factors in the range of grammatically different, possible expressions for the same set of circumstances, e.g.:

The rail workers

- *are striking*
- *are on strike*
- *are taking industrial action*
- *have withdrawn their labour*
- *have walked out*
- *have downed tools.*

We will generally find a set of semantically linked expressions for virtually any set of circumstances[17]. The set is different for each possibility. While we may discern some patterns, each set of verbal associations is idiosyncratic, and the use of a particular expression by a

[17] One might see these as potential 'multiple drafts' in Dennett's terms (see below).

particular person is dependent on a complex range of contextual and attitudinal motivating factors, which structural descriptions fail to account for. Another clear example is number agreement in the English verb, which involves several determining factors, only one of which is the grammatical singularity or plurality of the noun—*Parliament has/have decided* (collectively or as separate individuals), *Ham and eggs is my favourite* (two things seen as a unity), *A mother with her children have gone missing* (proximity of the last noun to the verb), etc. Furthermore, each part of an expression (and each combination) raises its own set of verbal and attitudinal associations (as in Lamb's *cup* example). Thus, *rail* is connected to all signs connected with railways—including *transport, station, train, signal, level crossing,…*—and *strike* relates to *dispute, management, unions, workforce, labour*, etc. By combining the two expressions we have further verbal associations—*disruption, negotiations*, etc. as well as attitudinal and experiential associations connected with railways or strikes or both[18]. Any instance of one of the above sentences in actual verbal interaction or written discourse can lead to a response or connection which depends on the priorities and associations of the speaker or writer. Of course, there may also be no connection with the preceding utterance at all, when the subject is changed or dropped. That unpredictability of response or discoursal connection is partly accounted for by the many different associational possibilities combined with the focus of interest or disposing factors of the speaker or writer.

What the examples show is that, as we introduce more perspectives on verbal expressions and see them in context, so the associations become less systematic and more unpredictable, and the perspective of (grammatical or semantic) structure becomes less significant and less explanatory. But it also becomes more difficult to get an overall view of a language or even a part of it. There are so many dimensions to the understanding of even a single expression that we cannot control all of them. I am certain Lamb is well aware of all this—our difference is over the interpretation or significance of these facts. In my view, our preoccupation with structure is due to the same kind of 'blurred vision' that Rovelli (above) sees in our understanding of the physical world. The dynamism of verbal communication comes from multiple coordinated verbal associations with a constantly changing perception of reality. A hierarchical structure is a way of representing some aspects of verbal behaviour, but its significance is an illusion that comes from a limited set of perspectives on an immensely complex issue and a desire to systematise mixed with the tendency to employ successful or ingrained communicational strategies repeatedly. To put it somewhat tendentiously, verbal productions ('language') are not the Lego-like constructions of structural mechanisms, but are rather patchwork quilts resulting from numerous determining factors.

6.0 Analogy and anomaly

We might ask where our adherence (addiction?) to structural explanation in linguistics comes from. Historically, since the mid-19th century there has been a recognition of the regularity or patterning of linguistic entities, and that has led to successful predictions (in historical-comparative linguistics) and explanatory models for *some* aspects of languages in structural frameworks. Structuralism is the triumph of analogy over anomaly in the ancient debate. The

[18] Such associations can, of course, be very varied. Railway strikes remind me of certain sections of the novel *Dr. Zhivago*, and its film representation—again the inextricable mixing of verbal and real-world associations.

emergence of monistic views in philosophy and neuroscience, combined with the need to integrate different perspectives on verbal phenomena (including the sort of observations above) leads to doubts about the validity of structural approaches, because languages are organic, natural processes, full of unpredictable variations. While there are certainly patterns in linguistic phenomena (at least from some points of view), one can still ask about the nature of the patterning and its role or position in the complex open systems that languages are. Monism, as noted, rejects mind-body dualism. Neuroscience teaches us of the billions of synaptic connections in the brain and of the involvement of numerous brain functions and parts in verbal behaviour. To the extent that structuralism implies a mind-body dualism in which language is a tool or instrument 'used' by speakers with a division between cognitive and executive functions (as in the standard models of communication originating with that of Shannon and Weaver, 1975, and many versions of linguistics), it is at odds with monism. Where there is a conception of a structural language core central to every utterance, it is at odds with neuroscience, which teaches of a multiplicity of simultaneous connections and varied brain functions, which is constantly being renewed. There is no single language centre in the brain. The idea of a conscious or controlling mind in verbal communication is untenable in the light of the time delay between unconscious verbal planning and conscious awareness of speaking. What seems to us to be contemporaneous, such as our perceptions or speech activity, actually takes place slightly before our awareness of them. We all live, as it were, in the past, but that implies that our sense of controlling speech activity is an illusion[19] (as Lamb also clearly implies.) All this leads one back to a reconsideration of 'anomaly', or at least a mass of diverse and unsystematic associations in multiple dimensions.

As noted above, the view of language as a system (or system of systems) developed out of the success of comparative-historical linguistics, which showed the considerable (and contextually near-universal) regularity of sound changes. This awareness of linguistic regularity could be used in a deductive-explanatory approach to linguistic phenomena in which analogy played a key role, and this top-down systemic view was transferred successfully to synchronic linguistics, where phonological and grammatical systems could account for the regularity of means of communication. As Delbrück (1904: 161) pointed out, the ancient debate between analogists and anomalists was decided in the nineteenth century strongly in favour of the analogists. Saussure's use of a hypothetico-deductive approach to the analysis of the indo-european vowel system and his later views on language as a system also contributed to the dominance of the analogical/structural view. The exceptions to sound laws, which could *not* be explained by analogy, extensively documented by Horn (1923), and the recognition that macro-level language systems were generalisations of a mass of micro-level subsystems (Twadell, 1935, and Firth, 1957) were not widely seen as a problem. Similarly, the enormous number of anomalies and unsystematic nature of supposedly regular systems have largely been ignored (Rastall, 2006). Moreover, there is little doubt that structural explanations and approaches have prospered over the last 120 years or so in a variety of cognate disciplines—linguistics, anthropology, psychology—as part of a wider ethos of a generalising explanatory approach to the diversity of human behaviour which

[19] Incidentally, this does not imply a denial of personality or individuality—every brain configuration is different, as is each external expression of it in social behaviour.

emphasises ‘underlying regularities’. The idea that language is a system (or structure) has been a dogma since Saussure and Meillet[20].

The initial dispute between analogists and anomalists concerned the question of whether ‘language’ had its origins in ‘conventions’ (analogists) or ‘nature’ (anomalists). Analogists pointed to regularities (in Greek) as evidence of systematic conventionality and anomalists to irregularities as evidence of an organic growth of language. In fact, from a modern point of view, there is no dichotomy here. It is clear that linguistic communication involves conventional distinctions which vary from language to language and which vary within languages, but it should be equally clear that linguistic conventions do not arise systematically, but arise organically (by nature) in social contexts. The regularities may change as some structures become more ‘successful’, i.e. are exploited by speakers, and others are used less or become opaque, as in the case of *if you please*, which was originally an impersonal expression with *you* as a dative, but which now seems to be a subject in a fixed phrase as impersonals gradually disappeared from English. Another example might be the gradual differentiation of simple present/past and ‘*do*’ present/past in English and the disappearance of *−th* forms in the third person present in favour of *‘-s*’ forms. Thus in Shakespeare, we find semantically equivalent forms such as *x goes/goeth* along with *x does go/ doth go* and *x went* along with *x did go*. While the *−th* forms gradually disappeared from normal speech, the *do* forms gradually became differentiated in function. There is a similar story of competing forms in the past simple and past participle with some forms becoming more ‘successful’—i.e. widely accepted—and others either disappearing or being restricted to local varieties. While there is a clear analogising process, the forces that bring it about and determine which forms emerge as ‘standard’ are not predictable. In the case of the past participles and past simple forms, we are left with significant (synchronic) anomalies such as *sing-sang-sung* but *cling-clung-clung*,, and *bring-brought-brought* along with the ‘regular’ *wing-winged-winged*. What we are describing is the spread of ‘memes’ in communicational behaviour (see below).

7.0 Conclusion

We need a better conception of ‘language’ (as acts of speaking) which will address and integrate the multiple perspectives on any linguistic expression. The following remarks are necessarily brief and programmatic, but indicate what such a conception could include.

Our reality is made up of interconnected verbal and non-verbal components. Language is not separate from perceptual, experiential, memorised, or social reality, but helps to provide a verbally constructed, virtual world in which verbal discourse is *part of the overall reality*, and is also the vehicle for social interaction and social persona. What others say to us or what we say to others creates a reality, which can be compared with perceptions, memories, judgements, etc. As we have seen, linguistic expressions are *loci* for verbal and non-verbal associations. Our reality at any particular moment or in any particular set of circumstances arises from the *interaction* of multiple disposing factors with existing linguistic means in the

[20] ‘La langue est un système qui ne connaît que son ordre propre’ [‘Language is a system which has only is own system’]—Saussure (1916/1972: 43). ‘La langue est un système, rigoureusement agencé, où tout se tient’ [‘Language is a strictly ordered system in which everything is mutually related’]—Meillet, 1921: 11.

form of associations which can be adapted to the communicational circumstances[21]. In this way, our reality is constantly updated, but also our linguistic means are constantly changed[22] through new associations and the effects of positive feedback, which favours successful communicational strategies. We all know that clichés, new meanings, new signs, new grammatical combinations spread through speech communities, while other expressions tend to disappear. Thus, politicians speak always of 'hardworking families' as a cliché; the signs, *brexit* and *brexiteer*, have appeared; the verb, *fix*, is used in a wide array of senses at the expense of *resolve, repair, put right, attach,* etc.; and the sign *how about*...? is now regularly followed by a predicative—*how about we eat*[23], as opposed to *how about us eating*. One can see that any diachronic change can be seen in terms of the favouring of a successful strategy. The spread of the continuous aspect in English from the present and simple past tenses to all tenses, which took place over a long period, can be seen as a case in point. Sound changes can also emanate in waves from a centre through a process of imitation. Such verbal means spreading through social interaction and imitation are 'memes', see above. As an expression is used for successful communication, it is applied in other contexts, which reinforces its use, and leads to it being used more. The more it is used, the more it is reinforced, and the more it is used in a positive feedback cycle (as Lamb also notes). An example might be the well-known and unpredictable shifting of prepositional use, e.g. recently *reason behind* (vs. *reason for*), *explanation for* (vs. *explanation of*), or *congratulate for* (vs. *congratulate on*), as well as differences such as *in search of extra-terrestrials* but *in the search for extra-terrestrials*. Such 'synchronic dynamics' involves the spread of 'memes' in a population. But this suggests a view of language in which there is constant adaptation to new perceived or conceived realities involving associations in multiple dimensions.

The mass of diverse associations that constitutes a language is a kind of organisation (but a very dynamic one in which similar means are constantly updated and created), and as such is subject to entropy—a tendency to become less organised with time, but even though language is constantly changing in detail, linguistic organisation—the mass of associative relations—is relatively stable (at least for the individual speaker for everyday communication and broadly across communities). Otherwise, communication would be impossible. Entropy can be reduced with the expenditure of more energy in open systems. Languages are similar to what Delsemme (2000: 146–7), following Prigogine, calls 'dissipative structures' in chemistry—'an open system that is constantly crossed by a flux of matter and energy which permits entropy to diminish and the system to become organized'. Language (on one definition of the term) is clearly an open system in this sense. As we have said, each communicational act updates and changes the organisation—but the 'organisation' must involve multiple factors in response to changing reality and to adapt verbal means to complex circumstances with multiple determining factors. All communicational activity requires considerable expenditure of energy to maintain the synaptic connections and to coordinate them in forming appropriate utterances. Without that energy, Lamb's complex system would

[21] Rovelli (2015: 18) says that physical reality is the interaction of forces—'...reality is only interaction' in his view.

[22] As von Humboldt said in connection with 'language as acts of communication' (1876: 56), language is not *ergon* but *energeia*.

[23] An interesting sentence for grammatical analysis, by the way. I assume it patterns like *how come...?*

tend towards disorganisation. However, a tendency to disorganisation can be seen in the unpredictable direction of discourse—whether the speaker's connection of ideas or the interaction of speakers in conversation. As suggested, that is due to the large array of possible associations arising from any single utterance. But disorganisation occurs also as verbal means are 'lost', i.e. are not maintained—as anyone will know who has stopped practising a foreign language. Similarly, disused expressions (perhaps because they are old-fashioned, e.g. *lest*, or because they no longer refer to a contemporary reality, e.g. *typewriter ribbon*, or because another expression is 'preferred', e.g. *honour guard* rather than *guard of honour*) drop out of the overall organisation or acquire associations such as 'archaic, 'old-fashioned', etc. Questions of the development and maintenance of verbal organisation need to be seen in the context of entropic forces and ways of resisting them.

In a monistic view, 'mind' is just the representation of the brain to itself and language is part of that representation as well as part of the means of representation. There is no controlling mind which 'uses language', i.e. selects and forms utterances, and then instigates an executive neurological system leading to speech, as Lamb also suggests. Rather, language behaviour is a continuous and multiple process in which there are verbal responses to a wide range of determining social, contextual, perceptual, and verbal factors. As the associations—verbal and non-verbal—are so varied in each instance of the process, numerous different responses are available at any one time. Thus, there are (what Dennett, 1991, calls) 'multiple drafts'. For any input, several responses are activated, and one is prioritised. That there are multiple associations is shown by the unpredictability of speakers' responses. That there is more than one 'draft' is shown by speakers changing their minds', correcting themselves, changing direction in discourse, etc. *The organisation of these drafts and the 'selection' of a draft lies in the adaptation and implementation of verbal means in the context of changing realities.*

In conclusion, then, linguistic structure (at least as it is usually understood in the form of ordered phonological, grammatical, and semantic systems) is an illusion which arises from a limited set of perspectives on verbal communication and our human propensity to classify and systematise, and which would be subject to entropic forces. Macro-level structures have uses as explanatory constructs for certain aspects of verbal phenomena, but are less important when verbal communication is seen from multiple perspectives—they need to be seen in the context of memetic behaviour, where successful combinations or verbal strategies are reapplied in different contexts and with different signs. We can have a better understanding of the role of language in our construction of reality by moving from singular perspectives to complex, multiple ones, and by focusing on the dynamic processes in the creation of meaning in real speech acts[24]. Linguistic structure is not an organising principle; it is an abstraction from our communication strategies and a product of rationalisation.

[24] For an alternative way of approaching verbal dynamics, see Rastall, 2006, 2015.

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Some thoughts on lexemes, the dome, and inner speech

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Abstract. Sydney Lamb's model focuses our attention on the physicality of language, of the signs themselves as objects in the external world and the neural systems the support them. By means of the metaphor of a cognitive dome, he demonstrates that there is no firm line between linguistic and cognitive structure. In this context, I offer physically grounded accounts of Jakobson's *metalingual* and *emotive* functions. Drawing on Vygotsky's account of language development, I point out that *inner speech*, corresponding to the common sense notion of *thought*, originates in a circuit that goes through the external world and is then internalized.

Keywords: Lev Vygotsky, Roman Jakobson, Sydney Lamb, inner speech, relational networks, language, linguistics, psycholinguistics, neurolinguistics, thought

1. Introduction: The physicality of language

For the past half century, Sydney Lamb has been arguing for an account of language that makes a clear and firm separation between language strings and the system that produces and comprehends them. Lamb is interested in that underlying system and has argued that it is best represented by a relational network where the nodes are logical operators. In reading his most recent exposition of his model, "Linguistic structure: A plausible theory" (Lamb 2016), I was drawn to his relatively informal metaphor of the cognitive dome, which he introduces about half-way through his exposition (Lamb 2016: 16).

Thinking about those topics led me in turn to ideas about inner speech advanced by the great Russian psychologist, Lev Vygotsky (1962). On the way there I offer some observations about Roman Jakobson's functions of language (Jakobson 1960) in relation to the cognitive dome.

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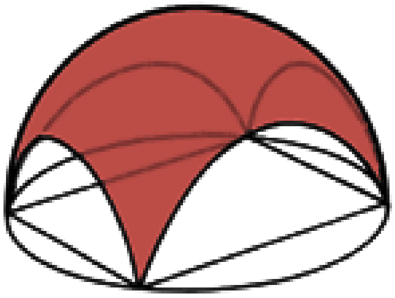
2. The dome and the word

Let us start with the cognitive dome. Here is Lamb's figure:



(Figure from Wikipedia: https://commons.wikimedia.org/wiki/File:Haengekuppel.png)

Figure 1. The cognitive dome

Lamb (2016: 16) asks us to imagine the legs as: (1) speech input, (2) speech output, (3) extra-linguistic perception, and (4) extra-linguistic motor activity. That is, the legs connect the cognitive system to the external world. The surface of the dome is the cognitive system itself. Lamb's point, with which I concur, is that nowhere on that surface do we find a clean boundary between language, which is the focus of Lamb's attention, on the one hand, and general cognition and action on the other.

As I thought about this metaphor it seemed to me that, to a first approximation, *that's just about everything*. Yes, as Lamb himself acknowledges, we perceive the world though multiple channels, and language is written as well as spoken, not to mention signed, whistled, and even drummed as well. But still, as a crude conceptual instrument, that dome is not bad.

In that spirit, let us ask a simple question: where do we find words in that model? The concept of *word* is not, of course, a technical concept. We may think informally of words as (more or less compact) things, but when you try to explicate the concept in the technical terms of Lamb's theory it becomes a complex network of entities. The most tangible aspect of a word would be a lexeme, whether spoken or written. Lexemes are external to the dome. Everything else about words, their meanings and syntactic affordances and the relations between those things and the lexemes, is distributed across the surface of the dome.

Since Lamb's theory is ultimately a neural theory, the dome requires a neural interpretation. Roughly speaking, the dome is the cerebral cortex. While the brain has a complex 3-dimensional structure, the cortex is basically a sheet that is crumpled up to fit inside the skull. The minicolumns Lamb (2016: 23–24) discusses run perpendicular to the sheet while cortico-cortical connections run beneath the dome from one area to another.

What, then, happens during conversation as one word follows another? There will necessarily be activation across the dome for the relational net associated with each word. The activity closest to the periphery will be tightly time-bound to the (physically external) lexeme.

3. Beyond the dome, and the internal milieu

Let us now look at the extra-linguistic aspect of the dome. That is where we find the world at large. The world at large contains other people. In particular, it contains the people one interacts with in conversation along with their gestures and postures, which are important for the conversation.

Though it may seem a bit strange to say so, the external world also contains one's own body. We can see much, though not all, of our body; it is there, in the world, like the bodies of others, though it is always with us, and closer in space to us. We can thus compare our body with others; and we can imitate their actions with our body.

The external world also contains texts, written or spoken. The speech of people conversing in Mandarin, a language I do not know, is not inaudible to me. I can hear it just like I can hear any other sound, whether a thunderclap, the squeal of a tire, a cat's meow, or the tick of a clock. But because my phonological system has not been trained on the sounds of Mandarin, I cannot hear it *as language*. Yes, I may *recognize* those sounds as language because I observe individuals in conversation. The noises they make at one another, what else can they be *but* language? That's different, however, from *hearing* them as language. My ear doesn't recognize the phonemes and morphemes, much less connect them with meaning. We can tell a similar story about written language. I'm willing to grant that Chinese characters are language because someone has told me that that's what those marks are and this disposition of sheets of paper suggests as much. But I cannot read or write those marks.

I would like to suggest that the fact that we can hear speech sounds, as sounds, is responsible for what Roman Jakobson (1960) called the *metalingual function* of language, the use of language to describe and discuss language itself. While the brain-based machinery of language is inaccessible to perception, lexemes are not. Lexemes may only be the external husk, as it were, of language, but their physical accessibility is the means by which the rest of language becomes accessible to perception and cognition. How much of philosophy is bootstrapped by means of that simple capacity?

Now consider Figure 2, which depicts the fact that the nervous system interacts with the worlds that are external to it:

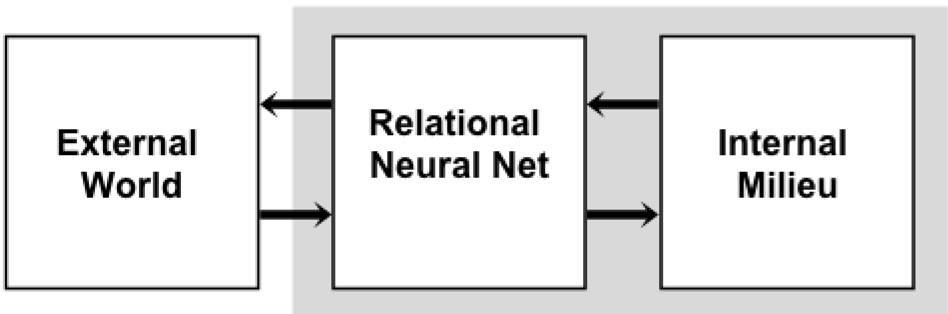


Figure 2. Interaction with Two Worlds

At the left we have the external world. At the center and right we've got the human organism. The *Relational Neural* net is Lamb's cognitive dome while the *Internal Milieu* is just that, the internal world of muscles and organs. The brain interacts with it through the autonomic nervous system and the endocrine system (cf. e.g. Panksepp 1998). This is the seat of motivation and emotion; to a first approximation, we act in the external world to keep harmony in the internal milieu. The vocal cry system operates through the same vocal system as the speech system and the ears that hear speech sounds also hear laugher and shouts of anger. Insofar as the internal milieu is expressed in language, we have Jakobson's emotive function.

Lamb's simple visual metaphor of the cognitive dome needs to be augmented to accommodate these facts. You can imagine this however you will. I wish only to make the point that it is this connectivity to the inner milieu that anchors the cognitive dome in an individual's life, in the hopes, dreams, desires, and actions of a person.

4. Thought as Inner Speech

This brings us to Lev Vygotsky's conception of thought as inner speech. The general idea is that as others direct the child's actions and perceptions through language, so the child learns to use language in controlling herself (Vygotsky 1962, Luria 1959). In effect, the child populates her brain with an other and uses that other as a mechanism to control her own mind.

When a young child is requested to do something, the linguistic channel in the child's brain analyzes the acoustic input and activates the appropriate cognitive and perceptual schemas. The command "come here" will activate a plan for locomotion while the command "look at the bunny" will activate a plan for directing one's gaze. As the content of the utterance is decoded, the motor schema, whether for moving her body or looking in a certain direction, is executed.

Not only can the child listen, she can also speak. If the child's utterance contains a command directed toward herself—and there is evidence on this (Vygotsky 1962 Luria 1959)—then she is using language to direct her activity in the same way that others use language to direct her activity. The route from the acoustic analysis to the execution of the action is the same in both cases, only the utterance's point of origin is different. In one case the utterance originates with an other, in the other case with the child herself.

The next developmental step, so Vygotsky's account goes, is that the child's self-directed speech becomes silent and internal. In a word, it becomes what is ordinarily known as *thinking* (cf. Lamb, 1998, 181–182). Given that this process starts with language which others direct to the growing child and involves mental structures for coordinating language and social interaction, this would make thought, in this sense, an inner dialog between virtual persons.

Some recent neurophysiological research bears on this. It has to do with what are known as efference copies, "internal duplicates of movement-producing neural signals" (Whitford, Jack, Pearson, et al. 2017). The abstract continues:

> Their primary function is to predict, and often suppress, the sensory consequences of willed movements. Efference copies have been almost exclusively investigated in the context of overt movements. The current electrophysiological study employed a novel design to show that inner speech—the silent production of words in one's mind—is also associated with an efference copy. Participants produced an inner phoneme at a precisely specified time, at which an audible phoneme was concurrently presented. The production of the inner phoneme resulted in electrophysiological suppression, but only if the content of the inner phoneme matched the content of the audible phoneme. These results demonstrate that inner speech—a purely mental action—is associated with an efference copy with detailed auditory

properties. These findings suggest that inner speech may ultimately reflect a special type of overt speech.

And inner speech, in Vygotsky's formulation, and Lamb's, corresponds to the common sense notion of thinking.

We must be careful about that idea of *thinking* or *thought*, for it is often used in an open-ended way to indicate a broad range of mental activity. That's not how I have been using the word. Saying that *thought* is *inner speech* is, in some measure, mere semantics, a matter of definition. Granting that inner speech is a real phenomenon, and that it comes about through a process of internalization, as Vygotsky has argued, let also us agree that the common sense notion of thinking seems to derive from it. We may also want to characterize various non-conscious mental activities as thought as well, but that is thought in a different sense. Given these caveats, it nevertheless seems remarkable to me that this most private of activities originates in a circuit of activity that necessarily goes through the external world.

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Reply to comments

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Abstract. This short paper contains brief replies to the comments that Richard Hudson, Timothy Osborne, Paul Rastall, and William Benzon made to my focus article, "Linguistic structure: A plausible theory", in this issue of *Language Under Discussion*.

Keywords: relational networks, tokens, types, dependency, referents, activation, structure, Vygotsky, inner speech.

I am grateful to the commentators for taking the time to produce their thoughtful remarks to my focus paper (Lamb 2016). I believe they require only brief responses from me, and I set them forth in the order in which the commentaries were received.

Richard Hudson

Tokens and Types. In relational network (RN) theory a token is the result of activation of a node or group of nodes representing the type. It is thus accounted for, for either producer or receiver, in terms of the operation of a linguistic system. The problem Hudson (2016, 40) mentions, that RNs do not provide for two tokens of the same type, would seem to be a problem only at the conceptual level of the network, but at this level it is not actually a problem after all, since whenever a new concept is actually introduced into or constructed by a system, that introduction consists of recruiting a new conceptual node, even though its representation at the lexical level may include a lexical item that is also used in representing another concept.

Hudson's assertion that a new node is needed "for every word, sound segment, letter or whatever" (Hudson 2016, 40), that is, for items at levels lower than conceptual, is not given any support and in my view is not supportable within the framework of RN theory. The

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problem here is the test of neurological plausibility: There are far too few cortical columns or neurons in the brain to provide separate neural representation for all the tokens of such lower-level items that occur during a lifetime, or even during a year of normal mentally active life.

Of course, as with any scientific endeavor, what we put forth as a theory at any point must be regarded as tentative, and while it accounts for a certain body of observations it invariably opens up further vistas, raising additional questions. And so I don't rule out the possibility that there is more to the problem of tokens that needs to be taken care of by future developments; it may be that linguistic processing requires ad hoc construction of strictly temporary nodes using neural equipment that can later be reused in new situations.

Dependencies. As Hudson's (2016, 40–41) account demonstrates, the dependency notation in syntax, which I have always found rather attractive, is a notational device providing an abbreviated means of representing information from two separate structural levels. But, as the original theory of "Stratificational Grammar" argued, it is essential, for complete understanding of language, to explicitly distinguish the separate levels. Using his example of 'French house', at the lexical level we have two words, while at the conceptual level we have the concept of a "French house", a subcategory of the more general concept "house"; and 'typical French house' is the lexical representation of a subcategory of "French house". At the lexical level we are indeed dealing with combinations, while at the conceptual stratum such nouns and noun phrases represent conceptual categories.

Incidentally, one of the interesting consequences of the RN approach is that categories actually seem to be represented as cortical territories, with subcategories as portions of such territorial representations.

Referents. Hudson's (2016, 41) comments concerning referents are quite cogent in my opinion. Hudson would want to provide network representations to referents in the outside world. His argument is generally in agreement with my position, which evidently was not presented with sufficient clarity. Relational networks do not provide cognitive representations for referents generally, since they are external to the brain and it would not be in the interest of neurological plausibility to attempt to represent them since they are too numerous for the brain's capacity. But conceptual representations of those selected referents that come to attention *are* represented mentally; they correspond more or less closely to what is "out there" and in awareness, although the correspondence is not as close as we might imagine, because of the vagaries of perception.

Activation. On the point of spreading activation, which provides a means of accounting for priming, I also agree with Hudson (2016, 41–42), and I have written about it elsewhere. An example is the topic of unintended puns, treated in *Pathways of the Brain* (Lamb 1999: 190–194).

Exceptions. In his comments on exceptions (or irregular forms) vis-à-vis default representations, Hudson (2016, 42) mentions the method used in RN, and I have never seen an alternative that works as well. Hudson's method depends on his treatment of tokens, which as mentioned above I find unsatisfactory.

Another point worth touching on is the treatment of the mentally pervasive 'isa' relationship, the relationship of subcategories to categories, as in 'a poodle isa dog'. In earlier work (e.g., Lamb 1999) I treated this relationship (in RN) with a node, as Hudson does, specifically the OR node. Now I see it differently, as a matter of cortical territories, as mentioned above. For example, animals appear to be represented in a particular area in the left temporal lobe, which is subdivided into subareas for different animals, while these subareas are further subdivided into smaller subareas, and so forth. This hypothesis, with supporting evidence, is discussed in the focus article (Lamb 2016: 30–33).

Finally, I agree wholeheartedly with the last paragraph of Hudson's commentary (2016, 42), in which he emphasizes the importance of linguistic investigation for an enhanced understanding of the mind.

I might add one further point that has not been mentioned in my earlier writing. The fact that relational networks can be seen as representations of actual neural networks of the cerebral cortex may tend to suggest that I believe *all* mental phenomena can be reduced to brain structures. This seems to be the prevailing view in cognitive science and in neuroscience, but I believe that it is mistaken, and that, especially if we look beyond language, for example to the phenomenon of consciousness and to various other phenomena (see for example Kelly et al. 2007), we easily find aspects of mind that are not so reducible, and must therefore be recognized as having existence apart from brain or any other matter.

Timothy Osborne

Osborne's (2016) comments concern the topic of dependency, one of the issues raised by Hudson and therefore a point that I have already commented on (above). Thus the alleged parsimony of dependency representation is a matter of notation, since dependency is, as mentioned above, a handy (and indeed clever) notational device for abbreviating information.

I just add one further observation: Osborne associates constituency with the work of Chomsky, but Chomsky used it because it was the prevailing method of dealing with linguistic combinations in the environment of mid-century American structural linguistics, a method that was practiced by structuralists in general, including his principal teacher, Zellig Harris.

Paul Rastall

Rastall (2016) has several provocative ideas in his commentary, but some of his points have problems that I will mention even though not all of them are serious. My responses are written in the order of mention in Rastall's commentary.

In his introduction, Rastall (2016, 51) states, "…Lamb (2016) proposes that 'linguistic structure' is a 'plausible hypothesis'". No, this is *not* what I was proposing. What I proposed was a plausible theory of linguistic structure; that is, taking linguistic structure as a given phenomenon (see following passage), I proposed a plausible theory to account for it. Rastall's next sentence also has an error: "He seems to mean that any linguistic organization or 'relational network' is a 'structure'" (ibid.). Perhaps I was not clear enough. I was taking 'structure', without seeing a need to define the term, as denoting whatever it is that enables a person to speak and comprehend, and to read and write in the case of languages that have writing systems. It is what, for example, a Mexican has that makes it possible for him to speak and understand Spanish, an information system of some kind that ordinary Americans don't have until and unless they take Spanish language lessons. And I take it as the job of the theoretical linguist to try to characterize that information. The relational networks arise out of the attempt to so characterize it.

This clarification of what I meant by the term *structure* will make it unnecessary, I hope, to respond to some of the issues raised in subsequent paragraphs of Rastall's commentary, including his section 2.

Thus, Rastall's third sentence is likewise erroneous in stating, "he appears to be … defending the idea of linguistic structure as 'plausible'" (ibid.). Rather, linguistic structure, in the sense just stated, is taken as the given, the information that needs to be accounted for in a realistic way. In this case, I also defined what is meant by *realistic*: The account must satisfy the plausibility requirements.

Now to an issue of an entirely different kind. In his next paragraph Rastall (2016, 52) writes, "His position is clearly 'monist' (i.e. it rejects a 'mind-body' dualism in line with most modern thinking in philosophy and neuroscience), advocating an "internal system' … activating all brain and physical mechanisms." This assessment is basically correct in the context of the paper under discussion, but it may merit some clarification. What I did, in writing the 2016 focus paper and in *Pathways of the Brain* (Lamb 1999), was to adopt, *as a methodological assumption,* the view that linguistic structure can be accounted for in terms of the brain. The value of such a methodological assumption is that it increases the motivation of the investigator to find a neurological basis. Without such motivation it might be tempting to give up too easily on troublesome problems of the investigation and to fall back on non-physical mental explanations. Proceeding on that assumption I did indeed find a neurological basis for language, and so one sees that the assumption was justified. But that fact does not in itself allow a jump to the conclusion that *all* mental phenomena have a physical basis. (That is something I used to say to my students when they would ask whether there might be any mental phenomena without a neurological basis.)

Rastall asserts that a phoneme like /t/ is a class, following a notion that was alive in linguistics a few decades ago. That concept is alien to relational network theory, where the closest thing we have to a phoneme is a nection or a node in the phonological network.

He also uses the concept of class in adherence to an apparent acceptance of the notion of a language shared by members of a speech community. In my paper I intentionally avoided getting involved with such an overly abstract notion as language (cf. Lamb 1986/2004), in favor of treating the linguistic system of an actual individual as a far more tangible entity. Rastall then goes on to bring up the ideas of Carlo Rovelli (2015, 42) concerning the 'blurred vision' we have because of our limited perceptions and intellects. I agree with his suggestion that Rovelli's point may be extendable to the world of social communication. He is correct in pointing out that, as he says, "Lamb's position is actually not too far from this".

I find the rest of Rastall's commentary interesting but not directly related to the paper under discussion, more easily relatable to conceptions of 'structure' from earlier days in the history of linguistics. I would claim that the various kinds of complexity mentioned can be accounted for in additional network structures not covered in my paper, which was, after all, an introductory account.

William Benzon

Benzon (2016) considers my metaphor of the cognitive dome, pointing out that one of its instructive features is the principle that no boundary can be found to separate the neurocognitive structure that supports language from that which supports cognition in general. Also important to emphasize is that it is only a metaphor and as such is, as he writes, "a crude conceptual instrument" (Benzon 2016, 74), a simplified representation of what is actually there in the neurocognitive system. He is also quite correct in pointing out that the 'external' world includes one's own body, an important observation.

We humans, in our feeble attempts to understand our world, like to visualize, so we build visual metaphors like the cognitive dome; but we need to remember that such metaphors and such visualizations are simplified models and that they can mislead if pushed too far. Some of the most interesting and challenging aspects of mind are doubtless beyond visualization.

Benzon's description of thought as inner speech is indeed in accord with my more extensive treatment in *Pathways of the Brain* (Lamb 1999) and the parallel to Vygotsky's formulation is welcome. I would only add that, as 'thought' and 'thinking' are ordinary non-technical terms, they are vague and ambiguous, and we have to recognize other kinds of mental activity that may or may not be included under these terms as used by different people, such as listening appreciatively to music, or meditating. And so I wholeheartedly concur with Benzon's final paragraph (2016, 77) while urging caution in the use of these terms.

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