

Did Neanderthals Have Language?

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Introduction

The following paper will attempt to propose a reasonable explanation for acceptance of Neanderthal capacity for language, and the probability that some form of language was used for social communication. This explanation will deal with brain expansion, and the secondary effects of brain expansion on the gross morphology of modern human and Neanderthal crania. This paper begins with an examination of language acquisition in modern human brain structure, and put forth that language acquisition, development, and capacity were the driving forces behind human brain enlargement. Language acquisition will be studied in detail and a theoretical model of brain development will be put forth to explicate this acquisition. A theoretical model will then be given to explain how this mechanism could develop the modern human brain. Finally, this expansion of the brain will be examined in light of morphological changes in the crania, and a comparison made between the evolutionary conditions that could select for the differences between modern humans and Neanderthals.

The Language Acquisition argument will be constructed in the following manner: A discussion of the theoretical mechanism of Universal Grammar, a discussion of the theoretical mechanism of "modularity of the mind", and the biological mechanism of brain circuitry acclimation. Pros and cons will be covered on these mechanisms, with the brain circuitry acclimation model being chosen as a reasonable theoretical model of brain development according to both philosophical and biological acceptability. Discussion on language acquisition will be followed by reasoning for language acquisition and development as the driving force in hominine brain expansion throughout time. This reasoning will be supported as theoretically possible by the evolutionary mechanism of genetic assimilation, which will be discussed in detail as the vector through which social pressure results in evolutionary change. Finally, this paper will focus on the consequences of brain expansion on gross cranial morphology, and the differences between modern humans and Neanderthals. This comparison will take into consideration evolutionary and social pressures as causes of these differences in the two populations, and then will postulate that Neanderthals had the capacity for language, but that there is no way to prove short of evidence of written language that they did or did not use a modern form of language for communication.

Language Acquisition and Ontogenetic Brain Development

Universal Grammar

The mechanism of "universal grammar" is a conceptualized system where specific rules are thought to be universally present in all language, a set of basic underlying grammatical structures required for language functionality. The basis for the modern concept of universal grammar was a 1957 book written by Noam Chomsky, entitled *Syntactic Structures*. This volume is generally considered "revolutionary" for the development of modern linguistics (Falk 1998: 463). The view of an all-encompassing set of structural language rules was not a new idea, and this concept was not the main reason for the academic success of the Chomsky paradigm. Rather, Chomsky's take on universal grammar was considered important because he, "did not restrict his work to the description of language structures, he sought explanations for the principles of human language" (Falk 1998: 463). Chomsky drew upon philosophy to construct a model of human language acquisition that purported that the essential grammar structures of language (the seventeenth and eighteenth century *grammaire générale* of rationalism) were a genetically transmitted entity.

Chomsky claimed that his Universal Grammar model explained the underlying homogeneity of human languages, the absence of "primitive" language types, and the seemingly savant-like ability of young children to master fundamentals of language use (Falk 1998: 463-464; Goodwin 1994: 100; Mithen 1996: 44). Universal Grammar became most widely associated with the latter phenomenon. Since Chomsky also insisted "that the extraordinarily rapid acquisition of linguistic competence by human infants and the degree of creativity displayed is so far beyond anything demonstrated by other species that it reveals a *qualitatively distinct* level of cognitive organization" (Goodwin 1994: 100; emphasis added), Universal Grammar became a *qualitatively distinct* trait used to define *H. sapiens* as a species. This distinction led the Universal Grammar model of Chomsky to be separated from its conceptual basis, and shifted to a biological basis by anti-evolutionists, even though there was and is no genetic or biological evidence of language rules somehow biologically structured in the brain. Thus,

the study of language has been and remains a citadel of anti-evolutionary sentiment. It is easy to see why anti-evolutionists would seize upon any excuse to accentuate the alleged differences between the class of men and angels, on the one hand, and the

class of vegetables and brutes, on the other. Anything to find a difference that is essential and qualitative rather than a matter of degree (Ghiselin 1997: 138).

This concept of differences that are qualitative versus quantitative is an important one when considering the Chomskian paradigm. The idea of Universal Grammar as a conceptualized theory that explains human language acquisition must be separated from the idea of Universal Grammar as a qualitatively distinct human trait. The use of UG as the former is a philosophically valid theory about what goes on in the black box of human language acquisition, while the latter use is an anti-evolutionary mechanism used to differentiate humans from all other species. In this latter capacity, UG is also assumed to be the correct and/or only mechanism of language acquisition. This stance is considered anti-evolutionary, because in claiming UG as a defining characteristic of *H. sapiens* in such a synchronic manner, the possibility of human evolution is implicitly denied. Since only humans have UG, and UG is present only in humans (a qualitatively distinct trait), then evolution beyond the present state of humanity is denied in light that a human population that changes will still have UG, and will thus still be "human". Conversely, since UG is only present in humans, an earlier non-human species could not develop UG because only humans can have UG, and if no species could evolve UG, then there was no human evolution. This use of Chomskian UG is obviously not scientifically, nor philosophically sound, but it shows the inherent danger in postulating discrete human traits on a non-quantitative basis.

When describing why UG is considered a reasonable conceptualization of the black box of human language acquisition, UG is often described as a biologically "triggered" behavior (Aitchison 1998: 560-579). Biologically triggered behaviors cover a wide range of physiological behaviors (e.g. sexual maturity), which are genetically programmed, but do not occur when understimulated by the environment (either macro- or microenvironment), or when under conditions of extreme stress. There are generally six accepted "hallmarks" of biologically controlled behavior that must be satisfied if UG is to be even considered a genetic predisposition:

- 1.) The behavior emerges before it is necessary.
- 2.) Its appearance is not the result of a conscious decision.
- 3.) Its emergence is not triggered by external events (though the surrounding environment must be sufficiently "rich" for it to develop adequately).
- 4.) There is likely to be a "critical" period for the acquisition of the behavior.
- 5.) Direct teaching and intensive practice have relatively little effect.
- 6.) There is a regular sequence of "milestones" as the behavior develops, and these

can usually be correlated with age and other aspects of development (Aitchison 1998: 561).

The first two hallmarks will not be discussed due to the inability to test for their veracity in UG. Since it is generally assumed that they are true (Aitchison 1998: 561-562), I will accept the null hypothesis of their veracity. The third and fourth hallmarks are also seemingly acceptable under UG, as shown in the case of "Genie" (Fromkin et al. 1998: 588-605), although the term "critical" period may be better used to refer to as a window of optimal language acquisition, rather than a window of language acquisition in any qualitative level of development (Fromkin et al. 1998: 602-603). The claim that direct teaching and intensive practice have relatively little effect on language acquisition is debatable but will be generally accepted in this paper. Eric H. Lenneberg has quantified the regular sequence of "milestones" into twelve sequences from twelve weeks of age up to four years (1998: 556-559). All normal children seem to go through these steps in the same relative order, but at varying ages. Therefore, for the sake of argument, UG will be considered to fulfill the generic requirements of a biologically "triggered" behavior.

Now that UG has been shown to be a feasible mechanism of language acquisition, as an unexplained biological mechanism, evidence beyond a model that fits the data must be considered. As a model of genetically programmed language structures, there must be areas of the brain that house these rules. Thus, if these areas are damaged, language functions should be damaged. Proponents of UG tend to focus on three pieces of evidence that seem to follow this supposition: brain lateralization, Broca's area, and Wernicke's area. "Lateralization refers to the fact that each hemisphere appears to be specialized for different cognitive functions" (Fromkin et al. 1998: 600). It has been consistently shown through experimentation that the left hemisphere of the brain is associated with language use in approximately 94% of humans (Curtis and Barnes 1989: 889-891). Broca's area is an area on the lower portion of the left prefrontal cortex, where damage causes a profound disturbance in the ability to speak (Deacon 1997: 281). Wernicke's area is an area on the posterior part of the temporal cortex on the left side, which, when damaged disturbs the ability to understand speech (Deacon 1997: 281). On the surface, everything seems to be providing evidence for UG.

However, there are serious problems with using these three examples as evidence for the existence of Universal Grammar. First, lateralization seems to be caused by genetic factors that are unassociated with language. Lateralization is caused by genetic

factors; this is seen in the beginning of lateralization universally *in utero* (Heny 1998: 649). Unfortunately for the UG proponents, the localization of the language functions in the brain can be switched to the right hemisphere when the left hemisphere has been removed or damaged. If language structures are genetically programmed, they would simply not form under such conditions, much as a new leg will not grow if a one's leg is cut off. While "the ability of the right hemisphere to assume this left hemisphere function is closely correlated with the age at which the injury occurs" (Curtis and Barnes 1989: 889), the fact that any language ability can be taken up by the right hemisphere after brain development has stopped (adults), indicates that a directly genetic originated structure is unlikely to account for language function and/or acquisition (Fromkin et al. 1998: 602).

Broca's area is also problematic as evidence for UG. If Broca's area were genetically constituted, the area would localize and form at some genetically and environmentally determined rate. The key though, is that if specific instructions existed in the genetic code for a structure that regulated the rules of language, that structure would localize specifically. This is not the case in Broca's area. An important distinction is that

child aphasia cases differ markedly from adult ones. Most young children show symptoms of something like Broca's aphasia regardless of where brain injury occurs within the left hemisphere. Thus, although language may be situated on the left by age five, localization within the left hemisphere may come later (Heny 1998: 649).

Since this same situation does not occur in adults, it seems to indicate that the language functions associated with Broca's area is distributed throughout the entire left hemisphere in early development. This denies genetic coding for a specific language center (at least in the case of Broca's area), because a genetically specified structure would localize immediately, and not have its functions spread throughout the entire left hemisphere.

Wernicke's area is also only tenuous support for UG. Since Wernicke's area is an auditory center, and the main dysfunction of Wernicke's aphasia is trouble understanding spoken speech, it may be likely that Wernicke's area has less to do with cognitive understanding and formation of language, but rather with mainly outside language perception (Deacon 1997: 255-256). It is unclear as to how a structure such as Wernicke's area would be related to UG, if UG were modeled as a mechanism of genetic language rule knowledge used to facilitate language acquisition, when Wernicke's area seems more involved in sound processing.

Concluding the discussion of Chomsky's paradigm of Universal Grammar as a possible mechanism of language acquisition, the evidence seems to point away from that possibility. UG seems to be a conceptual design, which was engineered to fit existing data (the "hallmarks" of biologically triggered behaviors), that is incapable of being empirically tested for its presence or absence. Although as a conceptual device it is not directly testable, one can inductively assume biologically definable structures that house the "rules" of UG. When examining evidence of possible structures to fit these expectations, the proposed structures show serious problems that do not clearly associate them with the theoretically present structures. While UG is not disproved by this analysis, it does seem to lose credibility as the "probable" mechanism of language acquisition.

Modularity of the Mind

Another mechanism that has drawn wide attention in the philosophy of the mind, is the "modularity of the mind" concept. While many different theories about brain structure use the modularity model of brain architecture (Fodor 1983; Gardner 1983; Cosmides and Tooby 1992; Greenfield 1991; Karmiloff-Smith 1992; Mithen 1996), all follow same general underpinnings. This common ground is, "according to the modularity hypothesis, the human mind is not an unstructured entity but consists of components which can be distinguished by their functional properties" (Smith and Tsimpli 1995: 30). In the varying modular hypotheses, the number of modules, their function, their intercommunication, etc., differs (sometimes considerably). However, most seem to agree that, "the basic distinction relevant to cognitive architecture is that between perceptual and cognitive systems, where the former pertains to the sensorium plus language, while the latter refers to 'central' systems responsible for the fixation of belief, for thought and for storing knowledge" (Smith and Tsimpli 1995: 30).

Since this paper is evaluating the viability of language acquisition mechanisms, I am primarily concerned with the perceptual systems, which purportedly include the language acquisition module. The modular hypothesis and the Universal Grammar hypothesis are not mutually exclusive. In fact, they are used to explain each other (Smith and Tsimpli 1995: 22-31). Universal Grammar is the information that governs the language acquisition module (the Language Acquisition Device), while the modularity hypothesis provides the biological structure needed to encapsulate the language principles. The arguments for a "modular mind" are similar to those used to explain UG, and as well, many of the arguments against are also similar. Before

examining the biological evidence for, or against, the modular hypothesis one must first consider the nature of a mental "e;module".

One of the earlier proponents of the modular hypothesis, Jerry Fodor, defines a module as an, "informationally encapsulated computational system – an inference-making mechanism whose access to background information is constrained by general features of cognitive architecture, hence relatively rigidly and relatively permanently constrained" (1990: 201). In Fodor's vision of modularity, the "perception" modules are informationally encapsulated; meaning each perception module cannot communicate with other perception modules. This view of modularity is not universal, but will be the accepted view cited here, since it is not the purpose of this paper to argue the philosophical merits of one modular hypothesis over another. Those that intertwine the modular hypothesis with the UG hypothesis envision modules as, "equipped with a body of genetically determined information specific to the module in question which, in the case of language, is UG" (Smith and Tsimpli 1995: 31).

While the merits of modularity are a hotly debated topic of discussion in philosophy classrooms, it is not important to the language acquisition debate beyond perhaps, in some very slight general way. It is mainly a philosophical mechanism that has little to no capacity of experimental proof. The one aspect of the modular hypothesis that may seem to provide some avenue of experimental productivity is the concept of the physically separated modules themselves. If, "perception is carried out by *modular systems* which are domain-specific, fast, mandatory, subserved by specific neural architecture – hence subject to idiosyncratic pathological breakdown" (Smith and Tsimpli 1995: 30), then if specific areas of the brain are damaged, specific functions will also be damaged. Here again we are faced with Broca's and Wernicke's areas. The arguments against using those two areas as "proof" were examined earlier, and the same arguments can be used against the modular hypothesis. While these two portions of the brain may or may not be a function of modules and/or UG, they are not explicit enough in their applicability to provide "hard" evidence for these hypotheses. As these two portions of the brain and the specific aphasia that occurs from damage to them are applicable as "proof" to any number of possible language acquisition mechanisms, they thus do not constitute proof. This is analogous to a prosecutor in a murder case "proving" that a suspect is the murderer by showing that he/she is physically capable of pulling a trigger on a firearm. It is too general a piece of evidence. Jerry Fodor makes the danger of using information of this type as proof explicit when he states: there are, in general, lots of mechanisms that can perform a given task, so that inferences from a task to the mechanism are up to their ears in

affirmation of the consequent; one knows about the philosopher who, just before they discovered the ninth planet, proved from first principles that there have to be exactly eight (1990: 207).

Other evidence seems to undermine the separate module concept. PET scans (Positron Emission Tomography) have shown that when the human brain does language tasks, different parts of the brain are active, and this is not consistent with the idea of a self-contained language module (Deacon 1997: 294-298). If language had evolved to fit the addition of a language module in the human brain, there should not be, "such an extensive distribution of linguistic processes in diverse cerebral cortical areas" (Deacon 1997: 298). Another piece of evidence that does not support the modular hypothesis is the recovery of some language ability in adult aphasiacs. Brain development has completed, and no new brain cells will regenerate, which makes it theoretically unlikely – under the modular hypothesis – that any function that is governed by a damaged or removed area could be regained. However, "in nearly all cases some recovery of speech functions is typical unless there are significant concomitant auditory and comprehensional deficits" (Deacon 1992: 132). If language in the human brain was modular, and genetically determined, then the location of specific functional areas should vary little between humans, but this is not the case. Studies that map brain function areas through brain stimulation have, "unambiguously demonstrated a remarkable range of variation in the localization of language functions from one person's brain to another" (Deacon 1992: 137). A philosophical objection to the modular hypothesis is that a highly structured brain with little structural and/or functional variability would be so specialized as to make evolutionary adaptation extremely difficult. Especially hard to reconcile with the needs of evolution is the idea of *informationally encapsulated* modules. It makes more sense that, "so as to be prepared for every possible combinations of features in the outside world, each neuron should have easy access to all other regions of the cortex" (Braitenberg and Schüz 1992: 95). These examples provide strong biological disproof of the modular hypothesis.

Therefore, the modularity hypothesis does not seem to offer any verifiable evidence for its validity outside the philosophical realm. While it is not verifiable as the correct conceptualization of brain architecture, neither is it invalidated. As a model of adult brain architecture, it holds much promise of being on the right track. The problem with applying the modular hypothesis to real organisms and, consequently the language acquisition module and its UG, is its essential genetic component. "Linguistic theory suggests that the universal principles and the parameters of variation are part of our

uniquely human inheritance, providing to us as children the genetic material that, in interaction with our environment, allows language to emerge" (Falk 1998: 464). While linguistic theorists believe they have found the silver bullet for what they perceive as the "poverty of the stimulus" and the "difficulty of language learning", they do not seem to concern themselves with how genetic inheritance works, or how such "genetic material" would have formed in the first place. These issues are only touched upon here, but will be covered in more detail later in this paper. Modularity, in this examination, is not seen to hold water in any real world sense, because it as a philosophical model with little to no biological evidence that can be construed as definitely verifying.

Brain Circuitry Acclimation Model

The final model that will be reviewed in this paper is the brain circuitry acclimation model. This model explicates a mechanism of language acquisition whereby the human brain adapts to language stimulus during its development. This mechanism differs from the first two models in one important way: it is backed up by explicit and implicit biological evidence. The specific model chosen here to epitomize this mechanism, is a variation that has been explained thoroughly by Terrence W. Deacon. In short, this theory advocates a brain architecture that is generally prescribed through genetics versus one that is explicitly prescribed, a brain circuitry that "evolves" during development as a consequence of stimuli input, and whose structure is adapted to language evolution, rather than language evolution adapted to brain evolution.

By advocating a brain architecture that is generally determined by genetics, as opposed to one whose final structure is totally determined by genetics, two pieces of evidence must be provided: (1) evidence that undermines the modular argument specifically, and (2) evidence that supports the general structure hypothesis. Evidence for (1) was provided above in the section on modularity. Evidence for (2) will be provided here. While some of the examples given for both (1) and (2) overlap, they have been separated based on their perceived greater utility in providing evidence for or against (1) and (2). This does not mean that the criteria are mutually exclusive; a piece of evidence may provide validity or invalidity for both.

Much evidence for the general structure of neural tissue has been amassed through transplantation studies. During normal development, "a significant fraction of the initial population of motor neurons is eliminated from the spinal cord" (Deacon 1997: 197). If the structure of the nervous system was genetically predetermined then the

elimination or addition of a limb should have minimal effect on the structure of the neurons. However, this is not the case. When a limb is removed during embryogenesis, there is more neural death than should occur, and when a limb is artificially added during embryogenesis, there is significantly less neural death (Deacon 1997: 197). Since the number of initial cells was the same, the nervous tissue did not grow more or less cells; it adapted to the stimuli coming from the new limb, or the lack of stimuli from the removed limb. If the cell structure was genetically determined, then little to no change in the neuron death rate should have occurred. Other evidence comes from brain tissue transplants across species lines. Brain tissues from fetal pigs were transplanted into the brains of adult rats. If the structures of the brain were genetically determined, or even somewhat determined within species genetics, then the chimeric brains that resulted should have been dysfunctional because of the differing connections the pig tissue would make, and the differing signals it would send. This was also not the case. The resultant brains worked well, with the pig tissue making the same connections and transferring information in the same way the rat tissue would (Deacon 1997: 199-200). This indicates that neural tissue is functioning along general mammalian guidelines versus total species-specific deterministic genetics.

Another piece of evidence that seems to support the general structure of the brain tissue versus a genetically determined structure, is secondary aphasia symptoms that seem to result as a consequence of one portion of the brain taking over for a damaged portion, and losing some of its own function. For example, "as spontaneity of speech' which refers to a severe paucity of spontaneous speech and an avoidance of prolonged utterances in the absence of mutism" (Deacon 1992: 133). This aphasia syndrome is usually associated with dorsal frontal lesions, but "it is also often reported as residual following recovery of speech in Broca's aphasics with inferior frontal lesions" (Deacon 1992: 133). This appears to be the result of one portion of the brain sacrificing a lower function in order to take over a more important function that was lost. This plasticity seems to support the idea of general brain architecture rather than a specific one based on genetics. Also, a general brain architecture would be more genetically efficient than specific brain architecture due to the huge amount of genetic information which would have to be stored, and whose integrity would have to be maintained over the generations, in a system where specific structures were present (Braitenberg and Schüz 1992: 100). This information would also have to take up more space in humans than in smaller vertebrates, but "although the human brain probably possesses hundreds or even thousands of times the number of neurons that are in some of the smallest vertebrate brains and millions of times more

connections, it does not appear that this has correlated with a significant increase in genome size" (Deacon 1997: 197).

This concept of the brain architecture being genetically determined in only a general manner begs the question of how this general structure leads to functional development in the human brain. In a general way, the size of a particular brain region is indicative of the functional aspect of its character. Those that are used more are larger; those that are used less are smaller. In addition, those neural pathways that are used more are strengthened through "exercise", while those that are not used much "atrophy" and are eliminated in the neural death mentioned above. This process determines the exact functional structure of the brain architecture, and is less genetically determined as it is environmentally determined. This is known because the structural "mapping" of the human brain occurs after neurogenesis, during infancy (Braitenberg and Schüz 1992: 100). This occurs, "by a parcellation process, involving the competitive interaction of axons and cells, which compete for synaptic space in a sort of synaptical version of musical chairs" (Deacon 1990b: 272). Terrence Deacon identifies three stages involved in this process:

- 1.) *Neurogenesis*: It appears that in the first stages of embryogenesis there is an increased production of neurons in a variety of cortical structures in the human brain (including neocortex, limbic cortex, cerebellum) with respect to a more typical cell productions in nuclear structures, such as diencephalon and striatum. This initial disproportion in neuronal populations precedes many of the processes that differentiate brain structures into functionally and architecturally discrete divisions.
- 2.) *Axonal migration and initial connectivity*: During the period of axonal migration that follows neuron birth, there is an over-exuberant production of axons and connections that will subsequently be pared down by competitive processes based on activity of the axons and probably also on correlated activity patterns with respect to other afferent axons. The shifted quantitative relationships between different brain structures results in a shift in the relative populations of invading axons that compete for synaptic space in different brain areas.
- 3.) *Parcellation and neuronal/axonal elimination*: The shifted proportions of potentially competing axons within a particular brain structure should be expected to bias this competition in favor of those axons from relatively enlarged structures and against those arising from unenlarged or reduced structures (e.g., the olfactory bulbs) (Deacon: 1990b: 272-273).

This can be synopsized by stating that, "those neurons which are often active together become more strongly connected, thus embodying the correlated appearance of things, features or events in the world" (Braitenberg and Schüz 1992: 95). This mechanism is vastly superior to a deterministic genetic mechanism because it needs less genetic information, making it less vulnerable to corruption, it allows for more acclimation to environmental conditions, and it is less costly in an evolutionary sense since it allows more flexibility for future genetic adaptations. Deacon provides a good analogy for this system when he states:

The logic of this process is essentially Darwinian logic: overproduction of random variants followed by selective support for some and elimination for most. It is similar to building a door by first building a wall and then later removing the portion of it that will serve as the doorway. Such a strategy, while appearing somewhat wasteful of material, is highly efficient in its use of information. It circumvents the difficulties of planning ahead and allows development to proceed with a minimum of design of regulatory mechanisms (1997: 195-196).

This brings us to the idea that the brain evolves to fit language rather than language evolving to fit human brains. This concept is applicable on both a micro- and macro-evolutionary scale. It is involved in the evolution of language and the human brain over the millennia, and is involved in the "evolution", or adaptation, of the human brain to language stimuli. The former mechanism is not highly relevant to the direction this paper is going, but is important in that it provides an evolutionary mechanism for language adaptation, which the modular hypothesis and UG fail to do (for reasons that will be considered in the following section). The latter mechanism follows the three-stage process laid out by Deacon. As specific neurological pathways are "exercised" by language stimuli, they become strengthened over time and eventually form the loosely structured language centers of the brain. "For this we need a network which is not predetermined but can be moulded by the activity of the neurons" (Braitenberg and Schüz 1992: 95). The brain circuitry acclimation model provides this network.

Discussion: Why UG Does Not Work

When considering why the brain circuitry acclimation model provides a more parsimonious mechanism for language acquisition than Universal Grammar and modularity of the mind, one must first consider the two assumptions that form the basis for the reasoning behind UG and the LAD. UG and modularity both propose that a

specific set of linguistic knowledge is innate. Smith and Tsimpli give the logic behind this premise when they state:

That some aspects of our linguistic knowledge are innate (more accurately, 'genetically determined') follows from a number of considerations. The most compelling of these are on the one hand, the existence of universal properties of language and, on the other, the poverty of the stimulus: the fact that as speakers of a language we know more than it is possible for us to have learned on the basis of the input we are exposed to (1995: 22).

These two aspects (poverty of the stimulus and universal properties) are the major cornerstones of the innate argument. However, there is a serious problem with their application as proof of a "genetically determined" origin. The problem with the application of universal properties to human language is that nothing has been conclusively shown to be a "universal" (Jannedy et al. 1994: 261). Some linguists have even applied the "universal" status to syntactical and/or grammatical rules that are admittedly not present in all languages, stating that "provided that the universal is found in some human languages, it does not have to be present in all languages" (Cook and Newson 1996: 27), as long as the rule is not broken in languages that it is not present in. This is especially problematic in that it opens the door – logically – to all idiosyncrasies of languages that are unique and not broken by other languages to become designated a "universal". While no unambiguously universal property has been agreed upon, the prospect of there being one or more is not necessarily disproved; however, if at least *one* cannot be proven, it does not seem reasonable to assume that there is one or more, and base further research and/or linguistic theories on the idea that they are present.

The concept of the poverty of the stimulus is even more problematic, for although the presence or absence of universal properties of language does not seriously impinge on the validity of the UG and LAD concept; poverty of the stimulus is critical. The burden of proof is on the theorist, and valid proof seems sadly lacking. While searching (in vain) for some research that validates this concept, one continuously gets statements such as, "Our knowledge of language is complex and abstract; the experience of language we receive is limited. Human minds could not create such complex knowledge on the basis of such sparse information" (Cook and Newson 1996: 82). All researchers seem to take this fact as self-evident for some reason. Saying something is so does not make it so, and sounding reasonable does not make it fact. Darwin's theory of speciation may sound particularly reasonable, but it was not

accepted as fact until it was proven beyond a reasonable doubt as possible, and as probable. Until such time as poverty of the stimulus can be proven at least probable by some kind of experimental evidence, it *cannot be taken as fact*. While theological logic may be enough to convince some people on "faith", academic and scientific validity should not accept it as enough. Saying that, "arguments within several religions claim that the world is so beautiful or so complex that it could not have come into existence spontaneously and must therefore be due to a creator" (Cook and Newson 1996: 85) does not in any way constitute proof.

Other problems with the poverty of the stimulus are in the nature of language itself. We, as human beings, think with language, and therefore use it constantly when we are conscious (using conscious in the sense of a waking state with alert awareness versus unconscious states such as sleeping, coma, stupor). Discussion of language origins tends to focus on a perceived necessary transition from thought in the way that animals' think (indexical, iconical, etc.) to the way that humans "think" (symbolic). Universal Grammar and modularity would require that human "think" in a symbolic manner from conception, with "thinking" being organic communication between cells in the early stages of brain development. It seems far more likely that when children are first exposed to language stimuli, ontogeny recapitulates phylogeny by the same transition to symbolic thought taking place in the infant's brain. From this point on, the infant will be thinking in simple symbolic terms that become increasingly complex as brain development, exposure to language stimuli, and language learning take place. Analogies to learning mathematics or games cannot compare to language acquisition, because we *use language even when we are thinking*. Perhaps so many critics disregard primate language acquisition research because if any other creature can learn to think symbolically and understand a "simple" language, the idea of a special language module with UG is inherently flawed. "The UG theory claims that such principles are inherently impossible to learn; if they are not learnt, they must be part of the human mind" (Cook and Newson 1996: 13). So if UG are properties of "human" language that are innate to a "human" language acquisition module, then if a non-human organism can learn to use a "human" language *at even the simplest level*, the last bastion of accepted human uniqueness falls away. Humans do not need to take a physics class and learn the law of conservation of energy to understand that if something that is moving hits some other object, the second object will move unless it is much bigger than the object in motion. Humans do not need to learn the law of gravity to know that when something goes up, it must come down. Do humans have physics genetically encoded in their brains? Of course not, we understand these principles because we use them all the time. The fact that someone cannot recite

physical laws does not mean he/she does not use them, in the same way that the fact someone cannot recite syntactical laws does not mean he/she does not use language. These concepts are not encoded in our genes; they are imprinted in our developing brains through constant usage from birth. Push on the door and it moves, pull on the blanket and you can get the toy, use language in a way that is understandable to others to get what you want, and you get what you want. This seems a reasonable comparison to make considering that researchers that support UG look for universals by seeing what syntactical orderings are nonsensical to native speakers.

UG and modularity are fatally flawed in their adherence to the idea of genetic determination. They provide "just so" theories with little to no biological and/or experimental evidence and are cloaked in a veil of pseudo-scientific validity. Cook and Newson state that, "UG theory is not making vague or unverifiable suggestions about the properties of the mind but precise statements based on specific evidence" (1996: 2). They go on to provide "scientific" proof by providing evidence that structure-dependency is universal in all human languages. How this provides scientific proof of UG is not clear to me, seeing as it merely proves that structure-dependency is universal in languages (proof of a universal grammar perhaps, but not of the Universal Grammar of Chomsky's paradigm). This is however, a function of what is of interest to which researcher. A linguist that studies similarities between languages may have little interest in why or how something such as UG could be innate, it is merely enough that they are. "Chomsky (1978), for example, has maintained that of course language evolved and indeed has an innate basis, but the fundamental mechanisms are universally present in all human beings, and that it is these that ought to interest linguists" (Ghiselin 1997: 139). This is akin to stating that of course there is a God and of course the Bible is the word of God, but what should interest people are the differences between Christian religions, or that of course aliens are visiting the earth and of course the government is covering it up, but it is the ways we can protect ourselves from alien abduction that should interest people. If you cannot provide some experimental evidence that a principle is true, then you cannot examine the aspects of that principle and progress. Biological evidence for UG is lacking, and evidence for UG and modularity having a genetic basis is non-existent. "Even if you can get the theory to cope with the examples, I don't see why the theory should be true" (Fodor 1990: 96).

The assumed validity of UG has created much confusion in the study of language acquisition and brain development. For instance, Jean Aitchison state:

We know for certain that language cannot emerge before it is programmed to emerge. Nobody has ever taught a young baby to talk – though it seems that there is nothing much wrong with the vocal cords of a newborn infant..." (1998: 562).

Researchers thus have an uninformed view of developmental anatomy, or an uninterested one. A newborn infant is incapable of speech for many reasons. For instance, the position of a human newborn's vocal tract (position of pharynx and larynx) is similar to other primates, and "ontological changes in the morphology of the vocal tract are linked with the appearance of articulate speech in human children" (Schepartz 1993: 101). Infants cannot speak because they have not developed the physical capacity for it. This says nothing of mental capacity. A human newborn's brain is only around 380 grams, but by the time of first speech (around a year old); it has enlarged to approximately 944.7 grams (Molnar 1998: 215). This indicates significant brain development must take place before a child can speak, and this development occurs in an environment of linguistic stimulation. A newborn is not capable of speaking, and the assertion that since no one has taught a newborn to speak, there must be some genetically programmed language center is utterly ridiculous.

It seems a much more parsimonious explanation to postulate that the brain is genetically structured to form a plastic architecture that can be moulded by environmental stimuli. In pure Darwinian terms, this would give an organism a better chance of survival. Evolution tends to dead-end on specialized species, and expand its boundaries on generalized ones.

Discussion: Why Brain Acclimation is a More Parsimonious Explanation

While a detailed review of how the brain circuitry model works will not be repeated here, it will be expanded upon in order to show how it fits all data in an unambiguous manner. The brain circuitry model provides a mechanism whereby a minimum of genetic material predetermines the organization of the brain architecture, a model that is more contiguous with evolutionary logic, and that is philosophically more sound than UG and modularity. While the cellular structure of brain tissue differs somewhat among species, its functional capacities seem to vary little (Deacon 1997: 199-200). This makes sense when seen from the evolutionary perspective. Since evolution is a slow process of small mutations in DNA creating variation, and regional isolation and functional advantages narrowing down genotypic variation by selecting for certain phenotypes (with chance, genetic drift, and bottlenecks making their presence felt),

differences between the amount of genetic information that determines specific structures (especially a universal like nervous centers) in close species should be small. If specific brain structures were genetically determined, adaptation to new environmental stimuli would be difficult. This would create a difficulty when climates changed, when new predators or prey entered the environment etc.

Another problem is the evolutionary time frame involved and the nature of the supposed module espoused by UG proponents. The addition of a language module would require a significant change to the genetic code over a short period of time. This addition would be unlikely to mesh well with the existing brain structure. "So many parts of the brain are connected to so many others that it should be astronomically unlikely that adding new brain regions or even modifying old ones could produce a result that worked well together, much less provide a functional advantage" (Deacon 1997: 194). It is an easier and more effective way to create a generic brain cell structure whose specific architecture could adapt to environmental stimuli. Under such general genetic guidelines, "multiplication of brain structures probably occurs most often by a process of parcellation and restructuring existing areas, with resulting subareas capable of taking on distinct functions" (Deacon 1990a: 224), with parcellation occurring after birth during subsequent brain development in a language filled environment. This is what is seen to be the case. While some researchers and/or authors may attribute modular (i.e. genetically determined specialized brain structures) to only humans, some simplistic modularity to human ancestors, and nearly none to animals (Mithen 1996: 65-72), one must keep in mind that even fairly early dates of the beginnings of human language (e.g. >300,000 B.P. [Kay et al. 1998: 5419]) are far too short a time for such a radical change in genetics to take place on a functional level. Morphological characteristics may change quickly, but differences in fundamental genetic structure take much longer.

If one accepts that the human brain structure is genetically similar to other organisms (especially to those that are closest in evolutionary terms: the great apes), the questions remain as to how language acclimation occurs in humans, and why it does not occur in animals with brains similar to ours; the chimpanzees. If our genetically determined brain structure is similar to other organisms, then we must think like other organisms from birth (and before). Ethologists and philosophers may argue the question of how animals think compared to how humans think, but the important distinction is that there is a fundamental difference. From birth, the infant is bombarded by stimuli, auditory and physical. These stimuli affect the developing brain by "exercising" certain neurological pathways, which become "set" when neural death

occurs in unused pathways. This is the mechanism whereby language structures (Broca's area, Wernicke's area, etc.) are developed, and lateralization of function occurs. Language acquisition seems a slow arduous process, with the first words at one year of age, first use of phrases at age two, and well established language occurring only at age four, where deviations from adult form is more style than grammar (Lenneberg 1998: 557-558). Why is seen when one looks at brain development at these ages, and considers the process that must occur during brain development for language understanding and use to occur. At birth a child's brain weighs 380 grams, at age one it weighs 944.7 grams, at age two 1025 grams, and 1330.1 grams at age four (Molnar 1998: 215). Over the next fourteen years, the child's brain will grow an average of only 8.2 grams (Molnar 1998: 215). The child's brain undergoes massive changes over the first four years of life, and relatively little from then on. This is why a child "masters" language around age four; this is the age where the child's brain development has reached its apex of developmental growth rate and is nearly adult size. During this time, the child must adapt his/her thinking into whatever language is stimulating him/her. Their thinking adapts to a symbolic style of thinking because it has to adapt in order to process the stimulation it is receiving, and to communicate effectively the child's wants and needs. Once this thinking is "set" in the brain structure, the child begins thinking in language, and thus *must discover the "universal" aspects of language that are relevant to his/her native tongue in order to think effectively since garbling these necessary rules makes using the language to think impossible*. Verbal language use is less important than thinking in the language.

The question of why apes such as chimpanzees do not learn language ("human" language) on their own is a matter of culture and biology. Chimpanzee brains *are* genetically different from human brains. They are smaller and are not structured exactly the same way in the relative amounts of cortex, cerebellum, etc. However, the evolutionary differences between our two species are not different enough to distinguish total functional differences based on genetics. The most important difference between a human infant in New Jersey, and a chimpanzee infant in Africa is cultural environment. If non-symbolic thought is the norm in brain tissue function, then no symbolic thought can emerge unless the infant is in an environment where it is exposed to symbolic thinking. Human infants are normally put in a symbolically rich environment; chimpanzees are not. The question of how symbolic thought first occurred in humans is a question that is interesting, but which is not directly relevant in this particular paper. Some researchers wish to think of language faculty as a uniquely human trait:

The language faculty is indeed held to be specific to the human species; no creature apart from human beings possesses a language organ. The evidence for this consists partly of the obvious truth that no species of animal has spontaneously come to use anything like human language; whatever apes do in captivity, they appear not to use anything like language in the wild (Cook and Newson 1996: 32).

But these researchers do not seem to understand that the fact that a chimpanzee, or any other animal, that has the *capacity* to think symbolically (e.g. the bonobo chimp Kanzi (Deacon 1997: 124-127)) proves that there is no "language organ" in humans. Just as a chimpanzee will not break the threshold of symbolic understanding in an inadequate environment, human beings will also not cross that boundary that is critical for acquiring language (e.g. "Genie"). The difference between the maximum capacity for this type of learning in apes and humans is a matter of degree, not kind. These differences are explainable by the degree of developmental maturity at birth, the total brain capacity (more cells = more connections, which leads to higher adaptability to stimuli), time of development after birth, and slight genetic differences that lead to different learning propensities (such as ease of language acquisition in humans). These genetic differences are the function of behavioral changes that have occurred in our two phylogenetic lines since our ancestral split, which caused a Baldwinian shift in selection factors on our two species. The factors slightly shaped the genetics that affect our brain structure in order to select for those slightly better at learning required skills for the species environmental niche. "Shakespeare wouldn't have gotten around to writing *Hamlet* if he had had first to rediscover fire and reinvent the wheel" (Fodor 1987: 129), and so we have evolved along different lines to facilitate our specific cultural and environmental milieu. However, it is important to distinguish that the difference is a quantitative difference, and not a qualitative one, since "if one accepts the monistic mechanism of contemporary evolutionary theory, then whatever differences that are between humans and non-human animals must be of degree and not of kind" (Goodwin 1994: 101).

Conclusion

Language is a product of relatively recent human culture, but our genetics are a product of millions of years of slow evolution. The most effective evolutionary mechanism is generality and the adaptability that results from it. Mechanisms such as modularity are anti-evolutionary in that they are adaptive specialization with little room for environmental change. The brain circuitry acclimation mechanism is more parsimonious in that it provides for a general brain structure that is based on genetics,

and a specific brain architecture that is based on environmental conditions during development. This provides for a better fit in understanding the differences between human language acquisition and primate acquisition of human language. It also provides a good fit as to why certain areas associated with certain linguistic functions are highly variable in their position in the brain architecture. This model also backed-up by physical evidence as well as philosophical evidence, in comparison with modularity and UG, which are backed-up only by philosophical evidence and biological evidence that can fit just about any model. All in all, the brain circuitry acclimation model provides a logical argument for a language acquisition mechanism that is in harmony with all the data, and is better able to account for evolutionary factors of language development.

Language, Brain Expansion, and Genetic Assimilation

Language Acquisition as a Primary Cause of Brain Expansion

The expansion of the brain during hominine evolution is caused by two major factors. The first is Cope's law, which states that, "body size increases during the evolution of a given vertebrate lineage, and given the universal correlation between body size and brain size, this results in concomitant enlargement of the braincase" (Henneberg 1987: 215). The second factor is that, "increasing reliance of hominids on complex behaviours enabling development of cultural adaptations will require at least the maintenance of a certain amount of nervous tissue, if not an increase, in the presence of reduction of other structures of the body whose functions are gradually replaced by technological and organizational adaptations" (Henneberg 1987: 215). It is obvious that some degree of encephalization occurs as a consequence of body size increase, however, as brains get larger they get less dense (Deacon 1997: 154). This means the absolute number of neurons in a brain may change little as a species evolves a larger brain. Thus, a body size increase may be partially responsible for the increase in brain size, but does not form an effective argument for an increase in cognitive ability. Also, "the increases in body size were quite small and would have made only a modest contribution to the increase in brain size" (Lynn 1990: 243). The second factor basically states that it takes at least as much, and probably more, brain power to use and maintain a technological adaptation than to use one's body for the same purpose. While this may or may not be correct in the way Henneberg frames the statement, cultural adaptations that require the use of brain tissue to analyze and process information should require a higher neural capacity as the complexity of the cultural adaptations rise.

Language is a cultural adaptation for processing large amounts of information, and as such, did not "pop" into existence, as proponents of modularity and UG seem to suggest. As a cultural adaptation, the *capacity* for language development must have been present before the appearance of language. "Selection must act on the actual activities of extant organisms – evolutionary forces cannot act on or select language skills unless a range of proficiencies in those very skills already exists" (Ragir 1992: 40). This capacity is what is important when considering why the brain and language abilities could increase over time. This capacity is a capacity for conditional learning, and is inherent in the architecture of the cortical network. This brings us back to the brain circuitry acclimation model.

"It is generally accepted that the cerebral cortex is involved in the production and perception of language" (Braitenberg and Schüz 1992: 89). The cortical network consists of a large number of neurons with varying axonal lengths, and those make varying quantities of synaptic connections with other neurons. Many neurons are represented in small areas of the cortex due to the length of the axons, thus the cortical network is extremely diffuse (Braitenberg and Schüz 1992: 92). This cortical structure is important since it facilitates learning through the brain acclimation model. The more diffuse the network, the more connections can be made between neurons, and the more adaptable the brain will be to incoming stimuli. Those individuals with larger and /or more diffuse cortical networks will have a greater capacity for "learning", or conditioning of the synaptic connections. Since individual organisms within a deme will have some variation that is due to differences in their genetics, a range of "learning" capacity will exist in a population. This capacity can be seen as a polygenic trait since the degree of expression of the capacity is highly dependent on forces such as nutrition and environment. Stephen Molnar explains polygenism with the following:

Factors of climate or diet influence development and growth. Though a person may inherit groups of genes that could promote the development of a large size leading to a tall adult, poor nutrition or disease occurring at critical growth stages would limit size below one's maximum potential. Also, there is individual variation in size and form even among sibs because of unique individual responses to similar conditions (1998: 188).

While an increased capacity for conditioned learning may or may not correlate with increased learning with respect to another individual with a lower capacity, chance

states that on average increased capacity leads to increased development of that capacity.

This discussion on neural connectivity capacity (assumed in this paper to correlate relatively linearly with cranial capacity and "intelligence") must now be put into the context of language acquisition. Language will be defined as "an all-encompassing system for conceiving of and communicating about the emotional and physical realms of human experience" (Schepartz 1993: 92). Language is both internalized within an organism as "thought", and externalized as "speech". Language capacity must have evolved before language, but internalized language must have evolved before externalized (in order to communicate with another one must think about that communication first). While some researchers purport that communication is not equivocal to language (Ingold 1994: 93-94), language is equivocal to communication and must have developed as a more effective means of relating complex thoughts in a social interaction than gestures and/or calls. "The literature on animal communication is replete with studies showing that mammals and birds (at least) are aware of the animate environment in a social way, that they can and do share information about its affordances" (Reed 1994: 120). So social communication in a generic species-specific manner is not an uncommon occurrence. Social cognition became a substrate for language development due to the increased efficiency of exchanging social information through the developing symbolic language rather than the basic hominine instinctual communication systems (gesture systems, call systems, etc.). Language capacity (as correlated with cranial capacity) could have been selected for through a process of Baldwinian selection of traits.

Baldwinian Evolution and Genetic Assimilation

Both Baldwinian evolution and genetic assimilation are important mechanisms whereby language capacity (as a result of brain enlargement) could have increased throughout time. The American psychologist James Mark Baldwin outlined a mechanism through which adaptations could affect the selection pressures that future generations would face (Deacon 1997: 322). This evolutionary theory became known as Baldwinian evolution. It is particularly useful in making the selection pressures that affect an organism more powerful, since there is direction to selection pressures rather than total randomness. In addition, Baldwinian evolution provides a way to account for adaptability since environmental pressures change relatively rapidly when compared to genetic change. Genetic assimilation is an evolutionary mechanism explicated by Conrad Waddington in the 1950s that explains how the capacity and intensity of

expression of a trait can become "canalized" from adaptive responses to genotypes (Marks 1989: 496). These two mechanisms are ways in which evolutionary trends become more directional than random, and allow for quicker adaptation to environmental stimuli than mutation of genes allows for. They are both important when considering why brains would have enlarged through the continued use of language in a social context.

Baldwinian selection is the mechanism that makes genetic assimilation possible in this case. "Baldwin suggested that learning and behavioral flexibility can play a role in amplifying and biasing natural selection because these abilities enable individuals to modify the context of natural selection that affects their future kin" (Deacon 1997: 322). For instance, if individuals emigrate into a colder environment to hunt an animal that is becoming rarer, but is important in these individuals culture (religious, mystical, etc.), then they will have changed the selection pressures that will affect their descendents to favor cold adapted characteristics (thicker body, more hair, shorter appendages, etc.). This behavioral decision may even be detrimental to the future generations because of the move to a hostile environment, and since the move may have no cause that will make them better able to survive, it goes against natural selection. Thinking organisms are not always ruled by Darwinian selection at all times (however, the selection pressures that will be faced after the move to a new environment will be Darwinian). While this process is not anti-Darwinian, it allows for behaviors or adaptations that occur during an individuals lifetime to affect the future fitness of their descendents. Baldwinian evolution is a shift in behavior that causes a shift in natural selection pressures, and genetic assimilation is the mechanism that allows for rapid adaptation to the new selection pressures.

The key to genetic assimilation is *capacity* or potential for a trait, since only mutation can cause entirely new traits. A model of evolution of a trait "therefore, should be (1) polygenic rather than macromutational; and (2) succeed, not precede, the behavioral change" (Marks 1989: 496). Genetic assimilation, in regard to human language evolution, works by individuals who elicit favorable responses to selection pressures being more likely to reproduce than others due to that favorable response. This differs from Lamarckian evolution since the adaptive response itself is not passed onto the offspring, but rather the adaptive potential of the parent organism. An organism that has greater adaptive potential will be more likely to respond favorably when selection pressures are changed, so that organism will have better reproductive success than a rival with less adaptive potential, and will pass that greater potential to its offspring. "What is being selected is not variation in the phenotype itself, but rather, variation in

the genetic underpinnings of the physiological system which may or may not produce the phenotype under variable circumstances" (Marks 1989: 496). Thus, the evolution for capacity of language is not selecting for those who have language, but those who have a greater linguistic capacity. Those with higher capacities will tend to have higher expression of that capacity (in absolute terms, not degree of). If language is the substrate of hominine intercommunication, and hence, of social interaction; individuals whose descendents learn quicker (adaptive response) and reliably (higher genetic capacity guaranteeing greater linguistic development, rather than a chance high degree of expression in an individual with a smaller capacity), will benefit in reproductive terms (Deacon 1997: 326).

Since "language", as a separate entity from animal communication, is inherently a form of symbolic communication, "once symbolic communication became even slightly elaborated in early hominid societies, its unique representational functions and open-ended flexibility would have led to its use for innumerable purposes" (Deacon 1997: 349). This increased reliance on language would have created intense selection pressures for those brains that were capable of higher orders of thought, and which were adaptive to changing response requirements (i.e. a minimal range of capacity size). This created a positive feedback loop where increased use of language led to selection for brains equipped to deal with increasingly complicated language, that in turn would have led to increased potential for language complexity and use. The selective pressures of language would have favored brains that had a greater capacity for conditional learning (larger, more diffuse cortical networks) for reproductive success. The higher capacities of future generations would have allowed higher development of language, and this would have created more pressure for higher capacity brains. Therefore, language may have been the driving force behind the increase in brain size, since language is largely associated with the prefrontal cortex, and the prefrontal cortex has shown the greatest proportional increase over time (Deacon 1997: 217).

Consequences of Brain Expansion on Cranial Morphology

If an increased selection for language capacity occurred as a consequence of increased social interaction, and a higher learning capacity is due to a more diffuse cortical network, then the fact that brain size increases with social complexity (measured by group size in non-human primates) (Dunbar 1992) should not be surprising. However, symbolic language communication is far more intensive in its use of cortical mass than normal animal communication. This high level of use imposed intensive selection

pressures for the formation of larger cortical networks that were more interconnected, causing an expansion of brain volume throughout time. Since this increased brain volume was the result of a manipulation of variation of cortical capacity, rather than replacement of genes regulating capacity with new mutated versions along with related genes that controlled other functions, brain growth began to outstrip cranial vault growth. To make up for this deficiency, bone material from the rest of the cranium (i.e., splanchnocranium and mandible) was transported to the neurocranium. This resulted in a reduction of the face and the lowering of the larynx, leading to the current speech capacities and cranial morphology of modern humans.

Earlier in this paper, an evolutionary mechanism was laid out whereby a behavioral or social adaptation could precede genetic canalization of a specific trait. Genes that control for skeletal growth and neural growth are not closely related, bone tissue and nervous tissue arise from different primary tissue layers: bone arises from the mesoderm, and nervous tissue arises from the ectoderm (Curtis and Barnes 1989: 952). Since social pressures for language are selecting for brains and not bones, differences in brain size will not correlate to differences in cranium. A larger brain requires a larger cranium, and the extra bony tissue must come from somewhere. "The principle of C.O.E. [conservation of energy] states that energy can neither be created nor destroyed but it may be transformed from one form to another; thus the total energy in any system will always remain constant provided it is a closed system which allows no gain or loss across its boundaries" (Middleton 1982: 14). The portion of the genome that relates to skeletal growth can be considered a relatively closed system, in that allele frequencies are seen as different forms of energy, and the only input in the system is mutation that occurs at very slow rates. Since the genome is expressed in the body, the skeleton can be considered such a system. While variation in the capacity for skeletal growth may make up a little for the increased brain size, with the brain growth acting as a stimulus to encourage a greater expression of bone growth capacity, the great increase in brain size will eventually outstrip bone growth and require some change. This change amounts to the cannibalizing of bony tissue from the splanchnocranium and mandible to the neurocranium.

Bony material contains calcium that is built into apatite crystals that react to mechanical forces by producing electric potentials (Camperio Ciani 1989: 19). "In normal developmental conditions, mammalian brain growth produces the mechanical forces to generate small electric potentials sufficient to stimulate brain case growth" (Camperio Ciani and Chiarelli 1992: 54). This electric charge is mediated through the local blood stream and produces an electrolytic effect that induces bone removal or

deposition. A negative charge results in deposition of calcium, and a positive charge results in calcium removal (Camperio Ciani and Chiarelli 1992: 54). The blood that carries out this removal or deposition must regain its electrolytic homeostasis after leaving the area of mechanical stress to prevent wrongful removal or deposition of calcium throughout the rest of the body. This imposes the regulation that for bone to grow, it must take material from close by. The increased mechanical stress produced by an increasingly large neurocranium caused material to be removed from the face area, resulting in a smaller less prognathic face.

In primates, skeletal weight scales isometrically with body weight, with skeletal weight accounting "for between 6 and 7% of the total weight of the individual independently of body size or species" (Camperio Ciani and Chiarelli 1989: 18). Thus, primates of equivocal size have equivocal amounts of skeletal tissue. The amount of bone tissue in the cranium is partitioned between the neurocranium and the splanchnocranium along an allometric scale: as the braincase increases in size, the face decreases in size (Camperio Ciani & Chiarelli 1989: 55). This is supported by experimental data from humans and other primate species. Microcephaly is a condition where the brain growth becomes arrested at an early age in ontogenetic development, and which causes a range of morphological characteristics that differ from the human norm such as:

the forehead is flat and receding, the greatest breadth corresponds to the bi-auricular plane, there is a pronounced postorbital constriction, and the temporal lines run high up close to the midline. Often a real supraorbital torus develops and the orbits come to lie in the front of the cranium. The face, on the other hand, grows disproportionately with respect to the neurocranium. The face not only grows in size, but its bones also become thicker, especially in the glabellar (in which large sinuses can develop) and alveolar areas. The chin becomes reduced and the prognathism is much more pronounced than in normal humans. The teeth are generally large in size and the palate is long and narrow. The base of the foramen magnum, when oriented to the Frankfurt plane, is directed downward or even posteriorly (Camperio Ciani and Chiarelli 1992: 55-56).

All these characteristics are indicative of pre-modern *Homo*, and all are caused by a reduced growth of the brain. Hydrocephaly is a pathological condition where excessive accumulation of intracerebral fluid causes an enlarged cranial vault. "This condition is often associated with palatoschisis (failure of the two lateral palatal vaults to close), and with a small size of the orbital septum, the alveolar regions, and the teeth" (Camperio Ciani and Chiarelli 1992: 56). These characteristics (failure of

suture closure, smaller size of facial regions and teeth) seem to be caused by the allocation of minerals from the splanchnocranium to cover the excess growth of the neurocranium. In addition, primates of roughly similar size (e.g., *Cebus* and *Alouatta*) that have different degrees of encephalization, show differences in cranial morphology. Species with larger brains have smaller faces, while those with larger brains have larger thicker faces (Camperio Ciani & Chiarelli 1992: 57). Neanderthals seem to violate this concept, an increased cranial capacity along with a retention of robust cranial morphology, especially in the splanchnocranium. However, Camperio Ciani and Chiarelli state:

The Neanderthals, a much more recent human subspecies (*H. sapiens neanderthalensis*), seem at first to represent a contradiction. Here a large face is accompanied by a large brain case. It can be shown, however, that the principle of overall isometry (or of "mineral homeostasis") in the cranium is not violated, but it is just reflected in another "strategy." In this case there is pneumatization of the bones (Moore and Lavelle, 1974). This "strategy" is usually described as an adaptation to a cold environment, but it could equally well be interpreted as a strategy to produce a large surface of bone with relatively little bony tissue. The presence of a massive facial skeleton with a large brain case in classic Neanderthals, therefore, does not contradict our hypothesis (1992: 58).

Evidence that also supports this is found in the distribution of variation in bone densities in modern human populations. Inuit groups are generally considered some of the most cold adapted modern populations, and when tested for bone density using photon absorptiometry, it was found that these groups consistently had less dense bones than U.S. whites (Friedlander and Jordan 1994: 336). U.S. blacks, which are generally considered to be more tropically adapted by ancestry than U.S. whites, consistently were shown to have higher bone densities than U.S. whites. This may reflect bone in cold adapted populations becoming more porous in order to insulate the body better, or allow body warmth generated by muscles keep the core of bones warm easier. In any case, since actual bone density cannot be shown for fossil samples due to internal absorption or leaching, it seems reasonable to expect Neanderthals to have had less dense bones than modern humans. Thus, there may have been no violation of "mineral homeostasis" in Neanderthal crania. Also, if Neanderthals were a significantly heavier species than modern humans, the 6-7% of body mass as skeletal mass on a frame of similar or lesser stature would indicate that Neanderthals should have more bone mass. This means that Neanderthals line may have had more room for brain growth before mineral compensation kicked in, giving them a more robust and prognathic splanchnocranium.

The position of the larynx is also affected by changes in brain size. While many researchers place importance on the development of the modern position of the larynx in the supralaryngeal vocal tract in the origins of speech (Laitman & Reidenberg 1988; Laitman 1983; Laitman and Crelin 1976; Lieberman 1984), it is more likely that the descent of the larynx is due to the reduction of the oral cavity when the splanchnocranium was reduced during brain enlargement. "The position of the larynx in mammals is always determined by the position of the tongue; the former lies closer behind the latter and they are attached to one another" (Camperio Ciani 1989: 17). The tongue is essential for food production, and not for speech. Aglossia (absence of the tongue) does not significantly impair speech to make it unintelligible, but does cause problems with food processing and digestion since it is necessary to push food to the back of the throat and for swallowing (Camperio 1989: 17). Smaller tongues are less effective at food production, so a safe assumption would be that the tongue has remained relatively the same size in human evolution (scaling for body size). The reduction in the face and jaws of *Homo* has caused the human tongue to curve and directed downward into the pharynx, and lower the larynx past the pharynx into the vocal tract. Thus, since the tongue is needed for food processing, but not speech, and is anchored to the larynx, natural selection for speech seems unlikely as a cause of the descent of the larynx into the vocal tract. It seems much more parsimonious that the reduction in the face and mandible forced the tongue backwards, and therefore force the larynx further into the neck.

Discussion: Neanderthals and *Homo sapiens*

This discussion has so far given an explanation for how language is acquired by children, an explanation of how language could have evolved and forced the increase in cranial capacity, and the consequences of brain expansion due to language on cranial morphology. This paper will now attempt to argue for a Neanderthal capacity for symbolic language, and a probability that some degree of symbolic language was present using the evidence presented throughout this paper.

The ancestors of Neanderthals were present in Europe by at least 800,000 B.P. (Kunzig 1997: 96; Lahr and Foley 1998: 157), and remained relatively isolated from African populations over time (Stringer & Gamble 1993: 193). Over this period, the Neanderthals reacted to selection pressures to adapt to the cold environment according to Allen and Bergman's Rules (Holliday 1997). Neanderthals carried more weight than modern humans (Bergman's Rule), and while the exact mass of Neanderthals is not known precisely, since all primates have a skeleton that weighs 6-

7% of their body mass, Neanderthals should be expected to have more robust bones than modern humans. Thus, an increase in brain size may have had less of an effect on decreasing the face, leaving them with a more prognathic face than modern humans. Regardless of the robustness of the Neanderthal crania, the internal size of the palatal cavity is not so much larger than modern humans that the position of the Larynx would be significantly different. Hence, Neanderthals were likely to have had the capacity for speech in terms of structural and motor characteristics.

The capacity for symbolic thought is harder to quantify. The fact that the Neanderthals made complex tools, made decorative body ornaments, may have took care of their elderly, may have buried their dead, etc., seems to indicate that there was symbolic thought processes occurring in their brains. The real question is whether symbolic linguistic communication had replaced more animalistic forms of communication. Decorating one's body and caring for another of one's species well being may indicate a sense of self and other, but they cannot prove whether symbolic communication went on between individuals; many animals have been shown to have a concept of "self" (Griffin 1992: 249), and animals like elephants will try to help an injured elephant, indicating an awareness of "other", and yet there is no symbolic communication. Although Neanderthal had slightly larger brains than modern humans, when scaled to body mass they have slightly smaller brains. At the very least, this would seem to indicate that either Neanderthals had been using symbolic language for a shorter period of time than the stock that led to modern humans, or that there was less intensive selection pressure for cortical capacity due to smaller social size or less social communication. Thus, if Neanderthals did have symbolic intercommunication as well as symbolic intracommunication, it was likely to be less complex than modern language in some respect, if only in capacity for vocabulary.

The key to the *Homo sapiens* replacement of Neanderthals may have been sheer weight of numbers. If humans had a larger social group size, then they would have had more intensive selection for language, giving them larger available cortical area to use for conditional learning, and a higher reproductive success since larger groups would afford more chances for mating and give a greater chance of offspring survival. If Neanderthals were in smaller, more isolated populations, then their reproductive success would be lower than that of humans, and they would have developed less available cortical area for conditional learning. In addition, if humans brought tropical diseases with them, many Neanderthals may have died from disease quickly, allowing humans to replace them easily. Neanderthals may or may not have had symbolic

language similar to modern language, but they did have the capacity for learning and using modern language.

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