

# **The Co-evolution of Language and the Brain:**

## **A Review of two contrastive views (Pinker & Deacon).**

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### Abstract:

This article is a review of two contrastive views on the co-evolution of language and the brain – *The Language Instinct* by Steven Pinker (1994) and *The Symbolic Species* by Terrence Deacon (1997). As language is a trait unique to mankind it can not be equated with nonlinguistic communication – human or nonhuman. This points to a special human brain architecture. Pinker's claim is that certain areas on the left side of the brain constitute a language organ and that language acquisition is instinctual. To Deacon, however, those areas are non-language-specific computational centers. Moreover, they are parts in a larger symbolic computational chain controlled by regions in the frontal parts of the brain. To Deacon, a symbolic learning algorithm drives language acquisition.

The increase in size of the human brain in relation to the body may be due to a “cognitive arms race”. Both Pinker and Deacon agree on the evolutionary advantage of the ability to establish and maintain social alliances and contracts and to outsmart social cheaters but they disagree on what this cheating involves. Pinker defines cheaters as social parasites, while Deacon defines them adulterers.

## 1 Introduction

In this paper I will discuss the ‘what’, ‘where’, ‘why’, and ‘how’ questions of language: What is language? Where is language in the brain? Why and how did language come to be reflected in the architecture of the brain? The discussion will be based on a comparison of two recent and contrastive accounts of language and evolution: *The Language Instinct* by Steven Pinker (1994) and *The Symbolic Species* Terrence by Deacon (1997). These two authors arrive at different yet in some respects quite similar conclusions.

First, in section 2, I will discuss the differences between language and non-linguistic communication, as this is important for the notion of species-specificity. Section 3 is an overview of the processes of natural selection. I will explain the differences between two subtypes of natural selection: *Darwinian* and *Baldwinian selection*. Then I discuss the relationship between language and the brain. First I give an overview of the basics of a simple *localizationist* model of language: a production/comprehension machine. In section 4.1 I focus on the distinction between *localized* (functions localized in a distinct area of the brain) and *distributed* (functions distributed over the entire brain, i.e. the opposite of localized). In other words, is language restricted and limited to a particular place in the brain or is it scattered all over the place, to put it crudely. As a natural extension of the former, I deal with *lateralization*: Is language found in the left or in the right side of the brain?

Section 5 discusses the co-evolution of language and brain. I first present short versions of both Pinker’s and Deacon’s theory and answers to the last three questions that opened this section: where, why, and how? In section 6 I discuss the major issues raised in the two theories and I draw my conclusions on the relationship between language and the brain.

## 2 Language vs. Non-linguistic Communication

What is language? The question may seem rather tedious and redundant. However, it seems that too often people believe that any kind of communication is equivalent to language. Surely, the sweet looking dolphins and whales must have languages and some day we may be able to communicate with them. This is just a romantic (and tiresome) fantasy and reality looks very different. Human language is distinct from anything else in the world!

Language is species-specific – only mastered by the human species – and as such it is an evolutionary one-of-a-kind “anomaly”. For something to pass as analogous to human language it must at least include something like morphemes, semantic and syntactic categories, syntax and a hierarchical structure. It must be productive; e.g. the formation of new words must be possible. It must be usable and useful in a creative manner, i.e. new appropriate utterances can be formed for any new situation. And it must be able to convey any information the speaker intends to express. In other words, language consists of discrete bits with unlimited combinations usable to express thoughts, intentions, feelings etc. – i.e. *digital*, *infinite*, and *intentional*.

Animal communication, on the other hand, is not infinite. It is used for organizing foraging and group movement, for identifying individuals, for establishing and maintaining social hierarchies, warnings, and mediating aggressive and hostile encounters. However impressive this list may be, it is still limited. This is something completely different from language. As Pinker puts it:

Nonhuman communication *systems are based on one of three designs: a finite repertoire of calls (one for warnings of predators, one for claims to territory, and so on), a continuous analog signal that registers the magnitude of some state (the livelier the dance of the bee, the richer the food source that it is telling*

*its hivemates about), or a series of random variations on a theme (a birdsong repeated with a new twist each time: Charlie Parker with feathers). As we have seen, human language has a very different design. (Pinker 1994:334; emphasis added)*

It is not a mere question of human versus nonhuman language. Humans also have nonlinguistic means of social communication which are analogous to that of other animals: facial expressions, various vocalizations, sobs, hugs, kisses, and gestures. Much of this has a kind of contagious "parrot effect", i.e. others tend to echo it, such as laughing and crying. This phenomenon is very common in the animal kingdom, e.g. when a vervet monkey spots a predator it immediately starts to give cries of warning. The other vervet monkeys cry along, regardless of whether they have actually seen the predator themselves or not. Again, this kind of communication is distinct from language:

*Some critical features that distinguishes automatic (unintended) forms of communication from intentional communication are characteristic of laughter. Laughter provides others with information about the laugher's state of mind and recent history, but it also exerts a more direct effect, a sort of compulsion to laugh along. [...] How odd and unnatural it would feel to enter a room where people were echoing each other's speech in the same way that they tend to echo each other's laughter! (Deacon 1997: 58; emphasis added)*

This was a very brief summary of the differences between language and nonlinguistic communication. A more thorough presentation of this subject would include a discussion of the rather unsuccessful experiments with teaching language to apes. However, as I mentioned

in the beginning of this section, too much elaboration on this matter is beside the point: language is not compatible with nonlinguistic communication – human or nonhuman – it is something else.

### 3 Evolution

Being distinct from other kinds of communication systems, language cannot just be an extreme variation of an existing widespread mode of communication – a kind of very complex variety or dialect of "animal talk". That would however place humans on the top of an evolutionary ladder making us the inevitable outcome of an evolutionary trend. This idea seems to be influenced by the Great Chain of Being from the 17<sup>th</sup> and 18<sup>th</sup> centuries (cf. Lovejoy 1936), in which all being were categorized hierarchically according to their amount of perfection; of course, near the top was man, ranked below angels and God. Similarly, man is sometimes still considered to be the highest being and therefore also the (perhaps) ultimate outcome of evolution.

But this is not the way evolution works. It is not an additive process. It does not make ladders like this; it makes something more like a bush with ever dividing branches. There is no unitary direction in evolution that would inevitably lead to humans with complex language. Evolution is a process of increasing *diversification* and *distribution*. Only in this very limited sense can one speak of a kind of direction in evolution. However, there is no unitary direction as such but rather an irreversible process. It is a gradual spreading out to whatever unfilled possibilities (niches) that are within reach. This happens by small variations of existing material – i.e. evolution consists of small mutations. Darwin (1859) called this *descent with modification*.

So, humans did not evolve *from* the apes but we evolved *with* the apes from a common ancestor. Language could have evolved (and *did* according to both Deacon 1997, Pinker 1994, Pinker & Bloom 1990, Donald 1991 and others) only in the hominid phylum after it separated from the chimps. Therefore, language is species-specific. We need not keep looking for homologies to language in other species in order to account for the existence language in evolutionary terms.

### 3.1 Natural Selection

Natural selection (Darwin 1859), or *Darwinian selection*, is the gradual adaptation of a species to its environment. This process of *descent with modification* applies to phyla of organisms with the three properties of *multiplication*, *variation*, and *heredity*, i.e. to entities that have the capacity to copy themselves. This copying is not perfect and it results therefore in variation. This variation builds up over time, possibly giving rise to traits that either increase or decrease the rate with which it reproduces. These traits are hereditary, which means that they occur in all subsequent copies of the same entity. So, the entities that reproduce most successfully – i.e. make copies of themselves that successfully copy themselves and are for example better at escaping predators or better at catching prey - will eventually become dominant and the competitors will die out. In short, Darwinian selection can be described as the adaptation of a lineage of organisms to the environment over vast spans of time.

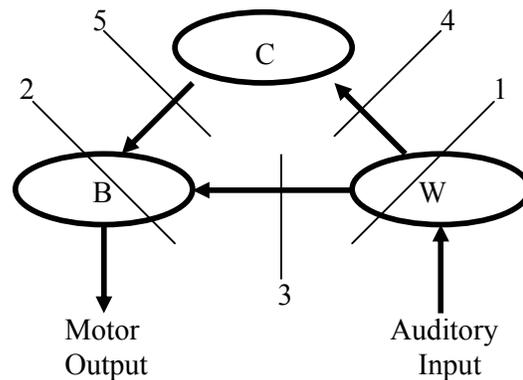
A modified version of this scenario is one in which the process is reciprocal: the environment changes as well as a consequence of behavior of entities. The theory that accounts for this is a modified version of Darwin's theory, first outlined by Mark Baldwin (1895) and therefore known as *Baldwinian selection*. In this version learning and behavioral flexibility play a role in biasing natural selection because these abilities can be used to modify

the context of natural selection, for example by moving into a new and different environment which asserts different selection pressures on the future generations. In other words, there is reciprocal transmission between genes, behavior (society), and environment. Genetic transmission affects behavior, behavior affects the environment, which in turn asserts selection pressures on the genes. The learned responses to the requirements of the environment throughout a lifetime are not passed on genetically to the offspring in one fell swoop (as argued by Lamarck (1809) in his *Philosophie zoologique*). Through behavior, the environment is changed so that the offspring that is best adapted and that has to learn the least, is favored. So, a trait that starts out as a product of learning need not remain so. If the environment is stable, there is selection pressure for this trait to become increasingly innate, because it can then be deployed earlier in life.

#### **4 Language in the Brain**

An approach to brain and function that places different functions, e.g. hearing, vision, speech production etc. in different specific brain areas is called a *localizationist* approach – each brain function is localized in a specialized area. The first empirical localizationist models of language were based on the findings of Broca (1861) and Wernicke (1874). Broca discovered that symptoms of expressive aphasia were linked to damage to the third inferior frontal convolution of the brain (since called Broca's area). The implication of Broca's discovery was that language was a unitary skill associated with a single language area in the brain. This, however, was quickly modified by the discoveries by Wernicke, who found that symptoms of fluent aphasia could be linked to damage to the first temporal gyrus (Wernicke's area). In his model of the brain, language was not conceived as a unitary phenomenon but as a complex of

underlying systems, all localized in the brain. A model of this ‘language machine’ is given in the figure below, adapted from Donald 1991: 47:



**Fig. 1: Model of aphasic disorders.** C = unspecified brain regions for conceptual elaboration, B = Broca's area, and W = Wernicke's area. The numbered lines indicate how lesions or destruction of the areas or their interconnections would result in the five major types of aphasia: 1: Wernicke's aphasia; 2: Broca's aphasia; 3: Conduction aphasia; 4: Transcortical sensory aphasia; 5: Transcortical motor aphasia.

The model in figure 1 illustrates the uniquely human capacity of language and implies species-specific brain regions: one for speech comprehension (Broca's) and another for speech production (Wernicke's). But both Broca's area and Wernicke's ditto are present in animal brains, cf. Deacon 1997, Müller 1996. This does not mean that other primates have language, but rather that the picture is more complicated: "So whatever might correspond to Broca's area in apes [...] is not a "call center," though it may to some extent be involved in vocalization control [...]" (Müller 1996: 616).

Another aspect of the model is that it accounts for different kinds of aphasia. Broca's (expressive) aphasia is usually associated with damage to Broca's area; Wernicke's (fluent) aphasia is usually associated with damage to Wernicke's area (leaving the other kinds of aphasia aside). Modern versions of Wernicke's expression/comprehension machinery can

be found in e.g. Obler & Gjerlow 1999. But the picture is not as neat as implied. The same kinds of language breakdown have been found with damage to other areas. According to Deacon (1997:307-308, based on research by Bates & Wulfeck 1989 and others) Broca's aphasia has been found with damage to Wernicke's area and vice versa in bilinguals. For instance in Italian-English bilinguals with damaged Wernicke's area display symptoms of Broca's aphasia in their Italian, while the English language of the same person shows symptoms of Wernicke's aphasia (see also Paradis, in press). Such dichotomies are not even confined to bilinguals (more on this in the next section). This also casts a shadow of doubt on the version of the language machine associating Broca's area with syntax and Wernicke's with semantics.

#### **4.1 Localized vs. Distributed**

Pinker (1994) claims that there is a specific language area localized in left hemisphere, based on the fact that in the vast majority of cases where brain damage leads to language problems the damage is in the perisylvian region.

The areas around the Sylvian fissure seem to be separated but in fact they are not. The cerebral cortex is like a large thick sheet that has been crumbled up to fit inside a too small container. So what appears to be adjacent may actually be separated and vice versa. Using MRI (Magnetic Resonance Imaging) scanning neuroscientists have constructed what the brain would look like if it was 'ironed' flat. The areas around the Sylvian fissure are not separate areas but parts of a contiguous region, "the language zone" (Gazzaniga 1989: 950). This perisylvian region is what Pinker calls "the language organ" (Pinker 1994: 307).

This does not mean that Pinker supports a version of the above-mentioned language machine – he explicitly discards the view that Broca's is the production area and Wernicke's the comprehension area. However, he does give Broca's area a central role in

grammatical processes and Wernicke's area a likewise position regarding the lexicon. This is not equal to claiming that Broca's area is the grammar organ. The matter is not at all that clear cut: "But to be honest, no one really knows what either Broca's area or Wernicke's area is for" (Pinker 1994: 311) and one out of ten patients with damage to areas in the vicinity of Wernicke's area can have symptoms of Broca's aphasia and vice versa (ibid.: 314). Furthermore, he states that there is no reason why language should be confined to the perisylvian area. Instead it might be distributed over other areas:

*From the standpoint of what the brain is designed to do, it would not be surprising if language subcenters are idiosyncratically tangled or scattered over the cortex. The brain is a special kind of organ, the organ of computation, and unlike an organ that moves stuff around in the physical world such as the hip or the heart, the brain does not need its functional parts to have nice cohesive shapes. (Pinker 1994: 315)*

In short, according to Pinker, language is somehow reflected in the brain in some sort of language area (for an account of his computational view of the mind/brain see Pinker 1997). The perisylvian territory is especially involved but language might be distributed over areas as well. This theory seems to be influenced by the conception that language is a system of morphosyntactic rules. I shall return to these matters below.

So, if language is distributed is the brain a unitary organ? No! Even though the infant brain is highly plastic, and to a lesser extent the adult brain as well, the brain is not "an unstructured equipotential mass" (Müller 1996: 618) or in Pinker's (1994) words "a meatloaf."

*Despite the microanatomical variability of the brain, at its higher levels of anatomical organization it falls nicely into areas, regions, and specialized parts that, in general, are functionally segregated or organized.* (Edelman 1998: 41; emphasis added)

(For a thorough account and discussion of neural plasticity and development see Edelman 1998, Elman et al. 1996, Müller 1996, and Bishop 1988)

Deacon 1997 concurs that language functions are distributed, but denies the existence of language specific regions. As mentioned, Pinker assigns language specific functions to Broca's area and Wernicke's area. Deacon, however, has a different approach: These areas are non-language specific *computational centers*. Moreover, they are weak *bottlenecks* in a larger computational chain, which explains why language breaks down when they are damaged. As mentioned above, evidence from studies of bilingual aphasics (cf. Paradis in press) shows that a syntax-semantics dichotomy with regards to Broca's area and Wernicke's area is at least dubious. As Deacon states, a better explanation is that Broca's area is responsible for *syntagmatic* relations and Wernicke's area for *paradigmatic* relations. A syntagmatic relation is a complementary relation; in linguistic terms for instance how nouns, verbs, and adjectives can be placed in sequence to form a sentence. A paradigmatic relation is one of substitution, e.g. the class of words that can be the subject of (substitute X in) "X is eating". According to Deacon, studies have shown that speakers of an inflectional language such as Italian who suffer damage to Wernicke's area tend to get Broca's aphasia (expressive aphasia) (cf. Bates & Wulfeck 1989 and Bates and MacWhinney 1991). Italian utilizes inflection to signal the grammatical relations whereas these are signaled by e.g. word order in English. The point is that the same underlying function is encoded differently in the two

languages and therefore different neural computational areas are used for this same function, which in turns leads to complementary associations with aphasic disorders.

Adding to the complexity is evidence from cases of *Williams syndrome*:

*Williams syndrome, a rare and genetically-based metabolic disorder (hypercalcemia) associated with a sharp dissociation of highly developed language versus low general intelligence and in particular, strongly disturbed visuoconstructive capacities.* (Müller 1996: 620; emphasis added)

Williams patients generally have an IQ of about 50 and are severely incompetent at problem-solving, at tasks such as tying their shoelaces, finding their way and drawing an elephant – but they are fully capable of describing an elephant eloquently, good at storytelling and recitation. Furthermore, they tend to have an intensely social personality and to be very sensitive to social information in general (cf. Deacon 1997: 260-278, Müller 1996: 620-621, and Pinker 1994: 52. See Bellugi et al. 1988 for a more thorough account of the syndrome). Neurologically, Williams syndrome is associated with a severe decrease in size of the more posterior cortical systems with sparing of the prefrontal cortex and cerebellum. Deacon claims that the sparing of the prefrontal cerebral cortex and the accompanying sparing of linguistic abilities is due to the bias towards symbolic learning associated with exactly this prefrontal cortex. I will return to these matters below. For now, the interesting thing is that almost the entire perisylvian territory except Broca's area is diminished in size in people with Williams syndrome. Pinker may have implied that the perisylvian territory might be the language organ, but paradoxically Williams patients seem to be fully competent linguistically while one would predict quite the opposite. The intact Broca's area is not the language area, as argued

above. So, again, the neurological language system has to be more distributed than around the Sylvian fissure.

Autism can be considered to be complementary to Williams syndrome as the syndrome is most notably characterized by social withdrawal and a lack of ability (and / or desire) to communicate – both linguistically and non-linguistically (cf. Fay 1988 and Deacon 1997: 273). As Deacon states (p. 274), the neurological basis of autism is still unresolved and no consistent pattern has yet been found. There appears to be a lot of variety in the symptoms of autism, cf. Fay 1988. Still, patients suffering from autism associated with communicative disorders tend to have the opposite abnormalities in the brain, i.e. decreased size of the prefrontal cortex and cerebellum, while the posterior cortex is intact.

Patients suffering from autism (with these kinds of neurological abnormalities) should exhibit excellent linguistic abilities, judging from the sparing of the suggested language areas. But the case appears quite the opposite. They tend to suffer from severe linguistic difficulties, if they have any language at all.

Judging from the sparing and diminishing of the prefrontal cortex in Williams patients and in aphasics respectively, it seems to have some important role in language.

## **4.2 Lateralization**

So far I have discussed the areas involved in language processing that are located in the left hemisphere alone. What about the right side of the brain, is it also involved or is language only reflected in the left hemisphere? Well, according to Steven Pinker, only the left side is involved. Language is by default located in the left hemisphere in the majority of right-handed normal people. Support comes from the fact that aphasia tends to be the result of damage to the left hemisphere:

*The evidence for the monopoly of the left is derived from the very robust clinical fact that aphasia rarely develops following right-hemisphere damage unless the patient suffered from early left brain injury, and from the fact that unilateral cerebral anesthesia of the right hemisphere will not cause loss of speech, while the same procedure on the left temporarily blocks language functions [...].*

(Donald 1991: 80)

However, as Donald states, these kinds of anaesthetic tests are transient and the linguistic tests accordingly limited and brief. It is not possible to test higher linguistic abilities, tasks that require larger spans of time. Furthermore, patients suffering from trauma to the right hemisphere typically do not show any signs of aphasia and are therefore not tested for language disabilities. These patients do show some symptoms of linguistic impairment, e.g. *aprosodia* – flat speech lacking tone modulation, or prosody. On aphasia and right-hemisphere damage, see also Bishop 1988.

Corballis (1989, esp. pp. 218-256) proposes a cognitive dichotomy of the brain. The left side is dedicated to generativity (identification of categories, components, and their order; the building of multi-part representation from these elements) while the right side is dedicated to holistic types of cognition. He doesn't concern himself with the anatomical details of the brain so the proposed generativity could be represented in multiple subsystems or in a single generative central processor. For discussion, see Donald (1991: esp. 70-82).

A much less restricted model than Pinker's and much more detailed than Corballis' dichotomy is found in Deacon (1997), who views language as distributed over the brain, not confined to the left hemisphere. He argues that this well established lateralization is due to innate computational biases that ensure the avoidance of computational 'noise' or indecision. The left side is biased towards speed-optimized computations and the right side

towards computations of large time domains. The left hemisphere is biased towards *rapid-speed analysis* and the right hemisphere is biased towards *long-term analysis*. This explains why the above-mentioned anaesthetic tests on the right hemisphere showed no linguistic disabilities, because the anaesthetic only has a short-term effect (i.e. short time span). *Syntax*, being a rapid-speed process, is not impaired and neither is intra-sentential analysis, such as word-word relations, which probably is (one of) the reason(s) why Pinker and others have restricted the localization of language functions (which he also conceives as generative) to the left hemisphere. The anaesthetized right hemisphere caused speech to become flat. Prosody has a supra-sentential domain and is affected by strokes to the right side of the brain.

Even though language seems to be spread out over the brain it is not a product of a unitary ‘meatloaf’ (a point on which both Deacon and Pinker will agree). It is modular in the sense that its functions are located in different areas of the brain. Rapid-speed morpho-syntax appears to be located around the Sylvian fissure of the left hemisphere while prosody and pragmatic abilities of coherence and cohesion appears to be located in the same perisylvian area on the right side. In this sense, language is both distributed and localized – a point on which both Pinker and Deacon will agree.

## 5 Co-evolution

How did language evolve in the brain?

[...] *The most likely explanation for the complex structure of the language faculty is that it is a design imposed on neural circuitry as a response to evolutionary pressures.*

(Pinker & Bloom 1990: 721)

For something to evolve by natural selection it has to benefit reproduction. Selection pressure arises if there is an advantage for an organism to possess the trait in relation to others that don't; i.e. if it enhances the probabilities for reproduction. So, how could language be an advantage to the earliest hominids?

The onset of the evolution that led to the human species and thus the break off from the chimpanzees is considered to be emergence of bipedalism in *Australopithecus afarensis*, freeing the hands for tool use. Pinker argues that the first traces of language could have appeared as early as the Australopithecines about 4 million years ago but he admits that evidence for a social structure plausible to support language is better with *Homo habilis* app. 2 million years ago. The Australopithecines used tools in a very crude form, whereas the *Homo habilines* used tools and cooperated in hunting for food, in securing safety, and nurturing. This kind of lifestyle asserts a cognitive pressure on the members of the community. On the one hand it offers support, protection, and reproductive opportunities, on the other hand the situation is open to opportunists – individuals who reap the benefits but who are not interested in paying the costs. So, the stage is set for *natural selection* to play its part regarding language. Pinker claims that there is pressure on the genes of the opportunists to evolve abilities to fool others, and thus pressure on others to detect subtle signs of deception. This in turn leads to pressure to evolve better and less detectable ways of 'cheating' (cf. Pinker & Bloom 1990: 725):

[...] *Outwitting and second-guessing an organism of approximately equal mental abilities with non-overlapping interests, at best, and malevolent intentions, at worst, makes formidable and ever-escalating demands on cognition. And a cognitive arms race clearly could propel a linguistic one.*  
(Pinker 1994: 368)

The pressure is on the ability to learn a complex communicative system that is useful in forming alliances by exchanging information and commitments. In this way, Pinker argues, selection would favor individuals with ever increasing linguistic abilities ever earlier in life, so that it would become a part of the genetic inheritance. So, what originally had to be learned with effort over time has become part of the genes, i.e. a case of *Baldwinian selection*.

The above mentioned “cognitive arms race” was the trigger of the enlargement of the human brain. *Encephalization*, the brain being unusually big in relation to the body, is not specific to humans or even primates, but it is rather extreme in humans (I shall return to these matters below). But, size is not everything. Language does not just pop out as an inevitable result or byproduct of a large brain (however, see Jenkins 1997). Neither did the brain expand because of a brand new neural part being introduced. As noted in section 3, natural selection works on existing material, not by divine intervention: there is no way that the human body-plan could produce for example wings, because what corresponds to wings in birds is present as arms in humans. Furthermore, as I discussed above, language is not confined to a single neatly delimited location, but spread out over several areas of the brain. So, language evolution / linguistic adaptation must have utilized existing brain parts by “rewiring” the primate neuro-circuitry.

As mentioned above, neither Broca’s area nor Wernicke’s area is specific to the human brain. Homologies have been found in other primates (cf. Pinker 1994, Müller 1996, Deacon 1997) but they are not used to produce calls or gestures. What corresponds to Broca’s area is involved in the control of muscles of the face, mouth, tongue, and larynx. Wernicke’s homologue is used to recognize sound sequences and to discriminate calls of others. This would have provided the process of evolution with the material to produce the human linguistic circuitry. Additionally, the position of the larynx is unique in humans, but its

existence is not specific to humans. This unique position has both pros and cons. There is for instance a high risk of food and drink falling into the lungs, because we can't swallow food and/or drink while breathing, but:

*The positioning of the larynx deep in the throat, and the tongue far enough low and back to articulate a range of vowels, also compromised breathing and chewing. Presumably the communicative benefits outweighed the physiological costs. (Pinker 1994: 354)*

The evolution of something originally evolved for something else is a sub-grouping of natural selection: *exaptation* (cf. e.g. Deacon 1997 or Pinker & Bloom 1990. For an account of how this principle applies to language change see Lass 1980). Briefly, Pinker argues that language evolved due to selection pressures on communicative abilities that would be beneficial to survival for a cooperative society and a cognitive arms race. By exaptation of existing brain circuitry language has come to be reflected in specific areas of the brain – the language organ.

According to Pinker, the language organ, being universally present in all human brains, contains the 'blue-print' that is the basis for human language: a universal grammar. This grammar consists of the basic principles underlying all the languages of the world. The language instinct enables the child to acquire its mother tongue without formal and / or explicit teaching and in spite of limited input. I will not go into details of generative grammar and the unfolding of the bio-program, but just give a (quite unjustly) brief account of how Pinker views language acquisition. For somewhat different accounts of the bio-program and the critical period see Deacon 1997, Elman et al. 1996, Müller 1996, and Pinker 1994. Heredity, the *language instinct* that provides the *basic design* of language, assures the ability to acquire a language. This language instinct, however, does not provide the details of

language; the *environment* has to supply the *specifics*. This process can be assisted by general cognition. This approach to language acquisition is essentially what is known as an *epigenetic* approach (cf. Elman et al. 1996 and Müller 1996), in which a sharp distinction between nature and nurture with regards to language is considered hollow: one is nothing without the other.

To Deacon (1997) the key to answering the question of why language emerged in evolution also lies with the society of our earliest ancestors. Deacon's evolutionary theory is one of natural selection as well, but it differs from Pinker's view.

The *Australopithecines* were social creatures living in groups – a lifestyle mostly associated with polygamy. In the animal world monogamy is mostly restricted to animals living in isolated pairs, while the most common reproductive social behavior is polygamy with one male having several females. But the earliest human ancestors were *monogamous* and living in social groups. Groups of pairs are in constant danger of being cheated sexually. For the hunting *male*, who brings food to the nurturing female, there is a substantial risk that he protects and feeds the offspring of another male, who could have mated with the female in his absence. The female, on the other hand, is in constant risk of being abandoned by the male, who could be mating with another female and feeding their offspring, which would be lethal for her, as she cannot leave the offspring. Another danger for the female is the chance of abduction by other males and attacks from predators, so she needs a protector as well as a provider (cf. Deacon 1997: 389). This kind of conflict is exactly what is needed for natural selection, or rather a subdivision of this called *Sexual selection* – the selection of features that only enhances mating probability but not necessarily survival (cf. Deacon 1997: 380)

So, according to Deacon, the time or rather the activity that asserts the biggest pressure on communicative abilities is mating. There is a need to find a reproductive partner, and moreover one that is faithful: a male that will provide food and protection for the female

and offspring, a female that will nurture the offspring, and crucially for both, a sexually faithful partner. In addition, assurance must be made that the other group members cooperate in these arrangements (as well as in hunting matters). The problem is how to assure this. How do you signal sexual monopoly and make sure that the message is understood?

*But if there is no unequivocal marker of allowable and unallowable sexual access, or appropriate sharing and provision of resources how can one tell who is cheating and who is not? How does one tell who is obligated to whom?*

(Deacon 1997: 399)

The solution is the establishment of a different social system or social order: the *symbolic society*, where each individual's position is related to everybody else's, and where this position is negotiated not by fighting but by symbolic means, which would be the *precursor* of language according to Deacon. Symbolic culture was a response to a reproductive problem only solvable with symbols, i.e. the need to represent social contracts.

But a symbolic language didn't just manifest itself. Deacon theorizes that alliances, contracts, and cooperation were established by rituals. The transition from a more concrete indexical reference (sign-object or sign-immediate situation relation) to an abstract symbolic representation (systemic sign-to-sign relation) is a very difficult step. This transition is much more easily brought about by the massive amount of redundancy and repetition offered by rituals. A modern social contract that still has a reminiscence of its original ritualistic and symbolic origins is marriage. The sacred marriage is (practically) universal and is embedded in rituals and ceremonies that still echo ancient times (for an account of human universals see Brown 1991 or the short version in Pinker 1994: 413-415).

So, like in Pinker's theory, the cognitive arms race is on, leading us to the question of how language came to be reflected in the human brain. First of all, the greater demand for and selective pressure on cognitive abilities is what leads to encephalization. According to Deacon what is needed are entities that learn more easily how signs can refer to something by its relation to other symbols not merely by co-occurrence, i.e. entities that more easily overcome *the symbolic threshold* (cf. Deacon 1997: 79). What is needed is a special kind of learning, a special kind of cognitive adaptation. Deacon argues that the brain should reflect language in its architecture, in such a matter that what is most exotic about human language corresponds to what is most peculiar about the human brain. Language, unlike any kind of communication found outside the human species, is a symbolic system; and (according to Deacon) the human brain is three times bigger than what would be expected for a primate of our size.

As stressed above, a larger brain does not inevitably produce abilities for language, so it must be important *in what way* the human brain is big. If we consider gross brain size then whales and elephants have significantly larger brains than humans do. A simple brain-to-body ratio is just as useless, as for instance mice and sparrows have larger brains in relation to the size of their bodies, and are in general not considered to be very intelligent. Furthermore, they do not speak a language. A third possibility is a part-whole ratio: bigger bodies need larger proportions of neural circuitry devoted to body control and maintenance. It seems to follow that a further enlarged brain would help this situation and leave more "cognitive space" open to intelligence. But then we are back to square one: whales are brainier than humans. The proper measure is that of part to part: which part of the brain is bigger in relation to which other parts? Let's first look at an interesting aspect of human growth:

*Our brains grow as though in a primate with an adult body size that well exceeds 1,000 pounds, and yet our body growth pattern is quite similar to that of a chimpanzee. Both the human brain and the rest of the human body grow according to expected trends for their target adult sizes. These trends just don't normally belong together in the same individual. (Deacon 1997: 174)*

This means that not everything in the human brain is larger. Due to the relatively smaller body size in relation to the brain, neural areas in 'direct' contact with the outside world through vision, smell, movement, and touch are reduced to the appropriate size (i.e. a smaller part of the brain is dedicated to these aspects), while areas with no direct outside contact will be relatively enlarged (that is, these are not reduced to the expected size in relation to the human body size). The human auditory areas are slightly enlarged (including parts of Wernicke's area), but the significant area is the prefrontal dorsal cerebrum, which is twice the expected size. It is not only a bigger brain it is also a very different brain.

Edelman 1998 describes development in the brain as *neural Darwinian processes* – one might call this “survival of the fittest brain part”. Neural Darwinism can be viewed as the struggle for domination by the extensions from the different brain parts during development. Each area extends connections to everywhere else in the organism, but the largest areas have the most connections and the smallest the fewest. Deacon claims that through this process the prefrontal areas (including Broca's area) come to control facial muscles, tongue, and larynx. Thus the prefrontal cortex has predominance over the vocal-auditory processes that are under visceral control in other primates; that is, these vocal-auditory processes are under skeletal (motor) control in humans as opposed to other primates in which the same processes are under instinctual control – directly influence by stimuli. In this important sense the human brain is *front heavy*.

This last point takes us back to the discussion about Williams syndrome and autism. As I discussed above, patients suffering from Williams syndrome are intellectually retarded. They are poor learners in general, but are excellent symbol learners. Williams patients have extra large prefrontal lobes in relation to the rest of the brain, which is diminished. They are also hyper social. All this seems to support the theory of a selection pressure towards humans more socially adapted and pre-adapted to symbol learning. Williams patients could be extreme cases of this selection: they have (relatively) enlarged frontal cortex, they are social, and their language is intact.

The complementary pathological disease to Williams syndrome is autism, which is associated with severe communicative difficulties and asocial behavior. Furthermore, these patients appear to lack what is called a “theory of mind”, which is the awareness of others as conscious agents with feelings and emotions and thus the insight that others may or may not think or know the same as one self. These patients have relatively smaller prefrontal lobes (cf. Bellugi et al. 1991), which may explain the lack of both symbolic and social abilities. Evolution, according to Deacon, seems to have selected for idiot savants of a special kind:

*One might characterize the theory I have proposed about language abilities in these terms: prefrontal development has made us all savants of language and symbolic learning. While still immature and exhibiting very limited learning abilities in most realms, two- and three-year-old children spontaneously solve symbol-learning problems “in their heads” that other species find essentially impossible even with considerable outside human support. (Deacon 1997: 416; emphasis added)*

## 6 Language of the Brain and Vice Versa

The discussions in the previous section point to a strong connection between the evolution of social structure, encephalization, and language. Dunbar (1988, 1990, 1993) has also stressed this connection. He proposes that relative brain size measured by the encephalization quotient EQ increases in primates with the size of the social groups they form. This is due to the complexity of the structure of these groups, which is very unlike the simple structure of e.g. cattle flocks. The cognitive demands of maintaining the complex of social relations lead to the evolution of language (see also the discussion in Donald 1991: 137-141. For another recent view of the evolution of language, see Foley 1997: 41-78).

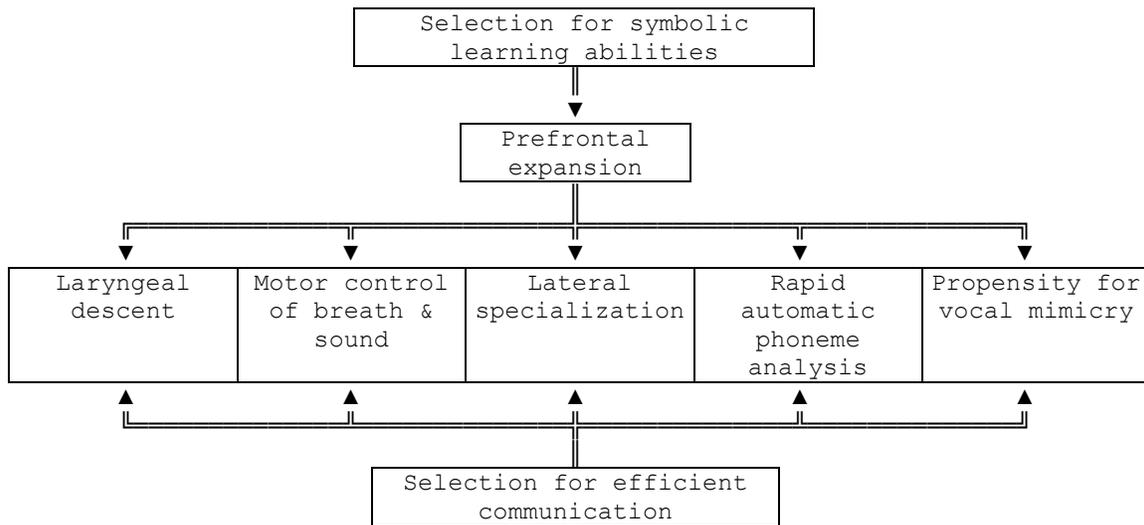
The encephalization of the human brain seems to be selected due to a “cognitive arms race”. Both Pinker and Deacon agree on the evolutionary advantage of being able to establish and maintain social alliances and contracts and to outsmart cheaters, i.e. those who do not ‘honor’ those contracts. They do, however, disagree on what this cheating involves. Pinker defines cheaters as those exploiting the benefits of protection and provision of the group while not participating in these activities – *social parasites*. Deacon defines cheaters as sexual cheaters, those who do not honor the marital contract – *adulterers*.

Both Deacon and Pinker concur that language has a social beginning, but the difference in the way they conceive cheating reflects the way they conceive language. Pinker proposes a cognitive module that was selected for by natural selection because of its advantages for *social* survival. This language module evolved by exaptation of areas that originally evolved for different reasons. Over time the brain adapted to the problems of language learning by ‘internalizing’ (in the lack of a better term) the basic principles of human linguistic communication, and thus easing the learning process. So why not internalize the entire system?

*Though there is always a selection to make learnable connections innate, this pressure diminishes sharply as most of the connections come to be innately set, because it becomes increasingly unlikely that learning will fail for the rest. (Pinker & Bloom 1990: 723; emphasis added)*

*[...] Even if the genes themselves specify the basic design of language, they might have to store the specifics of language in the environment, to ensure that a person's language is synchronized with everyone else's. In this sense, language is like another quintessential social activity. (Pinker 1994: 277; emphasis added)*

Unlike Pinker, Deacon believes that language has evolved for its advantages in choosing the right and non-adulterous mate. It is not so much a matter of survival but rather a matter of reproduction, hence sexual selection. He also stresses the exaptation of existing neural circuitry, and especially the important and initial encephalization essential for the evolutionary adaptation to language learning. A very special and difficult kind of *learning* requires a special kind of brain. So, in Deacon's view, the human brain is attuned to symbol learning and especially to language learning – no room here for Pinker's language instinct with innate language principles. Once the symbolic core adaptation – encephalization of the prefrontal cortex – is done there is selection for supportive adaptations to benefit efficient communication. This in turn put selection pressure back on the prefrontal lobes to 'take control'. This is illustrated in the following diagram (adapted from Deacon 1997: 353):



**Fig. 2: Illustration of how selection for symbolic abilities lead to expansion of the prefrontal cortex (the core adaptation) which in turn lead to distributed supportive adaptations. In time a more efficient means of communication evolves and the supportive adaptations become entrenched in this system. This in turn asserts selective pressure back on the core adaptation, the frontal expansion.**

Therefore Deacon claims that:

*[...] language must be viewed as its own prime mover. It is the author of a co-evolved complex of adaptations arrayed around a single core semiotic innovation that was initially extremely difficult to acquire. Subsequent brain evolution was a response to this selection pressure and progressively made this symbolic threshold ever easier to cross. (Deacon 1997: 44)*

All the physiological and neuro-anatomical specializations are selected for because they benefit a more efficient communication. The prefrontal expansion is selected for because of its supposed symbolic nature. In this sense, according to Deacon, language is a parasite on the

brain that changes and feeds on and adapts to the anatomy of its host, cf. Deacon (1997: 111-115) and Dennett (1991).

Deacon illustrates very clearly the many things that need to co-evolve to achieve a modern complex language supporting system. This clearly shows why language doesn't just emerge from a large brain. This points to a gradual adaptation only explainable through natural selection. So far Deacon and Pinker agree, but Deacon criticizes Pinker's generative approach for only providing the endpoint, what language evolution needs to explain – a description of the human linguistic competence. Furthermore:

*I think it also misses the forest for the trees, even in this endeavor [selectionist rather than non-selectionist]. I don't think that children's grammatical abilities are the crucial mystery of language. (Deacon 1997: 39)*

He states that a theory claiming that humans acquire language with ease because they have a genetically based instinct to do so is circular. Deacon's point to the quote above is that the central and crucial mystery of language is its symbolic nature. So, humans can and do learn language with such an ease simply because the human brain (genes again) has evolved to do so. I think that Deacon's story is just as circular as Pinker's, if this is what he considers circular. In my opinion, the main point is that the human brain has been altered (has adapted) by the forces of natural selection to assist in the problematic acquisition of language. Language and the brain have co-evolved to reach the present state. Complex language is not just the outcome of a complex brain, and a complex brain is not the outcome of complex language. The two have co-evolved.

Locating language in the brain is the harder part. Pinker suggests that the left perisylvian region is the default location of a 'language organ' but sees no problem in further

distribution of language over other areas. Deacon seems to be extremely focused on the prefrontal lobes and their importance for symbolic learning. As evidence he suggests patients with Williams syndrome. In spite of intellectual retardation they seem to be sensitive to symbolic systems, including language, which is why Pinker uses the phenomenon as evidence for the double dissociation between language and intelligence in general. Deacon considers Williams patients to be super “language-absorbers” or “symbolic entities”, but this may not be the case, cf. the following quote from Müller 1996:

*In adult WPs [i.e. Williams patients], phonological, lexicosemantic, and pragmatic language components appear to be intact as well although early language acquisition is delayed [...]. Relatively intact linguistic capacities in WPs can further be related to two nonlinguistic domains: First, high socioaffective function [...] which may be related to good facial recognition (in the context of visuospatial deficit [...]), and second, hypernormal auditory sensitivity [...] which suggests that WPs’ good language development may have a perceptual basis. (ibid.: 620; emphasis added)*

In addition, Müller suggests that WPs’ language learning is strongly based on rote learning. He mentions examples that have been found of use of strange prepositional constructions that can only be explained as overgeneralizations from idiomatic expression such as “once upon a time”.

*This may indicate that language acquisition in WPs is an extreme form of a nonanalytic “expressive/pronominal” style observed in some normal children [...]. (Müller 1996: 620; emphasis added)*

One should also keep in mind that evidence from pathology is only indirect at best. We should be very careful with any conclusions claiming that some area is exclusively devoted to a certain function if this function breaks down when the area is traumatized. Strictly speaking, this only shows that the area is somehow involved. Pathological cases show that language can be damaged and destroyed if certain parts of the brain are traumatized or removed, but usually not in a strict one-to-one fashion - they are tendencies of correlation. But they also point to the fact that language is not scattered over the entire brain as if a function of a general learning mechanism or the like.

I think it is safe to say that language has symbolic origins. Even Pinker admits that language required a cognitive arms race leading to the emergence of a symbolic communication system. Even if language evolution was driven by natural selection, which favors organs and devices for survival (rather than sexual selection, which favors competitive success in gaining mates for the sake of reproduction) the society in which it should be used had to be established beforehand. This means that symbolic communication (or at least thinking) had to be present for the establishment and maintenance of this social order. This, I think, makes Deacon's theory of why language emerged in the first place the likeliest one of the two. In fact, I think that the basic issue of disagreement between Pinker and Deacon is this: Pinker argues for natural selection – survival – and hence the crucial basics of symbolic communication have become part of the genes. Deacon argues for sexual selection – reproduction – and because of the need for social structure the crucial information on the symbolic system is (still) in the environment (society).

However, the question of instinct (Pinker) versus super-learning (Deacon) is, I think, not an either/or matter. As has been argued and discussed above, the brain is shaped and adapted to language. Through evolution both language and brain have changed and

increased in complexity. Deacon argues that the human brain is extremely sensitive to symbolic systems, especially language, because language has changed as well to better match the learning strategy of the developing brain of human children. This amounts to saying that language acquisition is more or less automatic and unavoidable in linguistic context. In fact this is also what Pinker and generative linguists claim. This is because the brain is designed to do so – it has evolved to manage linguistic material – and because language has changed to match the kind of brain designed to use it. On the points generativists concur. Deacon claims that humans have a special learning bias towards semiotic systems, especially language, cf. the many co-adaptations in the section above. Learning is not a monolithic process but specific to both species and task, so there must be a specific language learning mechanism. This may well be, but on this basis I would follow Pinker in his claim that the basic principles of language have become innate. In addition, Müller points out that studies have shown that Williams patients use rote learning and rely on hypernormal auditory sensitivity – good for picking up speech – and that they are very good at facial recognition (and are otherwise visuospatially handicapped) – this is good for learning who's who in the social system. This casts a shadow of doubt on the symbolic processor in the prefrontal cortex, as proposed by Deacon.

On the other hand it seems that the encephalized prefrontal cerebral cortex is important for language, as well as the areas in the perisylvian region of the left hemisphere. This does not mean that I am suggesting a language specific neurological organ. What I am suggesting is that these areas are *specialized* in certain kinds of *computation* utilized in language. In this sense, I think that there is a kind of default brain plan, in which *rapid-speed linguistic processing is distributed over specialized areas, usually (by default) located in the left hemisphere*. The processing of long narratives and such may be processed in the right hemisphere devoted to long-term relations.

So the result of this comparison of views of co-evolution of language and brain has a two-sided result on which I am sure both Deacon and Pinker would agree. On the one hand, the human brain has been shaped by and for language and has become *the brain of language*. On the other hand, language has changed to better suit the communicative demands offered by its users and the learning/acquisition of children and has indeed become *language of the brain*.

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