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Article

Relational Network Theory as a bridge between linguistics and neuroscience: An interview with Professor Sydney Lamb

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Abstract

Sydney Lamb is the creator and main developer of Relational Network Theory (RNT), a neurocognitive model of language. The theory's major manifesto, titled Pathways of the Brain, *was published in 1999. In several conferences given since then, Lamb has introduced a number of refinements, most of which have not appeared in print. Besides,* Pathways of the Brain *leaves open several questions which prove crucial to the theory's long-time followers and newcomers alike. In this interview, Professor Lamb discusses historical, technical, and practical aspects of RNT, addressing both recent innovations and recurring queries.*

KEYWORDS: COGNITIVE LINGUISTICS; LANGUAGE STRUCTURE; NEUROLINGUISTICS; RELATIONAL NETWORK THEORY

Introduction

Professor Sydney Lamb is arguably one of the most underrated linguists of our time. He is the creator of Relational Network Theory, a major theory of language that seems to offer an elegant synthesis between linguistics, cognitive science and neuroscience; he was the founder of the linguistics department at Rice University; his name has long been an entry in the *Encyclopaedia Britannica*; and he has been recently recognized as one of three

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luminaries in the field of language to have graduated from Yale University.[1] Any linguistics scholar with such credentials should require no introduction to those operating within the discipline. Yet, somehow, most of Lamb's work and ideas remain largely unknown to both professional and aspiring linguists.

Perhaps because of such a lack of recognition, not many interviews with Professor Lamb have been made available in academic circles. To the best of my knowledge, there are only three interviews that can be easily found in relevant media. The first one was first published by Herman Parret in 1974 and more recently reedited as a chapter in *Language and Reality* (Lamb, 2004a). Given the development of the theory at the time this interview took place, no reference is made to its neurological implementation. The second one, which was conducted via e-mail in 1998 and published the following year in a Chinese journal by Cheng (1999), deals with broad generalities of Relational Network Theory and offers no information that is not already available in its neurocognitive manifesto, *Pathways of the Brain* (Lamb, 1999). The third one was actually not a single interview but a series of interviews conducted by J. Paul Sank and aired in his Life-Net News & Radio. These were divided into ten MP3 files – each one dealing with a separate question. Both Cheng's and Sank's interviews can be found online at http://www.ruf.rice.edu/~lngbrain/.

Although somewhat outdated and even sketchy at times, such interviews can be seen as suggested preliminary readings to the present one, insofar as I have tried to avoid questions dealing with points already covered in them. Moreover, this interview might serve as a companion – or even an appendix – to Lamb's *Pathways of the Brain*, since it seeks to offer more precision regarding some of the topics the book addresses.

Without further introduction, what follows is the full transcription of an oral semistructured interview granted to me by Professor Lamb on November 5, 2011, on the occasion of his scholarly visit to Argentina. The questions have been organized in three parts. Part I deals with Lamb's influences and conception of language. Part II addresses some technical aspects of Relational Network Theory. Finally, Part III is devoted to the discussion of the applications, limitations and prospects of Lamb's proposals. Part II, in particular, presupposes some technical knowledge of relational networks. The other two are aimed at general audiences. It is my hope that this text will raise interest in, and divulge the views of, one of the foremost thinkers in the field. To this end, footnotes have been copiously used as references to various texts where specific ideas of Professor Lamb are explained in greater detail.[2]

Part I: Influences and conception of language

1. Professor Lamb, thanks for granting me this interview. I would like to begin by asking you who your main influences in linguistics have been.

First, I think I would mention Louis Hjelmslev, the Danish linguist. I never worked with him, but I read his *Prolegomena to a Theory of Language* (Hjelmslev, 1961[1943]),[3] to which I was introduced by one of my Russian professors at the University of California, Berkeley, Francis Whitfield. He is the one who translated Hjelmslev's *Prolegomena* into English from the Danish. And he also introduced me to linguistic theory, which I found to be very fascinating. Up to that point I had been planning to specialize in Slavic linguistics, which I now find particularly boring [*laughs*]. I was also influenced by another professor, Murray Emeneau, a fine gentleman who just died a couple of years ago at the age of about one hundred. And there was Mary Haas, the great American Indian language specialist.[4]

I must also mention Charles Hockett. I actually met him back in my days as a student, when I attended the Linguistic Institute held at the University of Chicago. (In the US we have Linguistic Institutes every summer, though nowadays they are held every other year.) Hockett was one of the (visiting) faculty members that year. I read his theoretical writings and I realized he and I were thinking along the same lines, back in the days of the structural linguistics of the mid-1950s. At that same Institute, I also met Floyd Lounsbury, a great anthropologist from Yale. I took a course in Iroquoian languages with him. In that course I was the only student – a very specialized topic, Iroquoian languages. In those days, teachers didn't have any PowerPoints or overhead projectors; instead, they would write things on the blackboard. So he would write things on the blackboard and I would copy them; but since I was the only student, one day he said: 'Why are we doing this? Here, look at my notes!' [*laughs*].

2. You mentioned that Hockett and you were thinking along the same lines. What notions did the two of you share?

In those days, structural linguists were trying to figure out the nature of the phoneme – that was mostly in the 1930s – and then by the time of the late 40s and early 50s, the focus was on trying to figure out the nature of the morpheme – the morpheme being a unit intermediate between meaning and phonology. Some people would say that it is a combination of phonemes, but that's not enough. And others would have different theories about it. Hockett was interested in that question and so was I. As a matter of fact, that question is what led me to the discovery of relational networks. Hockett had meanwhile come very close to that. In the early 60s, he published an article called

'Linguistic elements and their relations' (Hockett, 1961), in which he came very close to that same discovery, but he didn't quite get there.

Eventually I got there myself with the help of my other major influence, Michael Halliday. Actually, Halliday and I were influencing each other. We got together one day and I said 'I like your analysis of the English tense system,' and he said 'Well, I like your idea of stratification and realization.' He had been using the term 'exponentiation' and he said 'I'll use the term "realization" instead.' We were trading back and forth.[5]

I met him in 1964, and he showed me his notation for what he was calling systemic networks. At that time I was working on the problem of linguistic elements and their relations, and saw that his network notation was just what I needed to clarify my thinking about linguistic relationships. It was precisely in the fall of 1964 that I came to the discovery that language structure is a relational network. It doesn't have items or objects of any kind; it's all relations. I was aided in that by the help of notation. You know, we don't really think in the abstract. We think with the aid of words, or symbols, or notations of some kind. Now, that language is a system of relations is something that Hjelmslev had already said in his *Prolegomena* (the Danish original was published in 1943), but he had never demonstrated the truth of that idea. It wasn't until we had relational networks as a notation that it could be demonstrated.[6]

3. Are there any contemporary linguists whose work you admire?

Yes. I still admire the work of Michael Halliday. He's about five years older than I am, so he's been like my older brother in linguistics from the very beginning. I saw him most recently one year ago at a conference in China, and he's the linguist whose work I still admire most.

4. For over half a century now, you have been a fervent opponent of Chomsky's views of language. Your writings make it clear which generative theses you consider flawed. However, are there any generative principles or constructs that you agree with?

When I first heard about Generative Grammar and Chomsky, I was in that same Linguistic Institute where I studied with Hockett and Lounsbury. It was probably 1955 when I first heard of Chomsky. He and I both were in agreement that there were certain things about structural linguistics at that time that were misguided and needed to be changed.[7] To that extent, we were in agreement from the very beginning. But his proposals for bringing about that change turned out to be rather flawed, in my opinion.

Still, we were in agreement about some of the things that needed to be changed. For example, in structural linguistics, most people were using a procedural orientation. Instead of talking about linguistic elements and their relations, as Hockett did, they were talking about procedures that could be used, theoretically, to discover the structure of language. But you don't need to state a theory in the form of a discovery procedure. What you really need to do is to say what the relationships are, not how they would be discovered. Chomsky said that, and I was in total agreement. In fact, I was going to write an article about this topic and then I realized that Chomsky had already done it!

So this is where I agree with Chomsky. But I disagree with him on the grounds that he also has procedures in his theory that are undesirable. He didn't have discovery procedures, but he had derivation procedures – procedures for deriving sentences from, essentially, other sentences.[8] For example, in the passive transformation, first you start with a sentence in the active form and then you end up with a sentence in the passive form. That seemed to me wrongheaded. He then introduced the distinction between deep structures and surface structures. That would have been a good idea, if he had done it correctly. But he didn't do it right, because his way of getting from deep structure to surface structure was by a series of procedures. And that's not right. Deep structure is a structure, and surface structure is a structure, and what you need to do is show the relationships between them. And the best way to do that is *not* by means of procedures. Then there was the group from Ohio State – MacCauley, Lakoff, and Fillmore – proposing an alternative that maybe we should go from surface structure to deep structure – the so-called Interpretive Semantics. But that was also wrong, because you should do it without a procedure at all. You should have relationships that you could traverse in either direction.

5. Given all this background, what is your definition of language nowadays?

Let me begin by saying that I don't like that kind of question. I know that it's been common for people to try to define language … but aside from that, we have to be clear what it is we are trying to define. The trouble is that the term 'language' has many different meanings; so, which one of those is it that we are trying to focus on? Instead of trying to define language, I try to think of what it is that we're interested in. One thing that we can be interested in is linguistic structure, and we can look at that either in an abstract form – which is what most linguists do – or in a concrete form. If you choose the former, it gets very confusing, so I prefer to look at language in a concrete form, by considering the system that people have in their brains, which makes it possible for them to speak and understand speech. That linguistic system is what I focus on. It is a physical system. Of the many meanings of 'language', that's the one that I choose. I would say that, by way of definition, it is a physical system located in the brain consisting, essentially, in a system of relationships.

Now, let me give you a little contrast. Many people have tried to define language as something used by a social group – the speech community.[9] This leads to all sorts of problems when you try to define it, the main reason being that every member of a speech community actually has his or her own system, which is not exactly the same as that of any other person in the community. So it's impossible to define language as a system used by a group. That is too vague a concept. But you *can* define the individual linguistic system, in terms of the individual's brain.[10]

6. In that sense, one of your main proposals is that the individual linguistic system is not just 'one big system,' but that it has internal structure.

It does have internal structure, yes; and it can include knowledge of two or more languages. Usually it includes fragments of knowledge of many languages. And there too you have great differences between the systems of different people. Some people maybe know a hundred words of German, along with their English, and then fifty words of Spanish, and so on …

7. Evidently, yours is now a neurolinguistic theory. How do you conceive of neurolinguistics and how did you become interested in it?

First we should discuss what linguistics is. Linguistics, officially, is the science of language. Some researchers study phonology; others focus on semantics; still others work on comparing different languages and describing their respective evolution through time. However, not many people are operating in neurolinguistics, the field which studies how linguistic information is represented in our brain. This is what I'm interested in.

The field of neurolinguistics, a combination of language and brain studies, got started in as early as 1861, we might say. That year, the French doctor Paul Broca, studying people with brain damage, discovered that patients with damage in their frontal lobe were unable to speak, but they were able to understand language. Then, in 1874, Carl Wernicke had a patient who had sustained brain damage in his temporal lobe and couldn't understand, but was able to speak. This began the study of brain damage in relation to language.

My interest in the field, however, was sparked differently. Several years ago, my daughter Sarah was learning how to play the piano. She was six back then. I already had some intuitions as to how our cognitive system actually works, so I asked her: 'Sarah, when you hit that key with your finger, how does your brain tell your finger what key to hit?' She thought about it for a while, and then told me: 'Well, my brain writes a little note and then sends it down to my finger; then my finger reads it and knows what to do.' If you think about it, that doesn't quite make sense. Does the brain have a little pencil in there, and a piece of paper? And how does that piece of paper get down to the finger? And how does the finger read the note on that piece of paper?

We can ask the same question about how people talk. How does your brain tell your tongue what to do when you want to say a particular word? It doesn't write a little note, because there are no papers or pencils inside it. There must be another way. And, of course, there is: It's all done with connections – specifically, nerve connections. There are connections that go from the brain to that finger and move the muscles that make that finger work. In the same way, there are connections going to the muscles in your tongue. If I was going to figure out how language works, I had to do it without symbols. We can't assume that there are little papers with symbols and little eyes to read those symbols, and so on. It just doesn't work that way. That's basically how I got into neurolinguistics.

However, I discovered that language is a system of relationships before I knew anything about the brain. When I was giving presentations on this theory, people kept pointing out that relational networks resembled neuronal networks and asking me whether they were related in any way to brain structures. All I could say then was 'I have no idea!' I didn't know anything about neural networks. So I figured maybe I'd better learn something about the brain.

I was teaching at Yale at that time. I found a neuroscientist who was also working there, called him up, and invited him to have lunch. During that lunch I asked him to explain to me how neurons worked. He started drawing pictures on the paper napkins to show me how neurons are connected, and how impulses travel from one neuron to another … and the more he told me about how neurons work, the more astounded I was, because several aspects corresponded to relational networks, which I was developing on purely linguistic evidence. That was very encouraging. Ever since, I have studied the brain more and more, and I discovered that neural networks actually correspond to relational networks. That's a good thing because, after all, linguistic structure is in our brains.

8. People who are not familiar with neurolinguistics, upon first learning what the field is about, often ask: 'Where exactly in our brains do we have language?' How would you answer such a question?

It's a very interesting question. As it happens, language is not in just one location in the brain. It's all over it. Certain parts of language are mainly represented in specific parts of the brain, however. A lot of linguistic structure is in the left hemisphere; our recognition of speech is pretty much in the temporal lobe; speech articulation is in the frontal lobe, in a certain well-known area. But language is more than that. Think about semantics, for instance. We use language because we mean to say something, and semantics is all over the brain, involving both hemispheres. This makes sense because we use language to talk about everything that we can experience, and everything that we can experience is registered in different parts all over the brain. So we can say that language is widely distributed. When you're using language, you're using all parts of the brain.

9. In addition to this embodied conception of your object of study, what are the main theses of Relational Network Theory?

First, language is a system of relations. That's the most important one. I came upon this discovery back in the fall of 1964. I still remember the afternoon in my office when I came to that realization. At that time I didn't know anything about the brain, no more than anyone else. But now I would add that the system is embodied in the brain. For the last twenty years I've been studying the brain, and I could see how this relational network, as an abstract system, actually relates to neural structures.

When you look at language in terms of brain structures, you also find that the linguistic system consists of multiple subsystems. That's what the idea of stratification was all about: first you have a phonological stratum, then you have a lexicogrammatical stratum, and at the top you have a sememic stratum – where you have concepts and so on. Now we can, to a certain extent, assign different localities in the brain to these different systems, but not the way you might think. For example, phonology is not in one part of the brain, but in two major parts. There's production phonology in the frontal lobe, and receptive phonology in the temporal lobe. There's also a third part, in the parietal lobe, which is the somatosensory part: in order to control the articulators (the tongue, and the teeth, etc.), you have to know where they are and what they are doing. So, for phonology, we actually have three different areas. Phonology is spread throughout what is called the perisylvian area, but each part of that area has its own unique function.

When you go to the higher levels, they are even harder to localize. The lexicogrammatical system is partly in the frontal lobe, the part of the system which has to do mostly with prepositions, verbs, and syntax – verbs and syntax are very much aligned anyway. The posterior part of the brain is concerned with nouns and adjectives. And then, if you get to the semantic level, it's all over the brain – including the right hemisphere – because what we talk about with language is everything we can experience; and everything we can experience is represented all over the brain.

10. Now, this is perhaps a personal view of mine, but it seems like a proper occasion to ask you. I've always been of the idea that there are parts of our experience – of our mental life, of our emotional life, if you will – that *cannot* be realized linguistically. There seem to be certain concepts, or certain constellations of meaning and experience, that can be perhaps expressed through music or with images, while language doesn't even come close to expressing them. Would you agree with that?

Yes, I agree, absolutely. Certain things are in the brain somewhere, but somehow they are not quite accessible to being expressed in language. That's a topic I'm very interested in. As the saying goes, a picture says more than a thousand words. Actually, a picture, if it's the right picture, can say more than ten thousand words. And there are certain aspects of music that you can't even come close to with words, yes.[11] There are other things you cannot do with words. For example, somebody makes a particularly delicious dish, and you eat it and it's a wonderful experience to eat it, but you cannot describe with words that unique taste it has. But what you *can* do with words is write a recipe so others can prepare that dish and then experience it for themselves.

11. Going back to the history of your theory, is there a difference between Stratificational Grammar and Relational Network Theory, or are they just alternative labels for one and the same theory?

I would say that the answer is in between those two. Stratificational Theory is what I used to call the theory at first. I made a quasi-publication of it 1962 – it was published at the University of California but not widely distributed. In that version there were no relational networks. And then, few years later, *Outline of Stratificational Grammar* (Lamb, 1966) came out and that's when relational networks were introduced. But I still called it Stratificational Theory, because the emphasis was on the different strata of linguistic structure. So, the different terms provided different emphases.

Actually, it was Peter Reich, a student of mine, who said 'Why don't we just call it "Relational Network Theory"? Because maybe the most important thing about it is the relational networks and not the strata.' And I decided that he was right. From then on, I've mostly used the term 'Relational Network Theory'. It's a matter of what you want to give emphasis to. So we can say that the term 'Relational Network Theory' is used mainly in relation to the later versions, and 'Stratificational Grammar' with reference to the earlier versions; but in the middle there was a transitional period during which both terms were used. More recently, sometimes we talk about 'Neurocognitive Linguistics', since I started getting serious about how this theory relates to neural structure – that would be in the last twenty years.

12. So, nowadays, would it be fair to say that if I speak about relational networks I would still be talking about an abstract, non-neurological theory, whereas if I wanted to make reference to your neurolinguistic theory I should call it Neurocognitive Linguistics? Or could I still use the term 'relational networks' with reference to the neurological implementation of your theory?

You could still use the term 'relational network' because we can show, step by step, how relational networks are related to neurocognitive networks. But relational networks are the more abstract version. It's the same thing with chemistry, and physics, and biochemistry. You can talk about chemistry in more abstract terms without actually talking about atomic structures, or you can get down to a finer level.

13. A few minutes ago you were discussing the impossibility of locating certain linguistic functions in one single, discrete area of the brain. However, we have a lot of clinical evidence coming from cases of the different aphasic syndromes and the double dissociations established between them. Semantic aphasia, for example, affects semantic processing, but not lexicogrammatical or phonological processing. Can we take the selectivity of these syndromes as evidence of the inner architecture of the linguistic system, of which subsystems actually exist within it?

In brief, the answer is yes, we can. We can use this along with other kinds of evidence. The interpretation of a lot of that aphasiological evidence is improved with a good knowledge of linguistics. And we also have other sources of information nowadays … brain imaging, which is very hard to interpret, and there it also helps to have good knowledge of linguistics. Then there's the technique called transcranial magnetic stimulation … All these things go together and they tend to reinforce each other as evidence.

Once again, it helps if you have a good knowledge of linguistics. Consider, for example, people who study different kinds of anomia. There are patients with impaired access to words for vegetables – sometimes it's both food and vegetables – but their knowledge of words for animals is perfectly fine. If you show them the picture of an animal, they have no problem, but if you show them the picture of a vegetable, they can't think of the name for it. Some of the people that try to interpret what's going on in the brain in these cases have incurred the mistake of thinking that the semantics of a particular category is located in one part of the brain. Actually, we know that that's not true. We have to recognize the difference between the levels of lexical and semantic representation. And semantics is distributed throughout many parts of the brain. These patients just happen to have problems with some specific areas of that widely distributed system.

14. What is the difference between the notions of 'mind' and 'brain'? How does each of them relate to your conception of the linguistic system of the individual?

We know what the brain is, thanks to the work of neuroanatomists. It is a physical object. The notion of mind is not as clear-cut at all. 'Mind' is a vague word in the English language – and there are similar words in other languages which do not exactly correspond to it – with different meanings to different people. So, it's not at all like the term 'brain'. In my work I avoid using the term 'mind' for just that reason. For one thing, you're not going to be clearly communicative if you use it because it can be interpreted differently. And it means nothing really concrete to anybody, because it's not a concrete thing. So I just stick to the word 'brain'.

15. However, most theories in the field of cognitive linguistics have no biological concerns whatsoever. Does the absence of neurological evidence somehow compromise the validity of non-neurological cognitive theories of language (e.g., Langacker's Cognitive Grammar)?[12]

There is an article by Bert Peeters, published about ten years ago, called 'Does Cognitive Linguistics Live Up to its Name?' (Peeters, 2001). And the answer is no. He was talking of Langacker's theory mainly, and Langacker, of course, objected to that article. But Peeters still has a good point. Now, at the beginning I developed my own theory without knowing anything about the brain, but eventually I did look at the brain. When you try to see how to relate Langacker's theory to the brain, there's no obvious way to do that. Even less is there any way to relate Chomsky's theory to the brain. Lakoff has tried to develop a theory based on brain processes, but it's not getting anywhere. It's just too far removed from actual brain structures.

On the other hand, I find a lot of valuable things about Langacker's work. He has some great insights about semantics and other aspects of language. And then there's the people working on Construction Grammar, like Adele Goldberg. She knows nothing about the brain, but she's come up with some very good ideas about syntax. But the jury is out that you cannot ultimately justify a linguistic theory, in my opinion, without eventually going into the brain. What the proponents of non-neurological theories could do, so as not to go directly into the brain, is show how their theories relate to Relational Network Theory, since we already know how relational networks can be implemented in the brain.

Part II: Technicalities of Relational Network Theory

16. Let us now get more technical and discuss some specific aspects of your relational networks. I have noted that the nodes and lines which characterize relational network notation are very similar to those proposed by McCulloch and Pitts (1943). Did these authors influence your thinking or are such coincidences merely fortuitous?

It's just fortuitous. I didn't know anything about their work until people started pointing out the similarities you mention. You can see that my thinking was parallel to theirs in some aspects; they make use of basic logical distinctions that I was using too. There are 'and' and 'or' nodes in both theories, and in digital electronic networks they do the same thing – Boolean gates and so on. But what we have discovered in relational networks is that the 'and' and 'or' distinction is not a basic distinction after all. What we have is a threshold, and the threshold is variable. It can be of any value from zero on up, irrespective of the number of incoming lines into a node. The 'and' and 'or' are just special cases: in the case of 'and' nodes, the threshold coincides with the number of incoming lines, and in the case of the 'or' node, the threshold is just 1.

17. You propose that the cognitive system does not store symbols or objects of any kind. Instead, you propose that in an individual's cognitive system 'there are only relationships' and that 'all information is in the connectivity.' Would you please elaborate on these ideas? To many scholars, they seem to be the hardest notions to either grasp or accept.

I find it that the only way I can explain it is with the aid of diagrams. Now that we have the Spanish translation of my book[13] – or for those who prefer to read it in the original version – Chapter 4 contains the diagrams I'm making reference to. Once again, the rejection of symbols as the constituting elements of the linguistic system is not based on neurological evidence at all. In *Pathways of the Brain* (Lamb, 1999), I didn't use neurological evidence at all until the theory was fully developed – only in the later chapters do I introduce the brain. But we can say this much in words: if there are symbols in our cognitive system – as Pinker claims, though he ought to know better – how does the brain use them? Does it have little eyes to read the symbols? Are there any other sense organs in the brain? No, the brain does not contain any sense organs! Sense organs are all on the outside of the brain. The brain processes sensory information coming from the outside. There is no way that the brain could use symbols. There must be something else going on. We know from neuroanatomy that the brain consists of connections; there are neurons and their interconnecting fibres, and that's all.

Now, neuroscientists have not been able to tell us anything about how the brain actually works, about how it actually processes information. They can tell us how neurons receive and send activation, how synapses get formed and strengthened, what brings about long-term potentiation, and so on. But they can't tell you the first thing about how language works, for example – or any other cognitive process, for that matter. They're working with the hardware. It's similar to asking an electronic engineer to tell you how the computer translates, or how it calculates the orbits of satellites. They're working in a different area. Relational network linguistics has provided the answer to that question: how the brain processes information. The answer to the basic question of cognitive neuroscience has come from neurocognitive linguistics and nowhere else.

18. In *Pathways of the Brain* you advance the hypothesis that connections are implemented neurologically as cortical minicolumns. Now, in your most recent work, you are also making reference to functional webs à la Pulvermüller (2002). What would be the difference between cortical minicolumns and functional webs as the physical implementation of linguistic representations?

The functional web consists of interconnected nodes, and what I'm saying is that each node is implemented in the brain as a cortical column. The functional web is perfectly consistent with this claim. I suggested in *Pathways of the Brain* that the nodes of networks are represented as cortical columns. More recently, since Mountcastle's book[14] on cortical columns has come out I have a much clearer understanding of them. In *Pathways of the Brain* I also had functional webs, but I didn't use that term. When I talk about the network representation for a lexeme or a morpheme or things like that, all those are also functional webs. Now I find that this is a useful term to make some things clearer.

My contention is that each of the nodes in a functional web would be implemented as a cortical minicolumn or as a bundle of minicolumns. A functional web is distributed over a large area of cortex. If you look at just about any of the diagrams in *Pathways of the Brain*, you're seeing either a functional web or part of a functional web, consisting of multiple nodes linked by interconnecting lines.

Contiguous columns, which form a maxicolumn, are usually in competition with each other since they belong to different functional webs. For example, let's take a phonological web for a syllable – let's say, /kæt/. The final consonant is a /t/. That /t/ will be in contrast with other final consonants, and all of them will be clustered together in a maxicolumn, although each of them can belong to different functional webs. For example, that final /t/ is also part of the functional web for /pæt/, /ræt/, and so on.

So every node is represented by a column. Depending on how much learning has taken place, the columns for a particular node may be represented by a minicolumn, or a maxicolumn, or something in between that we would call a functional column.[15] It could be, and often is the case, that further learning will take place in the future allowing a column to be divided further into smaller functional columns, because you've learned some new distinction.

19. In relational network notation, the same type of node may be used to represent a phoneme, or a demisyllable, or a morpheme, or a lexeme, etc., and you presume that the physical implementation of *any* node is a cortical column, irrespective of the type of linguistic representation that they process. Are you saying that the same type of biological substrate may suffice to process either a phonetic trait, or a phoneme, or a morpheme, or a lexeme, and so on?

Yes, it's the same basic structure and the same basic process. The node itself, the column, doesn't know what it's doing. It's receiving activation and sending activation out, and what actual function that node turns out to have depends on where it's receiving information from and where it's sending information to.

20. In *Pathways of the Brain* you mention three possible mechanisms that could implement the delay element in ordered 'and' nodes. Today, over a decade later, have you been able to rule one of them out, or to offer more precisions as to how each of them works?

Yes. In the first place, we shouldn't think that we have to choose between those possibilities. The brain makes use of whatever equipment is available. Probably all three, and maybe even more, are actually in use. There is a clear source for fixed timing, namely the thalamus – and maybe whatever else is involved in brain waves. You have different frequencies of brain waves, each of which is an actual clock sending out impulses at fixed intervals. When we are awake and conscious, the thalamus sends signals sweeping through the whole cortex about forty times per second, so that's providing a regular clock. This kind of timing control probably is involved in many aspects of language.

There's another type of timing control, which uses the 'wait element' as described in *Pathways of the Brain*. The 'wait element' is a device that keeps activation alive by recycling it. We now find in the knowledge of cortical columns that every column has the potential for being a 'wait element,' because it can recycle information among its various neurons and keep that information active until it gets turned off by inhibitory neurons.

21. Is there a difference between this notion and that of 'reverberation'?[16]

Reverberation is something different, as it occurs *between* different cortical columns. For example, in an activated functional web, the different columns are sending activation back and forth among one another, which keeps the activation in the web alive. There is also the question of how long the activation is kept alive in actual processing. Maybe it can remain active for as long as we want. If I look at that glass of water and I keep thinking about the glass of water, the reverberation for that functional web will keep going for as long as I keep paying attention to the glass of water. As I keep watching, the web keeps receiving additional activation from my eyes while it stays active.

22. The two types of inhibitory connections recognized within Relational Network Theory (viz., the one landing on a node and the one landing on a line) closely resemble the two types of inhibitory connections found between cortical neurons (namely, axosomatic and axoaxonic inhibitory connections). Is this a coincidence, or was that distinction actually taken from neuroscience?

This is a really interesting case. It was not imported from neuroscience because I was making that distinction before I knew about neurons. In relational networks we also have inhibitory connections – we have the blocking element. In fact, we have two types of inhibitory connections in narrow notation, both justified purely on linguistic evidence. You could say it's just a coincidence that relational networks have the same two types of inhibitory connections present in the brain. But it's not a coincidence because, after all, language is something that is used by our brains. Of course, you first have to realize that language is a relational structure. Then you can start drawing models of this structure, and those models will be networks. As you refine your knowledge, step by step, you realize that you need two types of inhibitory connections. Only then can you look at the brain to see whether you find correlates of those two types of inhibitory connections.

Some fifteen years ago, when I was teaching classes at Rice, one of my students mentioned that he was taking a course in neuroscience and that there were two kinds of connections between neurons that exactly corresponded to the abstract distinction. It figures: if I'm describing language accurately, and if language really is a system in the brain, then it has to be that way. The linguistic finding that there are two types of inhibitory connections actually amounts to a hypothesis about what the brain must have in it somewhere. Then, when you find that, the hypothesis is confirmed.

23. Now, when it comes to drawing relational networks, how do you decide whether to use one type of inhibitory connection or the other?

It's hard to answer this in the abstract, without any drawings. But consider a case of alternate realizations, where you have the marked case and the unmarked case. There you always have inhibition going to a line. However, if you're talking about something semantic, then it's different. Take, for example, the categorization of CUPS and GLASSES. CUPS and GLASSES would be a case where you have concept nodes in a maxicolumn for DRINKING VESSELS, which then gets subdivided into a part for CUPS and another one for GLASSES. A property like HAVING A HANDLE would be excitatory for CUP but inhibitory for GLASS. There you would be going directly to the node.

24. Could you give us an example of how we process linguistic information in our brains?

Language, as you know, is very complicated. What people would really like to know is how a whole sentence works, but that's just way too complicated. So let's just take one word. I'll tell you about a particular experiment that was done, in which people were shown pictures of animals and all they had to do was say what the animal was.[17] We might think that this is something that happens instantaneously, but that is not the case.

What happens is that you see the picture with your eyes and that information goes down the optic nerves to the occipital lobe. From there, you have connections going to various places in the visual network, all involved in recognizing the horse as such and activating its corresponding concept. Further connections link the conceptual representation to the phonological image /hors/ in Wernicke's area (in the temporal lobe), and then activation proceeds to the frontal lobe, where movements of the speech production mechanism are organized. All this complex array of connections must be activated just to say the word *horse*. That's what the theory predicts. In the experiment I'm discussing, they use a brain imaging technique called MEG (magnetoencephalography), which can measure the time course of activation of different parts of the brain, and the results verified that this is exactly what happens. The interesting thing is that it takes six tenths of a second – i.e., six hundred milliseconds – from the time the subjects see the picture until they actually articulate the word. What appears to be instantaneous is actually a very complex process.

Part III: Relational Network Theory: Applications, limitations and prospects

25. Relational Network Theory is far from being a mainstream theory of language. It certainly does not enjoy the popularity of other theories, such as Generative Grammar or Systemic-Functional Linguistics, to name but a few examples. Why do you think it has not become more popular?

Well, there are many reasons that we can point to. For one thing, if you think about Generative Grammar as a very popular theory, you will find that Chomsky is a very prolific writer. He's been writing ever since he was in his twenties, and he has a huge volume of literature. I remember one night I heard from a colleague of his, Morris Halle, that Chomsky had come across a paper criticizing his approach to phonology, and he was so incensed that he stayed up that night and by the morning he had a finished paper [*laughs*]. Halliday is a very prolific writer too. I, on the other hand, did not publish much of anything. In 1966, I published *Outline of Stratificational Grammar*, and it was not until 1999 that I published another book. Of course, I wrote a lot of articles in between, but nowhere near the volume of Chomsky and Halliday. That's one of the main factors. If you want to be known, you have to publish a lot.

26. In order to work within Relational Network Theory, you need to reject many of the tenets upheld by the mainstream linguistic theories. Do you believe that, in a way, it has become dangerous for linguists to subscribe to your theory? Have you been 'blacklisted' somehow?

To some extent, that is the case. Back in the early days, when I was known to be opposed to Chomsky's ideas … there were various tricks being used to keep alternative views out of the public eye. Not so much in these days, though.

If you want to write a Ph.D. thesis from a relational network perspective, nowadays, there are no options available. As an Emeritus Professor, I am no longer allowed to supervise theses any more, and I'm practically the only one working within this framework. My students, over the years, have been interested in more practical things than neurocognitive linguistics. Something similar happened to Hjelmslev. He didn't leave any student who worked with him closely to carry on his work. His writings, though, influenced many people, including Halliday and myself.

27. Would it be possible (and, if so, useful) for Relational Network Theory to incorporate neurological evidence at a smaller scale than it has so far (e.g., different types of neurotransmitters, neuroreceptors, etc.)?

Yes, in neurocognitive linguistics we have an interface between cognitive linguistics and neuroscience, and there are no boundaries. Of course, it's hard to try to foresee anything. But, for example, in addition to local neurotransmitters, there are global transmitters, like dopamine and serotonin, which influence the operation of the brain globally. We can sort of tell when a person gets tired or intoxicated that there's a deficiency in certain global neurotransmitter – maybe an increase in norepinephrine – which leads to more excitation or inhibition of the overall processing. It would be possible to look into that, but of course you need a solid training in neuroscience.

28. Could Relational Network Theory be used to model non-linguistic aspects of cognition, such as vision, somatosensory perception, or motor action?

Yes, it can and should. I'm just waiting for somebody to do it.

29. How can Relational Network Theory contribute to foreign language teaching? Are there any pedagogical or didactic applications of the theory?

Well, there can be, but the interesting thing is that good foreign language teachers have really good intuition about how to teach foreign languages, and they've already been doing it the right way. We can show from neurocognitive evidence *why* they're doing it the right way. They have intuitively already found the way to do it well, for example, by using constant repetition – drills – giving students frames in which you substitute words, applying real-life contexts … all these things make the learning process easier in the brain, but teachers already know that.

More and more evidence shows that it's easier for younger brains, which have greater plasticity, and therefore it's easier for them to make new connections and to strengthen existing connections. Yet, people already knew that the earlier you start instruction in a foreign language, the easier it will be for a child to learn the language. Whatever insight you might get from neurocognitive linguistics has already been picked up by language teachers from other sources – sometimes, just from their experience.

There's a very interesting experiment that was done by Susan Ervin at the University of California, Berkeley when I was teaching there. They decided to test different methods of language teaching. They used three different methods, and they had several different language teachers – some were graduate students in linguistics. The teachers had to teach different groups for a period of about eight to twelve weeks, using these different methods. At the end of the experiment, the researchers found that the teaching methods made no significant difference in the students' results, but when they correlated the results with the teachers, they found that good teachers were getting good results no matter which method they used. It was the teacher who made the difference.

30. What are the limitations of Relational Network Theory? What can it not explain?

The more we learn, the more we realize what we don't know. There's a lot about syntax that remains to be explained in relational terms. We are now at the doorstep of explaining how syntax really works in the brain. The most basic part of syntax is the relationship between verbs and the nouns which co-occur with them. For most action verbs, there needs to be an Actor – corresponding with the subject in the ordinary situation – and in many cases there's also a Goal that realizes the object. By relating this to brain structure we can begin to see how that kind of things works. We can see that syntax is tagged on to ordinary behaviour. When you learn a word like *eat*, you know that there has to be an EATER and an EATEE (the eating entity and the food). This is also true in the actual process, quite apart from the linguistic representation. The process of EATING is known by children and used by them from the very first day they are born. When they eat, there is activation going on in the motor cortex controlling the muscles which are used for eating, and they also see and touch the item of food that they are eating – say, a cracker. That brings about activation in the posterior part of the brain – the visual part and the somatosensory part. All that information is connected to the concept of CRACKER, in the posterior part of his cortex. The motor representations take place in the frontal lobe, so there are connections established between the frontal and the posterior part of the brain, completely independent from language. The frontal lobe represents the process of EATING and the posterior areas represent the object of EATING. Later on, the child can attach these to linguistic representations. Very close to the location in the frontal lobe where the process of EATING is represented you have the linguistic representation *eat*. The object being eaten, let's say the cracker, will be connected to a phonological representation, /krækər/, in Wernicke's area. There are connections already present going from the morpheme *eat* to the morpheme *cracker*. They're just, as it were, slight additions to what is already there at the conceptual level. This needs to be pursued and developed from that very beginning that I'm just playing around with now.

31. Let me make sure that I understand your point here. Are you saying that the semotactics determines the lexotactics?

Yes, that's correct. That's exactly what I'm saying. And the lexotactics is not something that has to independently be formed in the learning process of language. It's just a few additional connections to the semotactics that is already there. The baby is dealing with combinations with processes and their participants way before he develops his linguistic system. Those patterns, I believe, are used when the baby is learning syntax.

32. Is there any other aspect that needs further development in relational-network terms?

There's also work to be done regarding the *given/new* distinction that Halliday has worked so much on – information structure.[18] Neither he nor anyone else has ever studied how that works in the brain. That needs to be done, and we haven't done it.

The given/new distinction is one of Michael Halliday's greatest contributions in linguistics. Most linguistics deals with only one of the three functions that he identifies – the ideational function of language. Now, in the *given/new* distinction, you have the *given* and the *new*. Relational network grammar can actually explain what's going on and why that is an important distinction. Remember, we are looking at language in relation to the information system in the brain. First, you have to realize that when two people are talking, each of them has his own information system, in the form of a network. One of the main reasons why people talk to one another is to exchange information. When a person A says something to a person B it is because A believes that B doesn't know the information he wants to convey. Otherwise, why would A say something that B already knows? Of course, there is the phatic function, but we can skip its discussion here.

When you're exchanging information, of course, there is a *given* and a *new*. The function of the *given*, in network terms, is to identify locations in the network where the new information is to be added. New information consists of new connections, and the given is what it is to be connected to. When you tell somebody 'That cat is named James,' you assume that the listener already knows which cat you're talking about – maybe it's a cat in the room. You also assume that the only thing that the speaker doesn't know is the name of the cat. Furthermore, you suppose that your interlocutor somehow wants to know what the name of that cat is. There's only one new item of information in that whole sentence, namely, the cat's name, James. Everything else is there simply to identify locations in the network. The only new thing is the connection to the name: the phonological form /prinsəs/ and the lexicogrammatical form *James* are already there, so the only thing added is the connection proper.

The given will always be represented in terms of dedicated connections, and the new will always involve a latent connection. Sometimes a latent connection needs to be added, sometimes only just a connection between two existing nections. When this happens, the latent connection becomes an established connection. By recognizing this, one is able to make sense of these things that Halliday has been talking about.

33. And what about the description of particular languages?

That's a good point, because it raises a big question: is it appropriate to use relational networks to describe languages, for practical purposes – e.g., writing a grammar of Chinese using relational networks? I'm not so sure that we should. You have to look at the reason for writing a grammar. If your reason is to write a grammar for learning Chinese, then it's better to do it with symbols. Relational networks account for what happens inside your brains. If you want to learn about the description of a language, you have to use your eyes, and eyes are really good at reading symbols. For such a grammar it's better to do it in words. That's another reason why Relational Network Theory has not become more popular in linguistics, because linguists are mostly interested in languages, as you might expect. But relational networks are actually about how the brain works and how language actually works. What linguists are interested in, surprisingly, is not how language actually works. They want to know how you can do things with languages.

Lockwood offered a relational description of Czcech[19] a few decades ago, and I myself described parts of English grammar throughout my career.[20] But even if you constructed a full network of, say, Chinese, nobody would be able to read it. Even somebody who knows relational networks would find it difficult to read. That's because relational networks are describing what's going on in the brain, but when you want to understand something by reading, you should use symbols, for practical purposes. Now, the same consideration applies to systemic-functional networks and Generative Grammar. I believe you will find that any of these generative grammars of Italian or English are not very useful. They don't tell you very much about Italian that you can use. These theories are not really suited for language description. It doesn't mean they are useless, though – however, I must say that a use for Generative Grammar has yet to be found. Systemic-functional grammars, for instance, have proven very useful to provide insights about language structure and how languages work.

34. Still, when we think of the systemic networks with which Halliday characterizes English, for example, we find some details which seem to be exclusive of English – or, at least, not applicable to the description of just any language. For instance, in English, the relative arrangement of the subject and the operator determines whether the clause is a declarative or an interrogative, irrespective of the intonation we apply on it. Spanish, on the other hand, works in an entirely different way.[21] What about these descriptive differences?

These differences you're talking about can be described in any of many ways, and they have been described many times before Halliday ever came along. Any of those descriptions is just as good, just as meaningful. Going back to the key point in the previous question, relational networks seek to characterize language in the brain and explore its connections with the rest of human cognition. This is where Relational Network Theory makes its contribution.

35. In 2011, *Pathways of the Brain* was translated into Spanish. Last year, Gordon Tischer released a computer program to design and test relational networks.[22] Also, a symposium was held in 2010 in search of intertheoretical links between your work and that of Halliday and Hasan.[23] Is Relational Network Theory finally resurfacing, or are these isolated, circumstantial events?

Well, it's impossible to tell. I heard someone was working on an Arabic translation of *Pathways*, and there was supposedly somebody working on a Russian translation, too, but I haven't heard anything about that recently. Some people have written about my work in Chinese. Other than that, who knows what might happen with the theory? I, for one, don't know.

Syd, thank you very much for your time and insights.

Thank you. It's been a pleasure.

Notes

1. On 5 October 2001, Yale University celebrated the 300th anniversary of its founding in 1701. The occasion was commemorated by a celebration held in Yale Bowl (the university's football stadium). It consisted in a 90-minute stage show with video, orchestra, celebrity hosts, laser show, and a fireworks display. In a section of the programme celebrating achievements by Yale graduates, William F. Buckley (an alumnus and a prominent journalist and TV personality) identified, for each of a large number of fields of endeavour, three or four persons who had graduated from Yale during those 300 years. Buckley was reading from a script that had been prepared by a scriptwriter in collaboration with the Tercentennial office at Yale. In speaking about Yale Men of Letters, he said, 'Noah Webster was the class of 1778. We know him as the father of

the American dictionary and he was also the publisher of the Blue Backed Speller. Sydney Lamb, 1951, changed the way we understand grammar. William Poole, 1849 was the first publisher of indexed periodical literature, and Sinclair Lewis, 1907, was the first American to be awarded the Nobel Prize for literature.'

2. Most of the references given are based on revised, updated versions of earlier papers by Lamb, as published in the compilation *Language and Reality: Selected Writings of Sydney Lamb* (Webster, 2004). In 2006, this book was reissued in paperback form as *Selected Writings of Sydney Lamb*.

3. Lamb's critical review of Hjelmslev's *Prolegomena* was first published in 1966 and then published in revised form in Lamb (2004b).

4. A brief reminiscence of Lamb's times as a student under Mary Haas's wing can be found in Lamb (2004c).

5. For an interesting discussion of these exchanges by both scholars themselves, see Halliday *et al.* (1988).

6. The full demonstration can be found in Chapter 4 of *Pathways of the Brain* (Lamb, 1999).

7. Lamb refers here to American structuralism in the Bloomfieldian tradition.

8. For a detailed discussion of Lamb's criticism of descriptive and derivational processes, see Lamb (2004d; 2004e).

9. Lamb's arguments against a definition of language as a socially-shared entity are fully developed in Lamb (2004f).

10. See Lamb (2006).

11. For a neurocognitive contrast between meaning in language and meaning in music, see Lamb (2004g).

12. See, for example, Langacker (1991).

13. The translation in question is titled *Senderos del cerebro: La base neurocognitiva del lenguaje* (Lamb, 2011).

14. Lamb refers to *Perceptual Neuroscience: The Cerebral Cortex* (Mountcastle, 1998).

15. Not to be confused with a functional web.

16. For an in-depth discussion of the notion of reverberation, see Pulvermüller (2002).

17. Professor Lamb is referring to a study conducted by Levelt, Praamstra, Meyer, Helenius and Salmelin (1998).

18. See Halliday (1994) and Halliday and Matthiessen (2004).

19. See Lockwood (1972).

20. Some morphological and clausal aspects of English have been described in Lamb (1966, 1999). A relational account of the basics of English phonotactics can be found in Lamb (1980).

21. See García and Gil (2011).

22. The software in question is called Neurocognitive Linguistics Lab and can be freely downloaded at: https://bitbucket.org/kulibali/neurocogling/wiki/Home.

23. Visit http://ctl.cityu.edu.hk/Portal_root/subsites/symposiums/2010/nov/CPLHH/LSS_conference.html for information on the symposium's topics and conclusions.

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