How the Dreeb Learned Language

Critical Path Analysis is a tool much used in business for project planning, but it can be applied in many other areas of human enterprise. Part of this tool allows for tasks or functions to be related to each other in a temporally significant order, such that some tasks are dependent upon others and some tasks can happen in parallel with others. This part of the tool is derived from the standard electrical circuit model, where measured inputs cause measured outputs by passing through a set of known components or processes. It provides a good metaphor for the language acquisition process, especially within the Component Grammar model: here, the components act as a series of functions and interact to generate new functions. As Cohen & Stewart would put it, systems are emergent from other systems, and in order to understand the emergent systems it is useful to know what they have emerged from.

For instance, in Component Grammar we see that Lexical Grammar is an emergent system from Lexis, Lexis is an emergent system from Simple Grammar, and Simple Grammar is an emergent system from Deixis, Connectivity, Instigator, Action and Recipient. What other functions are involved in this "circuit"? How far down into the mind can we go - or should we go - to find the roots of language? Can we build a viable model of the interaction of the parts of the mind that allow language?

In order to study this question we will use an imaginary creature, the Dreeb. Dreebs, like us, use language. It is their own language and probably much more logically consistent than ours. They think like us (but probably more logically), they have similar senses and they like to talk. How do they gain language skills? Nativists would have it that they have a similar mental structure to us with the same mental switches and language-building structures - there has to have been parallel evolutionary development. Pure Cognitivists would say that it is an inevitable consequence of brain size and complexity. Let us take the middle road: we will assume a series of innate functions, not directly related to language, and build upon those.

The following eight functions would seem to be a good starting point, and they will be considered to be the Dreebs' innate knowledge from its "genetic" inheritance.

Identity	The universe is composed of discrete objects
Arbitrariness	Objects are arbitrary
Mutability	Objects sometimes change
Stability	Objects often stay the same
Comparison	Objects have similarities and differences
Other awareness	Some objects have desires and needs (Beings)
Messages	Sounds contain messages
Emotions	Environmental mood is detectable from sounds

Of course, as with all matters genetic, the functions are actually produced by a complex interplay of molecules, and the processes these functions control are not simple on-off switches. Genetic features do not directly affect the organism; they play a large but indirect part in physical development, but even then they are constrained by a narrow range of viability. It can be argued that most humans look the same not because our genes make us the same, but because human genes try a whole range of development options, most of which end in early failure. It seems to be the case that they have a range of developmental possibilities, such that the exact same DNA will not produce the same individual being unless all the environmental factors are constant. Even in human twins, where the environment is pretty much constant for the vital first nine months of development, differences are detectable from birth. Genes are merely the first stage of a complex chemical process. Like the people who build a factory, they have very little effect on what it is subsequently used for, or how it is managed.

The chemical status of Dreebs, like humans, will vary, and their grasp of the eight knowledge functions above will cover a range of values, both in absolute terms between individuals and from hour to hour within each individual. To a large extent this will be completely irrelevant, as Dreeb society and language will be built with redundancies to accommodate these variations. But let us assume that Dreeb biochemical processes are, anyway, much more stable than ours (hence their superior logic?), which means that variation can be largely discounted.

When we look at these innate functions we see that they can be combined in various ways. In fact there are 28 ways they can be combined as pairs, creating a possible 28 new functions; and there is no need to confine our combinations to pairs. However, most of these combinations lead down cul-de-sacs, or to functions unrelated to language; and, anyway, we are concerned with the Dreeb here, so we can make whatever choices we wish in their internal mentation.

Let us assume three relevant functions, produced from pairs: Mutability and Stability combine to give us knowledge of Predictability (objects change, but in stable ways); Other awareness and Messages combine to give us knowledge of the Sender in a signal (sounds come from Beings who want to make the sounds); and Comparison and Arbitrariness give us knowledge of Containment (objects viewed as independent units can also be viewed as parts of other objects, or composed of other objects). We now have three new functions, and they can be combined with each other or with the previous eight functions. Once again, the full tree of possibilities will be pruned to give us just five new functions: knowledge of Actions, Contextual deixis, Classification, Repetition and Possession.

And so we go on, adding new functions until we have not so much a tree with neat bifurcation, but a complex root ball

of functions and links. Altogether, in the mind of the Dreeb we will identify 34 functions which feed into the language structure, and these are set out in the table below:

Item	Knowledge	Description	Source Knowledge
1	1. Identity	The universe is composed of discrete objects	Innate
2	1. Arbitrariness	Objects are arbitrary	Innate
3	1. Mutability	Objects sometimes change	Innate
4	1. Stability	Objects often stay the same	Innate
5	1. Comparison	Objects have similarities and differences	Innate
6	1. Other awareness	Some objects have desires and needs (Beings)	Innate
7	1. Messages	Sounds contain messages	Innate
8	1. Emotions	Environmental mood is detectable from sounds	Innate
9	2. Predictability	Objects change in predictable ways	1. Stability 1. Mutability
10	2. Sender	Beings generate sound messages	1. Other Awareness 1. Messages
11	2. Containment	Objects contain other objects	1. Comparison 1. Arbitrariness
12	3. Actions	Objects can be moved or changed	1. Stability 2. Predictability
13	3. Contextual deixis	The nature of an object is determined by context	1. Mutability 2. Containment
14	3. Classification	Some objects are alike	1. Comparison 2. Containment
15	3. Repetition	Sound from Beings contains significant repetitions	1. Emotions 2. Sender
16	3. Possession	Beings can own objects	1. Other awareness 2. Containment
17	4. Segmentation	Sound from Beings can be segmented into discrete units	2. Containment 3. Repetition
18	4. Recipients	Beings can change objects	1. Other awareness 3. Actions
19	4. Spatial deixis	Objects move	1. Identity 3. Actions
20	4. Analogy	Objects can be represented by other objects	3. Contextual deixis 3. Classification
21	5. Icons	Objects can be represented by segmented sounds (Words)	1. Arbitrariness 4. Segmentation
22	5. Instigators	Objects can directly change other objects	3. Actions 4. Recipients
23	6. Cause and effect	Changing one object can indirectly create changes in other objects	4. Recipients 5. Instigators
24	6. Indexes	Words can stand in place of classes of object	3. Classification 5. Icons
25	6. Nomination	Words can stand in place of objects	3. Possession 5. Icons
26	7. Connectivity	All objects are contained in a web of interaction	3. Classification 6. Cause and effect
27	7. Temporal deixis	Time can be treated as an object or as a process of change	4. Spatial deixis 6. Cause and effect
28	7. Symbols	Words are interchangeable in meaning	4. Analogy 6. Indexes
29	7. Self-awareness	The self has desires as well as needs	5. Instigators 6. Nomination
30	8. Simple Grammar	Objects can be placed in a story	3. Contextual deixis 5. Instigators 7. Temporal deixis 7. Connectivity
31	8. Machiavellianism	The desires and needs of other Beings can be manipulated to meet the self's desires and needs	6. Cause and effect 7. Self awareness
32	9. Lexis	Words can represent Actions and Deixis as well as Identities	6. Nomination 6. Indexes 7. Symbols 8. Simple grammar
33	9. Theory of mind	I know that you know what I think about you	7. Connectivity 8. Macchiavellianism
34	10. Lexical Grammar	Formal structures are needed to allow words to convey messages of who does what to who, and to create a narrative	9. Lexis 9. Theory of mind

These relationships have been set out in an Excel spreadsheet, so that the effect on Lexical Grammar of changing one or more of the innate inputs can be seen.

Knowledge of:	Product	80%	Formula Product Column (B)	Formula 80% Column (C)
1. Identity	100.00	OK		=IF(B2>79,"OK","Faulty")
1. Arbitrariness	100.00	OK		=IF(B3>79,"OK","Faulty")
1. Mutability	100.00	OK		=IF(B4>79,"OK","Faulty")
1. Stability	100.00	OK		=IF(B5>79,"OK","Faulty")
1. Comparison	100.00	OK		=IF(B6>79,"OK","Faulty")
1. Other awareness	100.00	OK		=IF(B7>79,"OK","Faulty")
1. Messages	100.00	OK		=IF(B8>79,"OK","Faulty")
1. Emotions	100.00	OK		=IF(B9>79,"OK","Faulty")
2. Predictability	100.00	OK	=INT(B4*B5)/100	=IF(B10>79,"OK","Faulty")
2. Sender	100.00	OK	=INT(B7*B8)/100	=IF(B11>79,"OK","Faulty")
2. Containment	100.00	OK	=INT(B3*B6)/100	=IF(B12>79,"OK","Faulty")
3. Actions	100.00	OK	=INT(B5*B10)/100	=IF(B13>79,"OK","Faulty")
3. Contextual diexis	100.00	OK	=INT(B4*B12)/100	=IF(B14>79,"OK","Faulty")
3. Classification	100.00	OK	=INT(B6*B12)/100	=IF(B15>79,"OK","Faulty")
3. Repetition	100.00	OK	=INT(B9*B11)/100	=IF(B16>79,"OK","Faulty")
3. Possession	100.00	OK	=INT(B7*B12)/100	=IF(B18>79,"OK","Faulty")
4. Segmentation	100.00	OK	=INT(B12*B16)/100	=IF(B17>79,"OK","Faulty")
4. Recipients	100.00	OK	=INT(B7*B13)/100	=IF(B19>79,"OK","Faulty")
4. Spatial diexis	100.00	OK	=INT(B2*B13)/100	=IF(B20>79,"OK","Faulty")
4. Analogy	100.00	OK	=INT(B14*B15)/100	=IF(B21>79,"OK","Faulty")
5. Icons	100.00	OK	=INT(B3*B17)/100	=IF(B22>79,"OK","Faulty")
5. Instigators	100.00	OK	=INT(B13*B19)/100	=IF(B23>79,"OK","Faulty")
6. Cause and effect	100.00	OK	=INT(B19*B23)/100	=IF(B24>79,"OK","Faulty")
6. Indexes	100.00	OK	=INT(B15*B22)/100	=IF(B25>79,"OK","Faulty")
6. Nomination	100.00	OK	=INT(B18*B22)/100	=IF(B26>79,"OK","Faulty")
7. Connectivity	100.00	OK	=INT(B15*B24)/100	=IF(B27>79,"OK","Faulty")
7. Temporal diexis	100.00	OK	=INT(B20*B24)/100	=IF(B28>79,"OK","Faulty")
7. Symbols	100.00	OK	=INT(B21*B25)/100	=IF(B29>79,"OK","Faulty")
7. Self-awareness	100.00	OK	=INT(B23*B26)/100	=IF(B30>79,"OK","Faulty")
8. Simple Grammar	100.00	OK	=INT(B14*B23*B27*B28)/1000000	=IF(B31>79,"OK","Faulty")
8. Macchiavellianism	100.00	OK	=INT(B24*B30)/100	=IF(B32>79,"OK","Faulty")
9. Lexis	100.00	OK	=INT(B25*B26*B29*B31)/1000000	=IF(B33>79,"OK","Faulty")
9. Theory of mind	100.00	OK	=INT(B27*B32)/100	=IF(B34>79,"OK","Faulty")
10. Lexical Grammar	100.00	OK	=INT(B33*B34)/100	=IF(B35>79,"OK","Faulty")

First, It must be emphasised that this is a model of a Dreeb's mind, not a human mind or any other kind of mind. It does not imply that the functions described are real functions of the mind (even a Dreeb's mind), they are a convenient shorthand for what may well be much more complicated processes. Nor is it intended to imply that these are the only functions or even the only relevant functions. The whole model can be treated as speculative - the functions chosen, the relative weightings (all functions are equal at an arbitrary 100%), the minimum input needed to activate a component (an arbitrary 0%), the level below which problems become obvious (an arbitrary 80%), the choice of simple product to determine synthetic function weightings, the links between functions, the order of functions: all can be disputed. Also, the term *innate* should not be considered to imply that the functions are genetically innate: the innateness is to the described process in this particular model. What this model does attempt to prove is that this approach (using a Cosmides and Tooby Swiss army knife view of knowledge linked to Mithen's functional determinism) can produce predictive results to help explain the way language works in Dreebs.

At only two points in this model are more than two functions brought together to synthesise a new function, and these could be further broken down if desired. Simple Grammar can be considered to be composed of General Deixis (Contextual Deixis plus Temporal Deixis) and Personal Narrative (Instigator plus Connectivity); while Lexis could be considered to be composed of Concrete Words (Nomination plus Indexes) and Grammatical Words (Symbols plus Simple Grammar). However, these are not issues to be addressed here, so the possible subdivisions have been ignored.

This model is designed to study language comprehension, not language production. In order to add production we would have to include things like Imitation (sounds can be copied), Approximation (sounds only need to be similar, not the same), Variability (the same message can be in different sounds), and possibly Metamessaging (a sound stream can contain indirect messages). But these would complicate the model and obscure the process being described.

In this model eight innate functions contribute to language; the other functions are synthetic, produced by the interaction of one or more existing functions. Five of the innate functions are concerned with object recognition - how objects are defined and how they behave; two are concerned with recognition of sound as a message carrier (the use of other senses by the sound-impaired has been glossed into sound); and one attribute is concerned with psychological issues (Other Awareness). The function of Other Awareness has been developmentally placed before Self-awareness for several reasons: first, survival is best served by predicting the actions of others, not by predicting your own actions; second, animals like cats obviously demonstrate a level of Other Awareness, but only basic signs of Self-awareness;

third, external awareness is a simple product of interaction between the brain and the senses, while internal awareness requires manipulation of internal models of external reality. Similarly, knowledge of Recipients is placed before knowledge of Instigators, which is in turn placed before Self-awareness: if the Instigator in a message is always the self then it requires no knowledge of the self - it is the default case; Instigators only need to be identified when the Instigator in the message is not the self; but this in turn leads to identification of the self as the default Instigator. Finally, the Simple Grammar in the list is knowledge of Simple Grammar (the ability to create novel messages), not use of it. Ant messages use aspects of Simple Grammar, but ants cannot be considered to know it. To paraphrase Budiansky: animal messages are not used because they mean anything, they are used because they work.

One function of this model is to show how deficiencies in the innate functions can affect language ability. The size of the differences (small changes at the top producing large changes at the bottom) is caused by the use of simple multiplication to determine synthetic function weightings. However, the effect of small changes in contributory functions producing larger effects in destination functions is real.

Some interesting effects are discernible in the model. The first is that a defect in knowledge of Stability causes a marked effect on both Lexis and Lexical Grammar, but knowledge of Symbols is completely unaffected. It could be argued that this is similar to the situation of Chimpanzees: a strong ability to manipulate symbols but nonetheless weak language skills. The second is that a small drop in knowledge of Arbitrariness and Comparison together produce a large drop in Lexical grammar, but little effect on Theory of Mind. Mostly, therefore, it is small defects in several functions that lead to large defects in Lexical Grammar: a 1% drop in all eight innate functions creates a 70% drop in Lexical Grammar. However, it must again be emphasised that these figures are arbitrary and only describe the effect, they do not measure it. A corollary of this 1% overall drop is that everything appears to be within acceptable limits until the young Dreeb reaches knowledge of Simple Grammar, where a sudden problem appears with no obvious cause: "he seemed to be doing so well...".

For the Dreeb we can say that the model is predictive, because we define the behaviour of the Dreeb. This is tautological and hardly scientific, and the real value of the model should be tested against the only language-using species we know: us.

The first step is to review the eight innate functions: could they be considered to be part of the human mind?

Knowledge of identity would seem to be innate for all living creatures: any animal dependent upon parents has to be able to identify them; any animal with common predators has to know them. Similarly, arbitrariness would seem to be basic: an object is identified by certain salient features, but the salient features will not be all the features of the object, nor will they be the same features each time. So long as a sufficient number of features are identified then an arbitrary cut-off can be applied and the object assumed.

Mutability and Stability are two sides of same coin. Sometimes objects change, sometimes they stay the same. They do not do both at once, but the synthesis of these two functions produces the knowledge that change is predictable. In humans there seems to be a constant dynamic between these two functions, implying that both have an equal and basic part in our make-up.

Comparison is more difficult to prove, mainly because it can be applied in two ways: comparison of unlike objects to find common features, and comparison of like objects to find differences. However, they are both basic to the issues of pattern recognition and making choices, and we know that even babies seem able to make choices between faces and other objects. While Comparison may actually be synthetic and not innate, it can nonetheless be considered innate in this process.

Other awareness would also seem to be basic; and, with Predictability, it gives a powerful engine for predicting the actions of predators and prey. (This function is not part of language, however.)

Finally, the function of recognising messages and environmental factors from sound seems to be intrinsic to our having language at all. It represents the genetic need to communicate, and establishes the channel by which this will be done. The mere fact that we have hearing implies that it has a useful Darwinian function - without use it would not have evolved. It is used throughout the animal kingdom to detect prey, predators, mates and rivals, so it is the obvious choice for other, less genetically inspired, messages.

Thus it would appear that all the language attributes of Dreebs are duplicated in humans. Humans, however, are not Dreebs. This paper does not examine or explain language in humans, it merely provides some interesting speculations upon the roots of language. It is not a scientific analysis, but hopefully it provides a base from which real science can be done. Whether this is a useful analogy or a misleading metaphor remains unproven.

Martin Edwardes, April 2002

Relevant texts:

Author/Editor	Book/Article	Publisher	Date	ISBN
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Calvin, William; Bickerton, Derek	Lingua ex Machina	MIT Press	2000	0 262 03273 2
Carter, Rita	Mapping the Mind	Weidenfeld & Nicolson	1998	
Cohen, Jack; Stewart, Ian	The Collapse of Chaos	The Penguin Group	1994	0 140 29125 3

Dennett, Daniel C	Kinds of Minds	Weidenfeld & Nicolson	1996	0 753 80043 8
Edwardes, Martin	Grammar & Language	Dissertation - UEL	2001	
Hamer, Dean; Copeland, Peter	Living with our Genes	Macmillan	1998	0 333 76017 4
Mithen, Steven	The Prehistory of the Mind	Thames & Hudson Ltd	1996	0 753 80204 x