**Pathways of the Brain**
**The Neurocognitive Basis of Language**
**Sydney M. Lamb**

## Chapter 1: The Window of the Mind

Words are not transmitted from the brain to the mouth and out - it is not a storer and processor of symbols.

Connectionism introduced by Carl Wernicke in 1874 and revised by Norman Geshwind in 1960's is used in clinical neurologists.

PDP explicitly avoids symbols but it is neurologically implausible.

Investigating Language
Historical-Comparative linguistics: comparing related languages across diverse tongues
Analytical linguistics: analysing, describing and categorising inc structural linguistics, generative grammar and functional grammar
Computational Linguistics
Sociolinguistics: variations in speech forms in relation to social differences
Traditional Grammar: tradition from ancient Greek and Latin
Prescriptive Grammar: rules about the correct way (There are dozens of alternative grammars)
Neuro Cognitive Linguistics: attempts to combine psycholinguistics and neurolinguistics.

"these mental subsystems are acquired by virtue of the almost automatic functioning of a vast network whose very nature is to acquire information (by building connections) as effortlessly as possible. The treatment of foreign language study in most schools and colleges, where it tends to be treated more as an intellectual investigation than as absorption of information through automatic mental processes, usually misses this important fact." pg8

"A basic problem of analytical linguistics is that there are an indefinitely many different ways to analyze texts and to classify their components which can be justified by data of the second kind." pg 10

Four kinds of evidence
- The organs and processes of speech production
- Linguistic productions of ordinary people.
- The processes of speaking and understanding
- The neurocognitive basis of language - the human brain.

The linguistics field and this book are characterized by a method of successive approximations....
The transparency illusion is that our minds make the internal process as invisible as possible.

## Chapter 2: Evidence of the first two kinds.

This chapter is a highly summarized (and often opinionated and dismissive) introduction to the history and practice of linguistics.

Speech and Writing are two distinct (and different) systems. They were originally similar but speech has changed more over the centuries.

Speech is more important than writing - children learn speech first - speech was developed thousands of years before writing - writing systems were based on what was spoken - in most human societies today writing does not exist or has been introduced recently - reading and writing skills have been typically confined to a few in society - when people think in words they hear them not see them - a spoken language can be written in various writing systems.

This book focuses on spoken language.

Phonetics

It is important that the transcription system used to record linguistic data is reliable.

Acoustic Phonetics - uses electronic instruments for study

Articulatory Phonetics - recognizes 1. the organs of speech (lips and tongue etc), 2. positions of articulation and 3. types of articulation. For most sounds there is a high correlation between the particular sound and the way it is achieved (ventriloquists and [r, s, z] are exceptions)

Phonology

Phonemes (ie /k/) belong at the level of PHONOLOGY, speech sounds and their articulations at the level of phonetics. The phonological level is more abstract than phonetic. Phonons include (Ap - Apical - with the apex of the tongue) ( Rt - Retracted - with the apex retracted or curved under) etc.

The term *morpheme* is used for the smallest meaningful unit of grammar.

There is a distinction between morphological and phonological segmentation. Grammatical units include discourse, sentence, clause, phrase, word and morpheme (e.g. re-act-iv-at-ions & sister-s). Phonological units include phrase, word, syllable, phoneme and phonon (e.g. Re-ac-ti-va-tions & sis-ters)

prosodic features e.g. Jennifer put her briefcase on

the *dining-room* table. Jennifer put her *briefcase* on the dining-room table. Jennifer put *her* briefcase on the dining-room table.

Words words words

syllables for a phonological word and morphemes for a morphological word need not be in the same place e.g. I'm going to vs i'm gonna vs amona.

Four types of word - phonological word, graphemic word (in written text), grammatical word (a combination of morphemes) and lexical word (aka lexeme). eg red herring is a single lexeme but two grammatic words. Consider American pit viper, undergo/underwent, understand/understood.

Meaning.

Paper, essay & newspaper correspond to one lexeme, paper.

Some terms to remember

Phonological units: phonological phrase, phonological word, syllable, phoneme, phonon.

Lexicographic units: Discourse, sentence, clause, phrase, word, lexeme, morpheme

The Word; phonological word, graphemic word, morphological word, lexical word (=lexeme)

**Chapter 3. The Stratification of Language.**

This chapter presents a brief survey of the kinds of relationships that are found between phonological expressions and their lexicogrammatical and semantic functions.

Arbitrariness - the relationship between the sound and the meaning is in principal arbitrary – but there are examples (high front vowels spoken with the mouth open correspond to smallness eg teeny/tiny slit/slot) and exceptions (big/small)

Quasi-morphemes – sl - tends to mean smoothly wet as in slide, slurp, slush, slip

The linguistic system is a complex of multiple systems. The levels of structure have been split into stratum (phonetic, phonemic & morphic) and tactical levels (word, phrase, clause, sentence etc)

- Realization: is the relationship between units of one stratum and another.
- Composite realization: where morpheme have more than one phoneme ie horse -> /hors/ = 4 phoemems
- Alternation: A morpheme has alternate phonemic forms eg wife/wives
- Portmanteau realization: combinations of morphemes have a combines phonological representation eg. Worse as a realization of bad (not bader)
- Reduplication: morphemes with phonological representation that are a duplication of part of their environment eg. In Monachi “paya” means water and “pappaya” means water in various places – puddles
- zero realization: plural forms of sheep and deer.
- Empty realization: an element can represent nothing at all on the higher stratus eg 'do' in 'I do not know'
- Neutralization: a unit on the lower stratum represents two or more on the upper stratum eg bet as in better or as in a wager.

An multilingual example is where one person has multiple languages but only one phonology eg “he speaks six languages, all of them in Russian.”. Children learning a different language tend to learn a new phonology as well.

There are also realization discrepancies within phonology and grammar:

- In phonology we have /nayf/ knife and /nayv-/ as in knives. The linguistic tradition is to “replace the 'f' with a 'v', but where and when does this happen?
- In grammar consider “the Queen of England's people” which has two syntactically different structures. Word boundaries need not

correspond to syntactic boundaries.

- In rough approximation most languages have 10-15 phonons, 15-65 phonemes, 5000-10000 morphemes and x0000's lexemes. Accordingly there are typically 2-3 phons per phoneme, 4-6 phonemes per syllable, 1-5 syllables per word and 1-4 morphemes per lexeme.

"Two concluding observations: 1. The linguistic system is not a single system but an interconnected group of different systems. 2. There is considerable world wide agreement among languages with respect to the overall organization of these structures and mechanisms." pg 49

**Chapter 4. A Network of Relationships.**

Objects and Relationships "the way to understand anything is to understand how it is related to other things to which it is related. The terminology is secondary – primary is the relationships" pg 53

"up" is towards meaning, "down" is towards production.

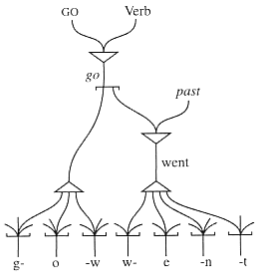

Figure 4-12. *The morpheme go as a location in a system of relationships*

The triangle node is an "AND" node. If the inputs arrive at the same point then they are concurrent, if apart then they are sequential (from left to right)

The other node is an "OR" node. The straight thru connection is the default path.

"***Recapping.*** If the relationships of linguistic units are fully analyzed, these `units' turn out not to be objects at all, but just points of interconnection of relationships. We may conclude that the linguistic system (unlike its external manifestations) is not in *itself* a symbol system after all, but a network of relationships, a purely connectional system, in which all of the information is in its connectivity.

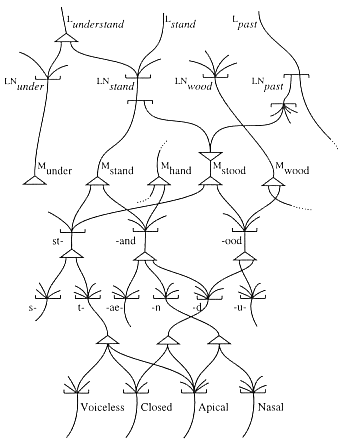

Figure 4-15. *Relationships from understand to phononic level*

As the information is in the connectivity there is no such thing as a separate memory, a place where things would be placed and from which they would later be retrieved. Rather, the memory is the connections themselves and is therefore widely distributed.

The form of network presented in this chapter is only a first approximation to the actual system. You will recall that we are using a method of successive approximations. As the exploration proceeds, we will be moving to notations with greater precision."

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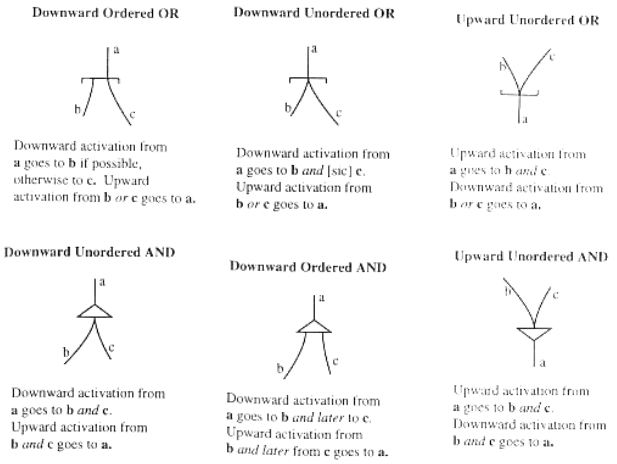
## Chapter 5. Components of Relational Networks.




For any notation system it is important to distinguish between the notation and what it represents. (eg consider a road map)

Nections. A internal line connects two nodes and has at least one end connected to the singular side of a node – all others are external lines. A Nection is one or more nodes surrounded by external lines.

We call this notation the compact notation but we also need the narrow network notation to expose the internal nection structure which is required to allow the two-way processing required.

Note in 5-7, four of the nodes in narrow notation are indistinguishable – one input, multiple outputs.

Note in 5-9, the new elements are inhibitory.

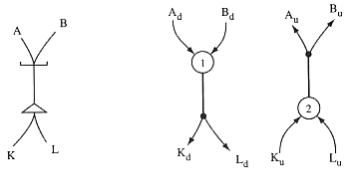


Figure 5-10. *Analysis of a compact nection into two narrow nections*

"Concluding observation: The relational network system is a parallel processor. Each nection is its own processor, and the ordinary operation of the system involves many nections, potentially widely distributed, working simultaneously and interacting in complex ways" pg 83.

## Chapter 6. Syntax

The idea of syntax is that although a structure is composed ultimately of words, its immediate constituents are (usually) larger than words, and they too have their own immediate constituents; there can be several layers of such constituents. Then a set of top down and bottom up rules are generated to describe the construction of sentences. Syntactic operations include producing clauses, preparation, master procedure, general rule application function, additional equipment and parsing. Not cognitively realistic.

Syntactic structure can be alternatively represented as a network.

" We now have a further reason why I consider it preferable to use lexumes rather than morphological words as the basic units of syntax. Lexemes have meanings; that is, they have semantic connections. Words as such have meanings only if they happen to coincide with lexemes, as they do only in simple cases.

Differences in sequencing are important to meaning – consider *He went back* vs. *Back he went*. To manage this we need to introduce a "wait" element which must be able to keep the activation alive during the period of delay and must wait for the appropriate amount of time.

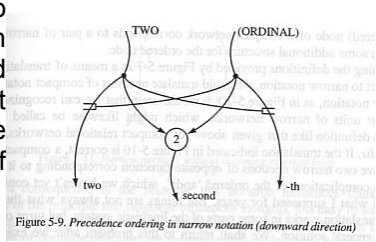



Figure 5-9. *Precedence ordering in narrow notation (downward direction)*

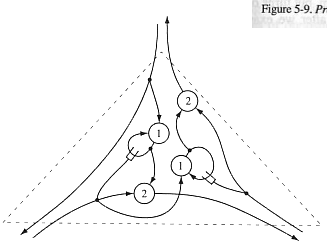


Figure 6-17. *A bidirectional ordered 'and' using feedback timing*

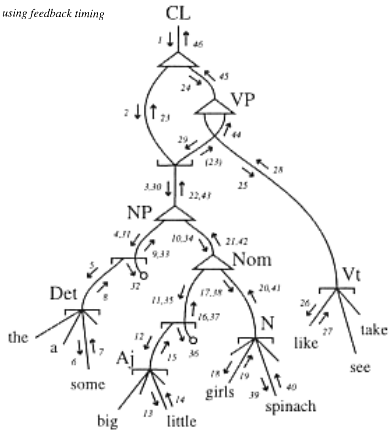



Figure 6-18. *Progress of activation during production*

## Chapter 7. Building models.

A basic function of the brain is building models. There is a real world, a mental system and a projected world. We build them with direct experience from the senses and hearsay (language) Four basic properties of models of the world:

1. the existence of boundaries,
2. the existence of enduring objects,
3. the basic difference between objects and processes, and
4. the existence of categories of objects processes and relationships.

Louis Hjemslex introduced analysis (breaking down) and catalysis (building up)

Introjective models (the opposite of projection) introject external features (such as language) into models of the mind or into internal representations assumed by such models. Introjection works ok on the direct output (speech) of the linguistic system but has difficulties when applied to indirect outputs such as writing and grammar.

The brain does not process symbols - that is a metaphor of a computer which is a little model of a human processing symbols with pen and paper (ie external extensions to the human mind). The hardware / software distinction is equally misleading. AI researchers overlook many important aspects of the biological brain.

The network model is not a metaphor, as it was constructed by considering the nature of speech rather than starting with a network (possibly neural) and applying it to speech. This has the advantage that the model can make predictions about the neural network which can be checked.

There has been a lot of discussion about neurologically implausible models. The models often have a few hidden layers with full connectivity rather than many hidden layers with 0.1% connectivity. These models start with random weights rather than zero which is strengthened. Biological brains start with minimal myelination (the insulation which enables neural impulse transmission) in the primary layers and builds its way out to the outer layers gradually.

## Chapter 8. Interacting Subsystems.

The linguistic system is not so much one system as a complex of multiple interacting subsystems.

All linguists have recognised a distinction between phonological and Lexicographical systems.

A higher level again is meaning where nections have meaning in as much as they are connected to meaning related nections.

Linguistics systems include both production and recognition capabilities. But. How is the system bidirectional? Are they separate systems? If so how do they communicate? Assume separate systems as a working hypothesis.....

Note that we can “hear” “inner speech” therefore we must have internal connections to activate the phonological recognition system.

Multilinguals that speak with an foreign accent do not hear with a foreign accent!

The dual system appears to introduce additional complexity but it really only distinguishes between a system where signals flow both ways and two interconnected systems with unidirectional signaling.

The recognition system is primary over the production system, probably larger and the former acts in the construction of the latter. language reception generally precedes production : vocab for reception is generally larger than production : articulatory production is monitored by reception in babbling of infants and the difficulty that deaf people have in learning to speak : “slips of the tongue” can be corrected : we can get from a words expression to meaning easily (meaning to word is harder).

Note in the visual system that when you visualize a bird you do not see an abstract “bird”, you actually

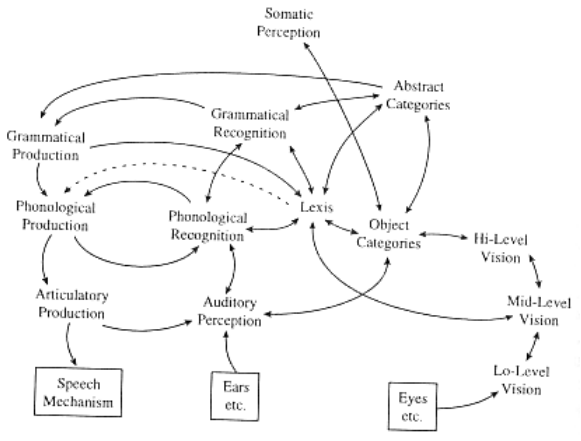



Figure 8-10. *Some mental subsystems related to language*

visualize a particular example of a bird, be it a sparrow, eagle, pelican or whatever.

I makes sense to consider one direction primary (and the other is in reverse) because the internal imagery is never as detailed as the reality.
But – the reverse direction is constantly operational – for instance when we see a babies head appear around the sofa we fill in the missing details.

We don't have enough terms in our language to label the meanings of all of the various kinds that we have. We have concept which is the multimodal integration of precepts (from a particular mode: audial, visual, olfactory etc). Part of the meaning of walk from a cognitive point of view includes what it feels like to be walking. We have nothing for the cognitive representation of a process so we introduce a new term PERFUNCT as the cognitive representation of a performable process. Also we introduce CONFUCT as the higher level cognitive representation of a performance.

**Chapter 9. Meaning.**

The lexeme cat is several steps removed from the concept CAT which includes images, audio, touch and other information received via language etc. Even the "object" concept is a product of our minds which relies on our tendency to mentally segment reality and assume self-identity through time of the resulting segments. "One of the consequences of the transparency illusion is our impression of the world comes in the form of objects, readily available to all and that language only needs to assign names to them." pg 142. Bengamin Lee Whorf noted that the world was more in the form of a "kaleidoscope flux"

Evidence for the distinction between lexemes and concepts: one lexeme can represent multiple concepts (polysemy) and concepts can be represented by multiple lexemes (synonymy). These usually go together – consider *hard* and *difficult*.

This chapter tests the hypothesis that conceptual structure can be represented by the same nections as linguistic structure. (nections can account for much but not all so some refinements are required).
"A crucial property of a conceptual system is that none of its concepts can be described without an account of its relationships to various other concepts." pg 147

A great deal of our knowledge about the world is about procedures and these procedures are hierarchical. These procedures are general and not about a particular instance (i.e. the dinner party procedure vs a particular dinner party.

Much of our knowledge is about people and their organization. Consider the hierarchical order of these however – ie since *male* is a property of *father* and *son* BUT *father* and *son* can be said to belong to the *male* category – so which is higher in the hierarchy?

"Our concept nodes for objects are actually nodes for conceptual categories." pg 151

"Generalizing this observation, we may say that the current impression we might have in our conscious awareness of a scene or a situation or a person results from a widely distributed representation of many nodes, usually of multiple subsystems; and it is the lower-level nodes, representing perceptual features, whose activation gives us our conscious experience, while the function of higher-level ones is to provide coordination of those lower-level nodes, so that they are kept active in concert. Those higher-level nodes provide the coordinated activation of the

nodes comprising the low-level distributed representations. They also make possible the coordinated spread of activation from one subsystem to another.” pg 152

A threshold node is required, of which AND and OR nodes are a special case.

When this is applied to social groups we again come up against the problem of deciding “which is more abstract?”

Events are instances of more general processes. Each process defines its own participants (they do not need to be made explicit in a sentence)

This chapter concluded with an open question. “How exactly are the nections for participants connected to those for the processes?”

**Chapter 10. Building Connections.**

Language development is largely a bottom up process in children beginning with gurgles but the learning continues through life.

Lexumes such as *hit* and *hit the sack* are built up from repeated use. Once they are stored as a unit there is no need for their meaning to be transparent (hit the sack is partially transparent)

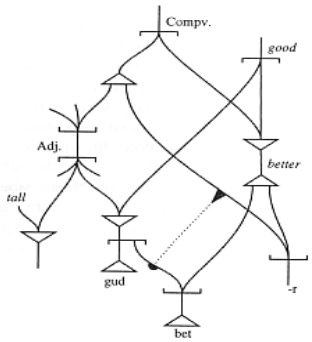
“The analytical linguist's revulsion for redundancy must make way for cognitive realism.” pg 164

New lexumes are initially constructed by recruiting existing parts but then the new lexume is gradually stored as a whole.

The lexical and idiomatic structures of a person may be expected to differ from those of all other people to some extent.

“SO we have two distinct processes; lexicalization, the recruitment of a lexical nection; and idiomatization, the process by which a lexical nection acquires its own distinctive semantic connections, often gradually.” pg 168

“complex lexemes must be recognized in a cognitively realistic model regardless of whether or not they are semantically transparent, for semantic obscurity is only a sufficient criteria for such recognition, not a necessary condition – complex lexemes may or may not be semantically obscure.” pg 169




“For cognitively realistic descriptions, it makes little sense to analyze lexemes into morphemes as much as is done in analytical morphology”. Pg 170 (eg break active down into act and -ive)

“Similarly, the word better is undoubtedly learned as a unit by just about everybody, despite its analysability into bett- and -er. The network structure for better as a unit for the comparison of good is shown in fig 10-3, with two coexisting catalyzes, since it is altogether likely, given what we know of the brain's ability not only to absorb details but to identify partial resemblances, that these two catylsis co-exist.” pg 171.

“So we hypothesis the presence of abundant latent connections which start out very weak, in effect zero

strength, and that each of them has the potential to grow stronger under suitable conditions.. ..... The process of learning a concept is a matter of recruiting a node which can integrate information from perceptual as well as other conceptual locations."

These processes are Darwinian in the sense that they are bottom-up (complexity built on top of the previous slightly more simple construct) and selection in the form of "winner takes all"

"1) The pathways of the brain are like pathways through a meadow or field or jungle - the more they are used the easier they become to use again. 2) Learning may be largely a process of selectively activating connections of latent nections - that is, recruiting nections for new functions. If so, the cognitive system is very adept at such recruitment, including the recruitment of high-level lexical nections for complex lexemes, both for those it has received and for those it makes up on the analogy of those it has received. 3) The learning that occurs in children uses the same process of connection strengthening that adults use. The difference between childhood learning and adult learning is mainly in the locations in which connections are being strengthened." pg 179

**Chapter 11. Traveling the Pathways.**

"Why is it that, in English and many others languages, the same form – who, which – are used for both relative pronouns and interrogative pronouns. Also when and where as in *their mother was on the phone when Tommy pulled the cats tail*. Also why in children as in *I did it why Tommy did it.* We have thinking without language as in musical or visual thinking. (note listening to music is one of the few activities that locks our thinking in the present rather than always thinking of the future or past)

phonological slips and cognitive mistakes are useful points of investigation to test the network (and other) models.

Inner speech is used for thinking, planning what to say and keeping a sentence alive while working to understand its meaning. People monitor their own speech externally but there are probably also internal inner speech loops to check what is about to be said. Similarly in comprehension when the listener supplies a missing word.

Consider "Are you ready to zoom to the camera store" the word zoom was probably chosen over go, go over, get over, get going or drive because of its connection with camera (zoom lens) and the network activation as a result.

"From analyses like those given above we may derive the following multi-part hypothesis: 1) The information system is a network (of course!) in which similar sememes are relatively closely connected, mainly by virtue of shared connections to ideonections representing their conceptual features of various kinds. 2) Activation comes in varying degrees. 3) Weak activation spreads automatically from an activated ideonection to those nections directly connected to it, and from there in turn onward, no doubt weakening with distance. Such spreading activation extends, by the same automatic Process, to lexical nections connected to activated ideonections. 4) Some activation gets through high-threshold nodes (for example, an `and' node) even if not strong enough to satisfy the threshold that applies in more prototypical circumstances. 5) When there is a choice of lexemes available to represent a given sememe, or a choice among related sememes appropriate to the situation, the one which has already been receiving activation, even if weak, is the most likely to be selected, other things being equal. 6) The activation spreads bidirectionally." pg 193

You don't get a reaction of humor from just being asked to visualise something weird. It also requires surprise and some global factors affecting thresholds

such as mood alertness and emotion.

Short texts commonly received in conversation involve constructing or strengthening connections and constructs an internal representation relative to the previously existing network. Changes at the semantic level occur less often (ie learn new concepts) but more often with children. It is essentially a creative process.

“Overlooking the creative aspect of interpretation can give rise to the illusion that meanings of texts are carried somehow in the message itself. This illusion is present in the common metaphor according to which messages convey information. They do not - they are just sounds. The information is the activated subnetworks of nections resulting from the travel of activation from the phonological nections that recognize the sounds. Consider the situation in which one person is telling another a story, and let us assume that it is a new story, not a familiar one. The interpretive process of the receiver includes building a conceptual representation of the events in the story and also of the participants if they are new to the receiver.” pg 198

The answer to the question at the top of the chapter is that What did John give Henry? Is an invitation to find something, triggered by an interrogative pronoun, is the same process as that called for by a restrictive relative clause.

Concluding Observations: 1) Speaking, speech comprehension, and most thinking are all alike in that all involve circulation of activity in the inner speech loop. 2) There is no such thing as the meaning of a text apart from an interpreter. And meaning is not conveyed by a text, as the usual metaphor would have us believe. Rather, elements of the text activate meanings in the minds of interpreters. 3) The processes of interpretation include (i) recognition, (ii) building of new structure, (iii) finding structure elements which conform to recognized criteria. 4) A text cannot be interpreted except by virtue of information already present in the system before the text is received. Understanding a text is a process of relating the results of its decoding to the already present information. 5) A text cannot be interpreted except by the construction of a semological representation which is connected, while being built, to those parts of the interpreter's internal information system which constitute the already existing information. The meaning representation of the text consists of newly connected nections and new connections to previously existing relational nections. 6) Semological structure can also be built on the basis of information from modalities other than the language, such as the visual. 7) Relative pronouns and interrogative pronouns have the same form in languages all over the world because they have the same basic cognitive function: an invitation to find a location in the cognitive network. 8) The linguistic-conceptual system of every person is different from those of every other person. There is therefore no possibility of perfect communication through language. 9) The meaning constructed by the receiver of the text is the same in all details and implications as that constructed by the sender only if the two have identical cognitive systems - that is, never.

**Chapter 12. The Ever-Changing Network.**

This chapter moves from a descriptive account of language to a view of how they operate and build – dynamic network relation theory.
Define creativity as the act of building networks of new connections by an internally guided process.
Lamb reviews the concepts of degree of activation, strength of connection and threshold function. In addition Lamb postulated a gradual unfocused weakening where a connection needs an ongoing level of activation to avoid atrophying. Focused inhibition can also occur when an existing connection is found to be too strong due to new information. "When there is enough activation on enough input lines of a latent nection to satisfy its initially low threshold, then those connections get strengthened a little and the threshold gets strengthened a little.

There are two ways of achieving repeated occurrence – an external and an internal mechanism – and the internal mechanism in turn has two kinds – thinking again about the combination and that which automatically occurs right away. That is, additional connections will be required for bi-directional processing and so these connections provide a path for internal reactivation.

".... integrating nections will tend to be maximally close to the nections for the features that they integrate." pg 218 "Assuming uniformity of speed of transmission for these latent connections, the limiting connecting property is that whose nection is farthest away. Thus among several competing candidates latently connected to a given combination of property nections, the one winning the competition will be that whose longest connection from the property nections is the shortest." pg 221 (a question! How does the nection know when all triggers have arrived???) "... as competing connections will tend to be adjacent ..... (there would need to be) inhibitory connections are present as built in features ..... even before any of them have been recruited for a specific use." pg 222

**Chapter 13. Sources of Linguistic Patterning.**

Types of patterning: 1) analysis of words into morphemes 2) Iconism of phonological features and complex phonemes (slip, slide, slurp etc) 3) Pholological alternation (sane & sanity, Nation and national) 4) symmetry in phonological systems 5) grammatical categories (noun and verb) 6) word order correlations (SOV japanese and Korean vs. VSO Tongan vs SVO English and Chinese)

Possible sources of patterning: 1) historical data altered over time 2) redundancy similarity 3) Epiphenominal reflections of other structures 4) Patterns due to ingenious linguists 5) chance.

Consider hamburg-er vs. ham-berger. There original came from Hamburg in Germany but the addition of chicken-burgers, beef burgers etc has made ham-burger more salient. Both can be represented in the brain as supporting structures.

The distinction between noun and verb makes cognitive sense as they mirror the fundamental cognitive structures, Object and Process. Verbs represent a process and a verb phrase represents an event (a verb is not an event). Noun and verb are merely labels of more profound perceptual systems (from both an evolutionary and developmental standpoint)

"... objecthood depends on our assignment of boundaries and the assumption of continuation through time with self-identity, properties bestowed by our minds then projected onto them." pg 241

"phenomena which are similar will automatically be perceived as more or less alike ..... (similarity) means having shared features; two nections will treat phenomena as similar to the extent that they share input lines and to the extent that the shared input lines have similar strength" pg 243

There is **Diversity** in linguistic expression as a consequence of the fluidity of language (both within and among persons) and some of these variants are more likely to **survive** than others.

"cognitive systems automatically support similarity ..... prepositions are like verbs in requiring objects and therefore ordinary people will (in effect) expect them to behave like verbs, and will therefore tend to treat them like verbs." pg 247

## Chapter 14. Sequence Management

Three possible mechanisms for sequence management - feedback timing, clock timing and self-contained delay element (which fires a short time after an activation is received). This problem of sequence management extends to many other areas such as dancing, playing games, music etc. The actual mechanism(s) in use is an open question.

Note that inner speech operates far more rapidly than actually speaking.

With semology sequencing is important to determine meaning - consider Todd kissed Susan. There is a proposal of a kind on interleaving of the two concepts to enable this to happen (seems unlikely to me)

Traditional linguistic treatment introduces both sequence and structure into language. The network approach is able to represent the "sequence" observed in language without introducing a "structure".

"The analogical principle can account for much of the ability of people to interpret and form new combinations; they simply make appropriate substitutions in previously learned combinations used as exemplars. This analogising ability would appear to be innate and universal. Moreover, the term 'universal' here may apply not just for language, as the process of forming and interpreting new combinations seems to be a very general mental ability, used in a wide variety of modes of behavior and perception.." pg 263.

Mutabel lexemes include "mother of all things", and "something is rotten in the state of louisianna". An example of a mutable sememe is "animal eat food".

How does a child learn the ordering of the major constituents of the clause? It is not possible to understand what eating is apart from eaters and eatees. The concept of the eater, eatee and eat must already be known before the label eat and its appropriate sequence is learned. "all conceptual similarity is based on shared connections, so different degrees of similarity differ in the quantity and strengths of shared connections" pg 270.

"... similarity supports itself; similarity is self reinforcing in cognitive systems and in the societies in which cognitive systems interact with each other." pg 271.

## Chapter 15. Linguistic Illusions.

In this chapter Lamb addresses a number of aspects of linguistics where academic effort has been expended on illusions.

Semiotic Fallacies - The failure to distinguish between the signifier (expression) and the signified (meaning) "it appears to be especially prevalent among schizophrenics and among postmodernists" pg 273. This is where the chosen notation influences scientific thought.

Monosemy assumption - that there has to be a single core meaning to any linguistic form - consider "throne of gold" vs "woman of gold" which makes this assumption untenable.

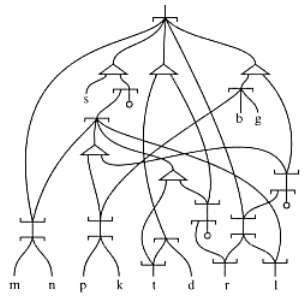


Figure 14-3. *English initial consonant clusters: Lockwood's account*

Linearity in phonology - written language is sequentially linear but spoken language is only largely linear. Words and morphemes as Illusionary objects - they are only tokens of the activation of a nection and do not exist as objects.

The illusion of rules of grammar - processing grammatical rules requires a homunculus and a means and place to store the symbols. There are also practical problems of processing these rules in the time that a real brain works.

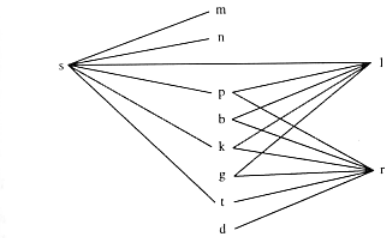


Figure 14-4. *English initial consonant clusters: Fischer-Jørgensen's account*

A single system vs a complex of multiple systems - People don't speak a language or not, they have a degree of fluency with a language. Language did not suddenly appear, it developed over time (better to ask if all of the spoken languages of the world evolved from a common source). There was no first language mutant (she

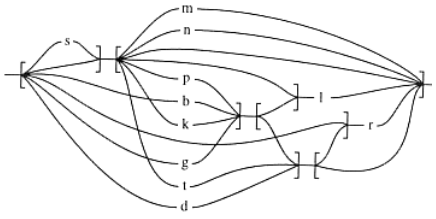


Figure 14-5. *English initial consonant clusters: Third version*

would have had no-one to talk to!).

Language and thought - we can and do think without language.

Language and intelligence - intelligence is not a thing, it is a combination of many diverse phenomena.

**Chapter 16. Introducing the Brain.**

This contains a very succinct summary of the brain anatomy. The 32 pages are already in summary form.

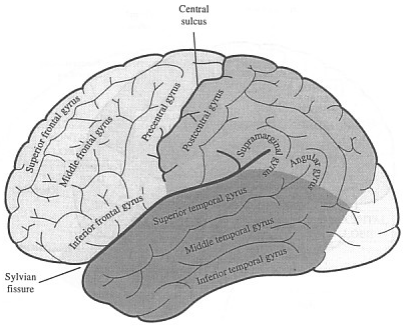



Figure 16-4. *Some details of the left cerebral hemisphere*

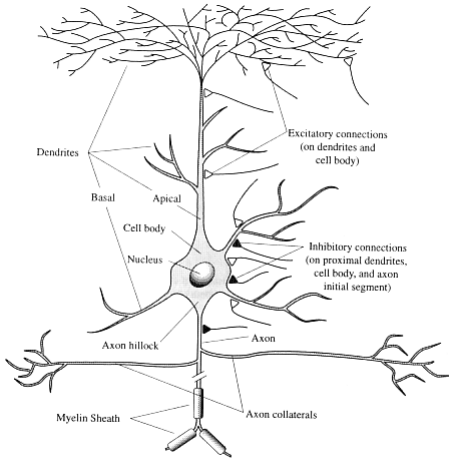



Figure 16-9. *A typical cortical neuron (scale: x500)*

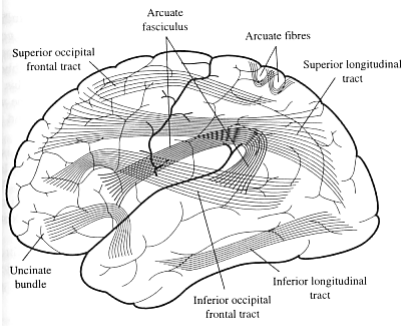



Figure 16-6. *Some long-distance fiber bundles*

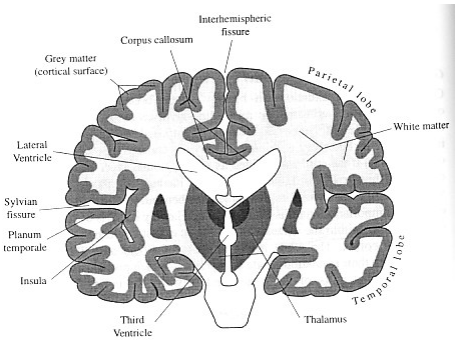



Figure 16-7. *Coronal section, showing grey and white matter*

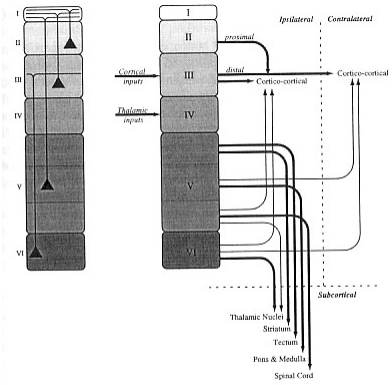



Figure 16-11. *Laminar distribution of pyramidal cells (at left) and extrinsic laminar connectivity (at right)*

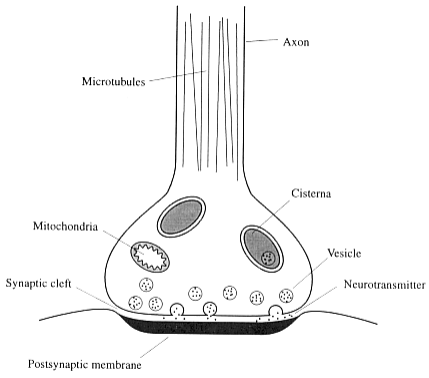



Figure 16-12. *A synapse (scale: x100,000)*

**Chapter 17. Neurons and Nections.**

The bottom up linguistic modeling process seems to be supported by observations into brain structure. The amount of activation coming into nections and neurons are variable, exitory or inhibitory and determines the output. The abundance hypothesis seems valid for both nections and neurons. The proximity hypothesis seems to be supported but with some adjustments regarding the speed of transmission available to different neurons. The cortical column seems to offer a viable implementation of a nection. The various properties of excitory and inhibitory connections appear to be supported by a large variety of neurons. There is neurological evidence to support bidirectional processing. Neurons seem to have a vast oversupply of connections (but most of them may well be latent).

Network modelers favor distributed representation over local representation. However, Lamb argues that distributed and local (functional) representation can exist in the network. He uses the traditional example of implementing and XOR function with 1 hidden layer and observes that, after training, the hidden nodes come to a functional representation of the two parts of the XOR function (ie a local functional representation).

Relational network representation of conceptual categories - includes a discussion about learning a category (the nexus of many prototypical elements) and learning an instance of a category (ie the category of cats vs a specific cat) where additional specific featured are encoded. The discussion includes the concept of feedback connections which activate other features of the category.

Local representation would seem not to have the feature of graceful degradation that we experience with brains. However, the 100's of neurons that die each day may well be the latent ones and when brains experience specific damage (such as a stroke) they do in fact experience loss of specific function. Further, there are multiple neurons in a cortical column (which implement a nection), and hence potential redundancy. (Another option in my opinion is that even if the "CAT" nection is lost then the remaining distributed representation simply recruits the next most viable nection)

Some (very) rough estimates of the number of neurons required resulted in order-of-magnitude viable results.

**Chapter 18. The Anatomy of Language.**

## APPENDIX

### Some Basic Principles of Neurocognitive Linguistics

1. We have to distinguish between the texts of a language and the system which is capable of receiving and/or producing texts. The latter may be called the linguistic system. We must also distinguish both of these from the processes of producing and understanding texts.
2. Linguistic structure can only be understood in the context of actual human beings, as an information system present in a person, a cognitive system.
3. There is no reason to suppose that properties of texts are directly present in the linguistic system. On the contrary, there is good reason to believe otherwise.
4. The linguistic system is connected to other subsystems of the overall cognitive system.
5. The mind is not a device for storing and rewriting symbols but a network system, whose information is in its connectivity.
6. The cognitive system does not have nor does it need places to store symbols like those of taxonomic or generative linguistics, or of rule based artificial intelligence models. Since its information is in the connectivity of the network it requires no storage space other than the network itself.
7. Likewise, the cognitive system does not need a little homunculus to interpret rules or other symbolic representations. It does not contain a symbol system. Rather, it is a system which interprets symbols coming to it from outside and which produces symbols.
8. The cognitive system does not need devices for comparing perceived inputs with internal representations in order to recognize things. Rather, recognition of something is the activation of the nection which responds to it as a result of activation of the nections which respond to its features.
9. The cognitive system is a parallel processor. Each nection is its own processor.
10. Learning is a process of selectively activating connections of latent nections.
11. `Constituent structure' is an epiphenomenon of the linguistic system, not a property directly present in it. The properties which led to its observation by linguists are (i) transition structures and (ii) semantic/functional connections.
12. Synchronic relations must be distinguished from diachronic processes.
13. The linguistic system can change at any time, and it can be expected to change every time it is used. Such changes in the network structure are of various kinds, mainly changes in strengths of connections and strengths of thresholds.
14. The linguistic system cum conceptual system of every person is different from those of every other person. There is thus no possibility of perfect communication through language. On the other hand, there are some similarities between the systems of any two persons from different parts of the world, allowing some degree of communication even among people who would commonly be thought of as speaking different languages.
15. The linguistic subsystems have their basic structural properties in common with other cognitive subsystems, including hierarchical organization and similar nection structures and network operations.

### Arguments for the Relational Network Hypothesis

1. If we start from the hypothesis that the linguistic system is made up of objects and then analyze the relationships of these objects to one another, we find that all of their properties are accounted for by those relationships. Their hypothetical `objectness' is therefore superfluous.
2. The linguistic system can't work as a system of rules and symbols, or a system of symbols and `patterns', the only other possibilities that have been proposed. The mind does not have little internal eyes (or other sensing devices) to read such symbols nor little internal devices and media to write and rewrite them with.
3. A network model applies well to obvious non-linguistic cases, such as the transmission of activation from the retina through the several levels of the visual perceptual system, from cognitive levels to muscles, etc.
4. The network model helps to explain phenomena of learning otherwise mysterious and unexplained, such as how analogy works, as in children's production of brang as the past tense of bring.
5. The network model provides a means of explaining phenomena involving association, including (i) context-driven lexeme selection, (ii) slips of the tongue, (iii) Freudian slips, (iv) Freudian forgetting, (v) the effects of connotation.
6. The network model provides an easy way of handling `fuzziness', prototypicality, and adaptability of the system to changing conditions and new situations, as well as the gradualness of learning of lexemes.
7. The network model allows all the linguistic

information of the system to be present at once and able to operate in parallel with other parts of the system, while also being organized in different structural levels - i.e., it has different levels without requiring serial processing on one level at a time.

8. The network model provides a simple and efficient means of accounting for the use of experience and of encyclopedic real-world knowledge in semantic interpretation.
9. A network with parallel processing can account for our ability to instantaneously recognize a face in a crowd and to instantaneously access the meanings of words coming rapidly in conversation - without searching, without the numerous comparison operations that would be necessary in a symbol-based system.
10. The network model correlates well with what is known about the brain from the neural sciences, increasingly well with more recent and current findings.

**Some Properties of Relational Networks**

1. Multiple subsystems, in different regions for different functions (phonological recognition, lexis, etc.), each with multiple layers, different numbers of layers for different subsystems.
2. Bidirectional connectivity: both feed-forward and feed-backward connections (i.e. to upper and lower levels), plus inhibitory connections to the same level. Feed-forward and feed-backward connections can be either to immediately neighboring levels or more distant layers or both.
3. Not fully connected - each unit is connected to many but not to all units of neighboring layers.
4. Connections have weights (strengths).
5. Connections carry degrees of activation, a given degree at any moment. Excitatory connections carry varying positive values, inhibitory connections carry varying negative values.
6. Activation on a connection at a given time is the product of its weight and its current value (degree of activation).
7. Each node collects activations from all incoming connections as `net input', adding excitatory activations, subtracting inhibitory activations.
8. Each node has a threshold activation function to determine the activation value to send out as a function of net input.
9. All nodes operate in parallel.
10. All learned items of information above the lowest levels (i.e. those at the interfaces) have functional distributed representations, headed by strictly localized convergence nodes at the highest level, which provide coordinated, potentially multi-regional, activation of lower-level nodes.
11. Initial state (before learning): Each node has, initially, many very weak connections (latent connections) to many but not to all nodes of neighboring layers. Such connections can be both local (intra-regional) and distant (extra-regional).
12. Bottom-up learning: Connections are strengthened when they are active while the node to which they are connected has its threshold satisfied; concomitant with this strengthening, the threshold function is adjusted, to be `less easily satisfied' in the future. Attention also plays a role, utilizing activation from a central area that has broad access throughout the cognitive system.

**Application of the Model to Conceptual Categories**

The following properties pertaining to conceptual categories should emerge automatically as consequences of the learning process as applied to the general structural and operational properties of the relational network. For confirmation, tests with a large-scale computer model are needed.

1. A category is represented as a subnetwork constituting a coarse functional distributed representation, headed by a central localized coordinating (convergence) node. The distributed representation is built on the basis of exemplars that have been experienced, and incorporates information of perceptual modalities as well as other concepts and is connected to the lexical system.
2. After activation by a sufficient number of exemplars, the properties most relevant for a particular category will have stronger connections than those for more peripheral properties.
3. Most of the casually encountered exemplars of a category get no separate representation but are temporarily represented as specific activation patterns (subnetworks) connected to the (one or more) high-level conceptual nodes which fit them.
4. An exemplar (eg. a particular person) which receives sufficient attention or induces sufficiently repeated activation is remembered, by means of a specific node that becomes dedicated to it, connected on the one hand to its properties and on the other to the one or more high-level coordinating nodes for categories in which it `fits'. Its individual properties are represented by a distributed representation, a subnetwork, comprising a subset of the nodes

of the subnetwork for those categories.

5. By virtue of feed-backward activation from a category node to the nodes for its relevant properties, activation of a category subnetwork will provide heightened activation to that subset of nodes currently receiving activation from the senses to which it is connected. Perception is thus a bidirectional process.
6. Feed-backward activation will also trigger inferences, correct or otherwise, by activating nodes for properties which have acquired strong connections to the central category node because of prior experience even if not currently receiving sensory input (eg. we can see only a part of a friend's face and perceive the face as a whole).
7. Some such inferences may be unwarranted in the particular instance; this is the source of errors association with `thinking in categories'.
8. The question of whether a given exemplar is or is not an example of a given category is answered by means of the spread of feed-backward and feed-forward activation. If the activation from nodes representing properties of the exemplar is sufficient to satisfy the central category node, then it is accepted as an example - such acceptance can be of varying degree, less for peripheral exemplars than for prototypical ones.

**Additional Reading**

Gerald Edelman 1987