Recent findings on the biological bases of language

Mine Nakipoğlu-Demiralp
Boğaziçi University

Bu çalışma, son zamanlarda dilin biyolojik temelleri üzerine yapılan araştırmaları inceleyerek bu konuda gelinen noktaları Türkçe'den de örnekler vererek üç temel başlık altında sunmaktadır. Çalışmada incelenen konular şunlardır: i. dilin doğuştan olduğu varsayılan yapısı ve dil için önerilen genetik sınırlamaların yalnızca dile özgü olup olmadığı, ii. erken dil edinimi sürecinde sesin algılanması ve ezginin dilleri birbirinden ayırmada ve ana dile ilişkin sözdizimsel yapıları belirlemede oynadığı rol, iii. dilin diğer bilişsel yetilerden ne ölçüde ayrıldığı ve araştırma bulgularının beyinde kendine özgü bir dil alanı açısından ne gösterdiği. Bu çalışmalar ışığında, özellikle dilin ses yapısının edinimi ve dil özürleri konularında Türkçe üzerine yapılacak araştırmalar, insanlığın belki de en önemli edinimi olan dilin biyolojik temellerinin daha iyi anlaşılmasına katkıda bulunacaktır.

1. Introduction

Since Aristotle who deemed brain just as an organ cooling the blood, attributing everything that makes us human beings to the heart, we have come a long way in recognizing the immense role of the brain in sensory motor activities, behaviors, emotions and even in consciousness. The journey in the pursuit of an understanding of the brain had been long and involved many detours, nevertheless scientists now know a lot more about the brain than was known earlier, owing mostly to the research of the past 150 years. Specifically, the advance of imaging techniques in the last decades has given impetus to studies which aim at exploring the neural correlates of higher cognitive abilities.

The past thirty years have also witnessed a growing interest in understanding the neural/biological bases of the crowning achievement of human beings: language. The core questions for the researchers working within a field that goes under various names including cognitive linguistics, neurolinguistics and, more recently, biolinguistics[1] can be grouped under four general headings:

1. The innate nature of language
   i. Is there a specific module for language in the brain? If there is, where does language reside and how is it represented in the brain?
   ii. What is/are innate about the knowledge of knowledge?

2. Language acquisition
   i. How is language acquired? How is speech perceived?
   ii. What kinds of cues infants initially rely on in sorting out the properties of their native language?
3. Language and species-specificity
   i. What makes language species-specific?
   ii. What are some recent findings on the language abilities of nonhuman primates and other animals?
4. Dissociations between language and other cognitive abilities
   i. Is language independent from other higher cognitive abilities?
   ii. What do patients with Specific Language Impairment (SLI) and Williams Syndrome (WS) tell us about the modularity of language?

This paper attempts to provide an understanding of the current status attained in the study of the relation between language and brain. It will start out with a discussion of the innate nature of language in section 1.1 The ensuing section looks at where language resides in the brain. In section 1.3 the representation of the initial state and how learning takes place in the later states are examined. Section 2 is concerned with speech perception and gives an account of how prosody plays a significant role in cueing infants in their long journey into becoming competent speakers. Finally, section 4 focusses on some cases of modular manifestation of language.

1.1. The innate nature of language

The question of whether it is nature or nurture that serves as a driving force for language has been at the center of debate since Chomsky entertained the idea that knowledge of language must be innate. Chomsky's *The Logical Structure of Linguistic Theory*, written in 1955, but published in 1975, laid the foundation of a theory which endevoured to characterize the innate human language faculty. This particular work and its successors (Chomsky 1957, 1959) contributed greatly to the demise of the school of behaviorism which held back any research on the biological origins and bases of language.

Today a near consensus has been reached among scientists that it is nature, that is, some innate constraints potentially in the form of hard-wired neural bundles that get the language off the ground and nurture, i.e. experience, that mostly sculpts it. Hence having reached a common ground with respect to the fact that there must be some biological underpinnings of language, researchers turned their attention to an understanding of the 'nature of nature' as Bates (1999:3) puts it. On the issue of the innate nature of language two different positions stand out in linguistic circles:

i. language is the product of an in-built neural system solely dedicated to language.
ii. language is the by-product of innate abilities, constraints that are not dedicated to language alone.

The first view is propogated by Chomsky who believes that there is a neural system specific to language and that system is somehow encoded in the genome resulting in the growth of a mental organ, that is, the language acquisition device (LAD).[2] Chomsky deems language as analogous to a physical organ, the basic character of which is genetically determined and hence common to the species:

> 'The faculty of language can reasonably be regarded as a language organ in the sense in which scientists speak of the visual system, or immume system, or circulatory system, as organs of the body..... We assume further that the language organ is like the others in that its basic character is an expression of the genes. How that happens remains a distant prospect for inquiry...'
>
> (Chomsky, 2000:4)

Therefore the LAD Chomsky outlines, the so-called initial state of the language faculty, resembles the growth of the other organs generally, hence is not something the child does but is something that happens to the child (Chomsky, 2000:7).

The proponents of the second view, the so-called emergentism (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, Plunkett, 1996) hold the view that there is something innate in the human brain that makes language possible but that something may not be a domain-specific device that evolved for language alone. Emergentists therefore acknowledge that all of the neural mechanisms that participate in grammar still do other things as well and the basic cognitive and computational abilities that we have, such as

> '...our social organization, our ability to imitate others, our excellence in the segmentation of rapid auditory stimuli, our fascination with joint attention... and perhaps above all our ability to create and manipulate symbols...'
>
> (Bates, 1999:35)

which are present in the human infant for the most part even in the first year of life, give rise to language.

At issue then is whether what is encoded in the genome is dedicated solely to language, suggesting a mental organ for language, or whether the resulting circuitry grows not for language *per se* but permits other types of processing as well. If there is a specialized subcomponent for language in the brain, in the event that it gets selectively damaged, it is largely possible that the other capabilities of the brain would remain intact.[3] If there is no such subcomponent, however, neither in healthy brains nor in injuired ones would it be possible to attribute a particular activity of the brain to a specific language function. These issues are difficult to tackle, nonetheless with imaging techniques it has been possible to obtain some preliminary results with respect to whether there are highly specialized areas for language in the brain or not. In the next section before we explore the specifics of the areas involved in language functions, I will first outline some recent findings on the left hemisphere dominance in language functions.

1.2. The site of language in the brain

For more than a century now, the left hemisphere of the brain is known to be the primary site where language resides. What still remains an intriguing question is why such an organization evolved. Though we do not have an answer to this particular question yet, through research carried out since mid-seventies we know more about the specifics of language localization in the brain. Contrary to earlier beliefs that the hemispheres of the brain are symmetrical (Lenneberg, 1967), it is now known that the hemispheres are asymmetrical and this asymmetry mostly stems from a larger temporal plane (planum temporale) in the left hemisphere (Wada, Clarke & Hamm, 1975, cited in Stromswold, 1995:860). The temporal lobe of the right hemisphere starts growing in the thirtieth gestational week, that of the left hemisphere, however, starts developing ten days later and surpasses the size of the right temporal lobe shortly after (Chi, Dooling and Gilles, 1977, cited in Stromswold, 1995:860). The asymmetry in the hemispheres is thought to be a by-product of the greater development of the left temporal plane which until recently was believed to be exclusively dedicated to the processing of speech sounds. Highly interesting results coming from a study done on profoundly deaf people, however, reveal that even in the absence of sound and speech there is cerebral blood flow in the temporal lobe when deaf people are processing signed languages (Pettito et al., 2000). As hypothesized in Pettito et al., the temporal plane may be a site that is specialized for more abstract properties essential to language. Hence the results reveal that the temporal lobe should be considered as a site for processing of language not because of its sensitivity to speech *per se* but mostly because of the patterns encoded within the lobe itself which may also get triggered by different modalities such as vision, hence explaining the activation in the case of profoundly deaf people.[4]

What these findings appear to indicate is that contrary to earlier beliefs that the hemispheres are equally ready for language at birth (Lenneberg, 1967) we now know that the left hemisphere appears to be materially ready for language prior to birth with a larger temporal plane, which is a tissue that plays an essential role not only in the acquisition of spoken languages but also in sign languages. Though this appears to be the case, it is also known that especially child brain is quite plastic and can reorganize in the event that left hemisphere is injured. Most children with early focal brain injury are observed to achieve normal or near- normal levels of language ability despite damage to the areas which are essential for language in the adult brain (Bates et al., 2001).

Let us now turn to a description of what else is known apart from this anatomical variation between the hemishpheres attributing a particular role to the left hemisphere and crucially to the temporal lobe. A further piece of evidence illustrating the role of the left hemisphere in language, especially in adult brain comes from the so-called split brain patients. In normal human beings the communication between the hemispheres is maintained via a bridge of nerve fibers called the corpus callosum connecting the two halves of the brain. In epileptic patients, when the hemispheres communicate, an electrical discharge might follow leading to a seizure. With a drastic surgical operation severing the corpus callosum it has been possible to relieve the patients of such seizures. Roger Sperry, a neuropsychologist, performed such operations starting in the 1960's and until the time the operations were banned in the early seventies researchers had been able to gather evidence with respect to how the hemispheres are specialized along certain lines. One major finding of these operations was that the unity of the hemispheres is lost and they start acting locally when they are surgically separated. When the corpus callosum is cut, the part of the brain that maintains contralateral vision is not touched at all, i.e., it remains intact and just as in the normal human beings, the left visual field is perceived by the right hemisphere and the right visual field by the left. In experiments conducted on split brain patients the patients were presented with a visual stimuli in their left or right visual fields divided by a separator. When, for example, presented with the picture of an apple in their right visual field it was possible for the patients to name the object since the information in the right visual field goes to the left hemisphere; when, however, the same object was presented in their left visual field, the patients were unable to name the object since the information processed by the right hemisphere could not be transferred cortically to the left, thereby illustrating the primary role of the left hemisphere specifically in speech production.

The left hemisphere's primary role in language can also be evidenced in the hand preference of the majority of human beings. It is estimated that about 90 percent of the world's population is right-handed and the remaining 10 percent is left-handed or ambidextrous (Skoyles, 2000). A recent study seeking to understand the relation between hand preference and language activation in the hemispheres shows that out of a total of 50 right-handed and 50 left-handed volunteers 96% of the right-handers have language lateralized to the left hemisphere and four percent shows a bilateral lateralization. By contrast, only 76 percent of the left handers show language lateralization to the left hemisphere. Of the remaining 24 percent, 14 percent have bilateral activation and 10 percent right hemisphere lateralization (Pujol et al., 1999). It is also suggested that the right hand use for gestures might have evolutionarily linked the left hemisphere of the brain with language functions (Place, 2000). In the next paragraph, I will turn to a discussion of what else is known about the specific areas that get activated in the left hemisphere.

Recent studies reconfirm the century-old fact about the general site of language in the normal adult brain and indicate that in every language function whether it is phonological, lexical or syntactic processing or speech production the activation in the left hemisphere invariably exceeds the one in the right hemisphere. Moreover, the activation centers around the perisylvian area (which refers to an area surrounding the sylvian fissure -- a fold separating the frontal lobe which hosts Broca's area from the temporal lobe, home of Wernicke's area) (Stromswold, 1995; Bates, 1997). One single area that appears to stand out, particulary in speech production, is the *insula* which is a small area buried into the folds between the frontal and temporal lobes (Bates, 1997:12).

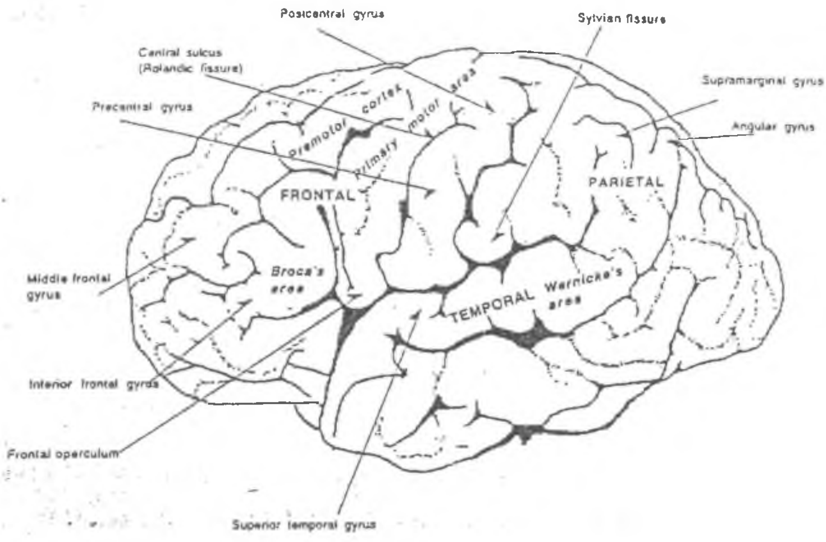

Figure 1. Lateral view of the left cerebral cortex (adapted from Blumstein, 1995)

When the question of the site of language is considered from a neurological point of view, the findings obtained over the last twenty years provide little support for a locationist (modular) view which attributes most language functions to a specific area. The findings also suggest that it will take a long time and will require techniques which would capture the image of a neuron or synapse to pin down a discrete brain area with dedicated language functions. Therefore at the neuronal level, aside from a near consensus that language resides in the left perisylvian areas we do not have finer evidence for the modularity of language. At a nonneuronal level we can talk about cases where language dissociates from other mental activities but even in such cases there appears to be no unambiguous anatomical correlates of language abilities. The specifics of the conditions where language dissociates from other cognitive skills will be discussed in detail in Section 4. The ensuing section concerns itself specifically with the knowledge of language comprised in the initial state and the role learning might be playing in the attainment of later stages.

1.3. Initial state of language and learning in later stages

When one scrutinizes the idea of a predetermined initial state of language faculty two questions immediately arise:

i. how much of knowledge of language is prescribed in the initial state and what is the nature of that knowledge, and
ii. how much of it is learned after birth?

What is at issue then is the extent to which language is inbuilt and learned. Chomsky argues that there are abstract linguistic principles (such as structure dependency principle and principle of merge)[5] encoded in the genome that characterize the initial state of all human languages but as yet how the genes determine the initial state and the brain mechanisms involved in the initial state is not known. In addition to the principles, there is a small set of parameters which act as variables before they are set (e.g. head parameter, pro-drop parameter, etc.). In the Principles and Parameters model of Chomsky which constitutes the so-called Universal Grammar (UG), parameters come in binary values and are set to the value required by the language of exposure during language acquisition. This model therefore assumes that infants equipped with UG already possess some knowledge of language - the specifics of which are under investigation - even before they are born.

Noone denies that there is extensive learning involved in the acquisition process. Nevertheless what sources are at the service of infants for them to process and compute information leading to learning had not been carefully explored until recently. A particularly interesting study in this regard shows that with only a two-minute exposure to a synthesized speech stream consisting of four three-syllable artifical words, 8-month-old infants were able to learn to analyze the stimuli and to group sequences of syllables solely on their distributional properties (Aslin, Saffran & Newport, 1999). In the precursors of this particular study, researchers first attempted to find out on what cues infants rely in segmenting words in a continuous stream of speech. The results from these initial studies showed that infants have a capacity to use transitional probabilities in determining word boundaries. Since the pioneering work of (Hayes and Clark, 1970, cited in Aslin et al., 1999) it has been known that a large number of sounds might occur at the ends of words but within a word the number of the successor sounds is more limited. In the Turkish sentence below:

(1) Çocuk bir top buldu
'The child found a ball.'

The transitional property of the last /p/'s of *top* 'ball' being followed by /b/ in *buldu* 'found' is not high since /p/, across a word boundary, can be followed by many other consonants such as */d/eldi*, */g/ördü*, */k/aptı*, */p/atlattı*, */s/attı*, among others, hence the transitional probability between /p/ and /b/ is less than 1.0. Within a word, however, the number of consonants the word *top* and specifically the /p/ of *top* can be followed by is only a handful. (2) below illustrates some examples indicating that there is a high transitional probability (i.e., 1.0) between for example /top/ and /ç/, /l/, /r/ and /t/.

(2)	top-/ç/u	top-/l/um	top-/r/ak	top-/t/an
	football player	society	earth	wholesale

Aslin et al. (1999) question whether infants utilize such transitional probability cues to segment speech into words and, on the assumption that this information may be implemented in inferring word boundaries, they conduct a set of experiments.[6]

In the first experiment conducted, a set of 8-month-old infants were each familiarized with two minutes of artifical language corpus consisting of four three-syllable nonsense words as listed in (3a). (3b) represents how the infants heard the sequence generated by a speech synthesizer and uttered in monotone:

(3) Familiarization phase
a. dapiku – tilado – buropi – pagotu
b. dapikutiladoburopipagotudapiku…

Each infant was then tested with two of the four words from the language corpus and two non-words made up of test words:

(4) Experiment 1 (Testing phase)
dapiku – tilado – tupiro – golabu

Within non-words, i.e. the last two words of the sequence in (4), the transitional probabilities for the two syllable pairs were 0.0 (that is, in the familiarization phase /tu/ never follows /pi/, similary /pi/ never precedes /ro/, etc., rendering a low transitional probability). Aslin et al. report that infants preferred to listen to the novel non-words longer than the familiar words, thereby indicating that they can discriminate between them by grouping sequences of syllables based solely on their distributional properties. Since the infants' performance could have been solely due to discrimination, Aslin et al. conducted a second experiment to rule out this possibility. The design of this experiment was similar to the first; the experiment differed, however, with respect to how the three-syllable test items were constructed. In addition to *dapiku* and *tilado* two new test items were constructed. These items were part-words consisting of the final syllable of one word and the first two syllables of another word of the sequence given in (3). E.g. *pipago* below is made up of the last syllable of *buropi* and the first two syllables of *pagotu*.

(5) Experiment 2 (Testing phase)
dapiku – tilado – pipago – tuburo

Thus in contrast to the non-words that never occurred in the familiarization phase in Experiment 1, the part-words in (5) had appeared in the familiarization phase in Experiment 2. The results of the second study revealed that infants again listened to the novel words significantly longer despite the fact that they were familiarized with parts of the non-words in the familiarization phase. That is, what appears to be a word in Exp. 2, e.g. *pipago*, is a part word in the familiarization phase, i.e. buropi – pagotu, nonetheless the infants were found to not consider it as a familiar word. By listening to it more, they showed some inclination to take it as a new word. Aslin et al. attribute this difference to the fact that infants compute the different transitional probabilities of the words and part-words and, putting these lines of evidence together, conclude that infants can perform a statistical learning mechanism which in turn suggests that some aspects of early development can best be characterized as resulting from innately biased statistical learning mechanism rather than innate knowledge (p:377). This study of Aslin and his colleagues has attracted considerable attention as being one of the first studies which solidly shows the learning capabilities of young infants.

In sum, in this section we have become familiar with issues that lie at the heart of the research that concerns itself with innateness and learning. The most natural conclusion to draw from the discussion would be that language acquisition and later processing result from some assumed innate abilities. Furthermore, these abilities to whichever modality they pertain, e.g. speech, vision, etc. provide some constraints which form a guideline for later learning. In short, the innately specified constraints might provide the means for the infants to succeed in learning a language by statistically computing the possibilities. Having dealt with some of the issues surrounding the questions in (1) in the introductory section, in section 2 below, I will move on to the next question which pertains to language acquisition.

2. Language acquisition

Though researchers have speculated that language acquisition gets under way long before the infant starts producing his/her first words, earlier work on language acquisition was mainly concerned with language production, primarily because of the lack of techniques and methodologies to test a nonproductive infant. In recent years, however, it has been possible to explore the linguistic capabilities of babies before they show any sign of production. Assuming that the majority of the readers would already be familiar with the major findings of the field of language acquisition from the first year of life onwards, coinciding with the production of words, in this section I will restrict myself only with a discussion of some of the compelling evidence that show the linguistic capabilities of babies prenatally and in the early months of life. Therefore, the discussion in the following section will center on speech perception and how it might serve as a cue in infants' formulation of the syntactic structures of their native language.

2.1. Speech perception

With innovative techniques developed in the past 15 years it has been possible to learn more about what the infant knows about language as a fetus, i.e. pre-natally or post-natally. The fetal brain is known to perceive speech stimuli from twentieth gestational week onward (Karmiloff & Karmiloff-Smith, 2001; Bates, 1997). This capability was first identified in the babies of some psycholinguist mothers who volunteered for the insertion of a tiny microphone on the outside wall of their uterus (Karmiloff & Karmiloff-Smith, 2001:13), making it possible to measure the sensitivity the fetal brain shows to the speech stimuli. In one of the methods used, the fetus is first habituated to a certain auditory stimuli via speakers placed on the abdomen of the mother until the point the baby gets bored with it. After habituation is achieved, i.e. a stable heart rate or a kicking rate is maintained, the baby is presented with a novel auditory stimuli. In the last trimester of the pregnancy, the fetus responds to a change in the stimuli with an increased heart rate and/or a kicking rate, hence showing that the baby is able to process speech in the womb.

Post-natally, very young infants are known to be highly sensitive to acoustic properties of speech and can perceive speech in terms of categories, that is, voicing and point of articulation contrasts can be processed by very young infants (Miller, 1990:88). The ability to hear categorical contrasts, though at first considered to be species-specific to the extent that it was believed to have evolved exclusively for speech, was soon discovered to the surprise of many as a capability that various species have. In a famous study by Kuhl and Miller (1975), chinchillas, animals with auditory sensitivity akin to humans, were shown to perceive the boundary between consonants. In the identification of phonemic contrasts, the time interval between the release of a consonant and the onset of vocal fold vibration plays a major role. For example, in the production of [b] with the release of the consonant, the vocal folds start vibrating and they continue vibrating throughout the articulation. In [p], there is a delay between the release of the consonant and the onset of vocal fold vibration. This delay called VOT (Voice Onset Time) enables a person to discriminate between a voiced and a voiceless consonant. When humans are presented with a speech stimuli consisting of [ba]-[pa] sequences, for instance, stimuli with low VOT values, 25 milliseconds or lower are perceived as [ba] since the interval between the release and the vocal fold vibration is short; stimuli with high VOT values, exceeding 25 milliseconds, are perceived as [pa]. Therefore for humans there is a perceptual break for the discrimination between [b] and [p] at 25 (precisely, 26.8ms) milliseconds. When chinchillas were tested (for a detailed set up of the experiment, see Miller, 1990), it was found that the perceptual break was at 23.3 ms, illustrating that chinchillas' auditory sensitivity is very much like humans', hence indicating that speech perception is not a human trait. Apparently a subset of the mechanisms that humans implement in the use of language, in this case categorical perception, is also accessible by animals.

2.2. Prosody and language discrimination

In addition to the genetic blueprint that babies are assumed to be endowed with, that they can process speech stimuli in the uterus might potentially equip them with knowledge of language from early on. Apparently, this knowledge is also at the disposal of the babies immediately after birth. In some recent highly compelling work on infants, a few-day-old infants are found to discriminate between their native language or between two nonnative languages on the basis of prosody alone. Mehler (1988, as cited in Guasti, 2002) has been a pioneering work in paving the way for many researchers' designing experiments which confirmed the initial results. In these experiments, to assess the babies' ability to discrimate languages, a habituation-dishabituation procedure is implemented and this procedure particularly exploits the sucking behavior of babies. In this procedure babies are first habituated to utterances in their language as they heard from a loudspeaker and made to recognize that their sucking would trigger stimulation, hence the more they suck the more stimuli they receive. After a stable sucking rate is maintained, that is, after when the infants get bored and start sucking less, the babies are divided into two groups, one constituting the experimental group to which new stimuli, i.e. an unfamiliar language, is presented and the other control group which continued hearing the old stimuli. When the sucking rate of the control group was compared with that of the experimental group the latter was found to suck more which is interpreted as discrimination between two languages. In this particular experiment one could argue that the baby is already familiar with his/her native language so discriminating it from an unfamiliar one may not necessarily pose a big challenge. But this observation can be immediately ruled out when infants' performance on discriminating two nonnative languages is studied. Five-day-old infants born into a French speaking environment are found to discriminate between English and Japanese (Nazzi, Bertoncini and Mehler, 1998), four-day-olds to distinguish between English and Italian (Mehler, 1988, cited in Guasti, 2002). Thus with minor exposure to the languages in question the babies are able to perceive them as belonging to different categories. Discrimination is not an easy task and the infants must be relying on some specific representation of languages which makes it possible to isolate some properties pertaining to a language. Mehler (1996) suggests that infants rely on the rhythmic properties of languages and proposes the so-called rhythm-based language discrimination hypothesis which assumes that newborn infants have a representation of the utterances of a language as a sequence of vowels. Mehler holds that vowels attract infants' attention more than consonants since they are more salient, i.e., have stress and are louder, hence making it possible to render a rhythmic representation of languages on the basis of vowels alone. Mehler's proposal implements a classification of languages developed by phonologists such as Abercrombie (1967) and Ladefoged (1975) according to which it is possible to categorize languages in three classes:

(i) stress-timed languages	(Dutch, English, Russian, Swedish, etc.)
(ii) syllable-timed languages	(French, Italian, Greek, Spanish, Turkish, etc.)
(iii)mora-timed languages	(Japanese, Tamil), etc.

As discussed in Guasti (2002:34), in stress-timed languages since the syllable structure is quite varied, the interval between vowels is long and irregular which directs the hearers' attention to the recurring stress. By contrast, in syllable-timed languages the syllable structure is less varied, hence rendering a shorter and more regular interval between vowels. Finally in mora-timed languages the distance between vowels is even more regular and shorter than in syllable-timed languages and hearers are believed to perceive recurring morae.

According to this proposal if the unfamiliar languages to which the infants are exposed belong to different classes with respect to their prosodic patterns, the infants will be at ease in discriminating between them. When the languages the babies perceive belong to the same class, however, discrimination will be difficult or impossible. This prediction is borne out with the result that four-day-old French babies are found to fail in discriminating between English and Dutch, both stress-timed languages (Nazzi et al., 1998). Furthermore, failure in discrimination continues until the end of the first six months, a time that coincides with the beginning of the infants' ability that enables them to sort out the phonetic and phonotactic properties of their native language.

Just like speech perception, early discrimination of unfamiliar languages on the basis of prosody may not necessarily be just a common human possession. In an interesting study, by running experiments on human infants and cotton-top tamarin monkeys, Ramus et al. (2000) demonstrate that the latter can discriminate between languages as successfully as the babies. In this experiment, two- to five-day-old 32 infants and 13 tamarins were exposed to synthesized speech stimuli in the form of utterances; 20 in Dutch and 20 in Japanese (it was ensured that one language is head-initial and the other head-final). Infants were tested using the high amplitude sucking technique and the habituation-dishabituation procedure. The tamarins, however, were tested with a head orientation technique which measures the head turn response toward a loudspeaker when the monkeys are presented with different stimuli. During the habituation phase of the experiment the infants were habituated to ten sentences in one language first and then exposed to ten sentences in the other language. As Ramus et al. report a significant increase was attained in the sucking of the infants following a change from Dutch to Japanese. This can be taken to conclude that infants can discriminate sentences of Dutch from those of Japanese solely on prosodic cues. Similar results were also obtained from the tamarins. To ensure that discrimination follows from prosody, the researchers further tested a new set of 32 infants, this time by playing the synthesized sentences backwards. The infants failed to discriminate a backward played stimuli and this finding therefore suggests that newborns' language discrimination capacity may depend on specific properties of speech that are obscured when the stimuli is played backwards. Similar results were obtained from tamarins as well and they failed to recognize two distinct languages in backward played sentences. The general conclusion drawn is that some aspects of human speech perception may have built upon preexisting sensitivity of the primate auditory system. Hence as the discussion in the previous paragraphs reveals, the rhythmic properties, that is, the prosodic patterns of languages play a major role in infants' getting attuned to languages and sorting out the similarities and/or differences between them. The knowledge of prosody at the disposal of young infants also appears to cue them in identifying the basic syntactic structure of their language.

2.3. How prosody sets the head-parameter

Relying on the fact that languages vary both with respect to prosody and syntax, Nespor, Guasti and Christophe (1996) propose that there can be a correlation between a certain prosodic pattern and a value of a syntactic parameter. They suggest that prosody might be playing an essential role in cuing syntax, specifically in setting the head parameter. One of the well established facts capturing the variety observed across languages is that languages for the most part fall into two groups: those having their complements follow their heads, that is head-initial languages, and those having their complements followed by the heads, head-final languages. In head-initial languages it is assumed that the salient item within a phonological phrase is the last word. In head-final languages, however, the salient item is the first one rendering the prominence to fall on the first item (Nespor et al. 1996, as cited in Mehler, Christophe & Ramus, 2000). Consider the three sets of phonological phrases from French, a head-initial language and Turkish, a head-final language below:

		French				Turkish	
(6)	a.	[la	pomme	rouge]$_{PP}$	b.	[kırmızı	elma]$_{PP}$
		the	apple	red		red	apple
	c.	[dans	la chambre]$_{NP}$		d.	[odanın	içinde]$_{NP}$
		in	the room			room	in
	e.	[manger	la	pomme]$_{VP}$	f.	[elma	yemek]$_{VP}$
		eat	the	apple		apple	eat

The phrases in (6) also correspond to phonological phrases and, as illustrated above, in French, a head-initial language, the prominence falls on *rouge* 'red' in (a), *chambre* 'room' in (c) and *pomme* 'apple' in (e) as they are phrase final. In Turkish, however, a head-final language, the prominent units are the phrase initial ones; *kırmızı* 'red' in (b), *odanın* 'of the room' in (d) and *elma* 'apple' in (f). Nespor et al. argue that infants use this information to set the head parameter either to the head-initial or the head-final setting thereby computing some structurally significant information about their languages.

To conclude this section, we have seen that infants' use of prosody to glean the basic syntactic structure of languages suggests that phonology plays the guiding role in a rudimentary parsing of the speech stream. Nespor et al.'s study is a significant first step in showing how and when a young infant can set one of the most essential UG parameters[7]. Further findings discussed in this section also show how on the basis of prosody alone both infants and a certain breed of monkey can discriminate languages. In this section, though we have seen that categorical perception and language discrimination are abilities that can be implemented by chincillas and tamarins as well, it goes without saying that only humans had been able to exploit them to acquire language. Since a detailed account of the linguistic abilities of primates and some other species is the topic of the next paper in this volume, in the following section, I will move on to the fourth issue raised in Section 1 and turn my attention to a consideration of some conditions where language appears to act independently of other cognitive abilities.

3. Independence of Language from Cognition

In this section I will briefly examine three pathological conditions which show how language can dissociate from other cognitive abilities. The conditions under examination are: Specific Language Impairment (SLI), Williams Syndrome (WS) and the case of Christopher, an idiot savant, who shows a precocious talent for languages.

SLI is a condition in which language is impaired while all other cognitive abilities remain intact. By contrast, in WS, while all other cognitive abilities are defective, language is partially spared. Over the last few years, as Gopnik (1999: 263) states, SLI has gained significance due to the fact that it may have the potential to tell us something about the biological basis of language. SLI is a promising candidate in the search for the genetic bases of language because it is the only condition in which some parts of language are defective while all other cognitive abilities are spared. Therefore with an intact cognition except for language, it may be possible to locate a specific source for the impaired part of language.

Some striking facts about SLI are: (i) it affects the inflectional morphology, in particular, the tense, agreement morphemes of languages and (ii) it may have a genetic component since it runs in families. When family history of individuals with SLI is studied, a multigenerational impairment was found. In a study of a single extended family (the so called K family), 16 members of the family were found to be impaired while 13 had absolutely normal language (Gopnik, 1990). Gopnik (1999) further reports that out of 95 individuals with SLI studied at a project conducted at McGill University, 53 of the subjects had been found to have at least one affected first or second degree relative. The etiology of this impairment is not known yet but according to one hypothesis SLI is an auditory deficit and it primarily affects function words since they are nonsalient (that is, they lack stress) at least in some languages, rendering them unperceivable and unprocessable. Some interesting cross linguistic findings, however, indicate that while English speaking SLI children omit inflectional morphemes (such as the past, present tense markers, the copula, etc.) Italian and Hebrew-speaking SLI children use such morphemes properly since they are salient in those languages (Leonard et al., 1992, as cited in Guasti, 2002).

In individuals with SLI, it is only language that is defective, furthermore there is no evidence of mental retardation or hearing loss. By contrast, in WS children, cognitive abilities except for language are severely impaired. Some caution has to be exercised in describing the language abilities of WS individuals as intact since it appears that they have relatively better spared lexical and grammatical abilities compared to other individuals with mental retardation such as Down Syndrome (Karmiloff-Smith et al., 1997). To give an example of how the language abilities of individuals with SLI differ from those with WS, let us take a look at the individuals' use of the English past tense. While WS subjects have no trouble in forming the past forms of regular verbs in English, contrary to the individuals with SLI, they have considerable problems with irregular past tense forms. Since the past tense formation with regular verbs requires the application of a rule but the irregular verbs are learned by rote and stored in the memory, suggesting that the systems that subserve their processing must be different (Pinker, 1998), the problems the WS population shows with irregular forms might arise from a deficit in their working memory.

The third pathological condition, Christopher's case, provides an interesting example of the independence of language from cognition since the patient not only has one language intact despite a nonverbal IQ of 42-72 at the age of 30 (equivalent to the IQ of a normal child between 5-10 years of age) but partial knowledge of at least 16 languages from different language families (Smith and Tsimpli, 1995). With respect to the etiology of Christopher's impairment all that is known is that Christopher was diagnosed with hydrocephalus and high functioning autism but an MRI scan showed no evidence for a localized brain injury. As discussed in Smith and Tsimpli, from 3 years onward Christopher had begun to show fascination with languages and he started learning them on his own by reading books. At the time he was studied he showed mastery in 16 languages which enabled him to translate back and forth in each and every one of them. One interesting note to pass on about the linguistic abilities of Christopher is that when he was exposed to some data from an artificial language called Epun, he could not learn it since the language was designed to violate the structural dependency principle. This finding clearly shows that an artificial language which does not follow the rules of natural languages was nonlearnable. Christopher's case, taking into account that he was institutionalized at the time of the study, constitutes the most drastic example of how language might dissociate from other cognitive abilities.

To summarize then, in a few cases language appears to behave independently from other abilities, though we are far from suggesting a separate module responsible for the manifestation of language in the brain, research specifically on SLI might provide important evidence for the genetic bases of language.

4. Conclusions and future prospects

The goal of this paper has been to acquaint the interested reader with only some of the recent findings on the biological bases of language, specifically speech perception, the role of prosody in very early language acquisition and conditions where language appears to dissociate from other abilities.

Since the idea that we have an innate disposition to language has been put forth, a tendency is widely apparent among linguists to attribute many properties of language to the initial state. A most recent example is a suggestion in Stromswold (1999) which argues that since English speaking children never make mistakes in the distribution of for example, the English auxiliary *have* as in *He has left* and the lexical *have* as in *He has a house*, the knowledge of the distinction between functional and lexical categories must be inbuilt in the system from start.

Undoubtedly such assumptions are ill-founded and they would hold back research about how language can be learned. Though it is difficult to test the linguistic abilities of unexpressive infants, some new techniques provide the researcher with powerful means to glean even the language abilities of fetuses. Techniques testing the computational abilities of infants would provide us with much better insights with respect to the nature of the initial state and the subsequent states of language acquisition and might lead to the proposal of a more basic initial state which is comprised of contraints not solely dedicated to language.

By presenting these findings, this paper also attempts to promote much needed research on Turkish in the areas of the acquisition of phonology, specifically the phonemic contrasts, phonotactics, prosody, etc. and in language disorders, in particular SLI. Crosslinguistic evidence is available on SLI and evidence from Turkish would definitely find a welcome place in piecing together the condition of SLI.

Notes

[1] Jenkins (2000) popularizes the use of the term biolinguistics which was coined in the 1950's to refer to the relation between biology and language.

[2] When one looks at the innateness of language in evolutionary terms two perspectives stand out that endeavour to explain the origin of an innate LAD: exaptationist and adaptationist. As Kirby (1999:123) states proponents of the first type. Chomsky (1988) for example, argue that natural selection plays only a minor role in the evolution of LAD. This hypothetical language organ is also considered not to have evolved bit by bit with respect to its functional consequences, but is rather assumed to be plugged into the brain in a single accident of prehistory (Deacon, 1997:36). Under the exaptationist account, neural structures which had evolved for (an)other purpose or purposes were reappropriated for language; to put it crudely, neural structures were exapted to play a particular role in language. Though this view offers a single-step evolutionary account which is much easier to comprehend, it appears to ignore the details of language origins or of finding any evidence for symbolic representation in the ape brain, etc. The adaptationists, however, such as Pinker (1994), Calvin & Bickerton (2000), Knight, Studdert-Kennedy & Hurford (2000) deem natural selection as playing a key role in explaining the origin of the LAD. Pinker, for example, argues that a language instinct could have gradually evolved through the action of natural selection. Adaptationist view heavily relies on the assumption that human language confers a survival or reproductive advantage on the organisms that have it and deem language as a remarkable social adaptation. Reconciling the two views, Hurford and Kirby (1995, as cited in Kirby, 1999:125) suggest that a faculty for some form of proto-language was a primate exaptation from neural structures serving mental representation, but the human LAD has adapted from this precursor and has evolved through selection for the function it now serves.

[3] The specialized component of language is also referred to as a module which is a term mostly implemented in the locationist models of language. This paper uses the term modularity only in the sense of an encapsulated component for language in the brain.

[4] Visual information apparently plays an important role in language processing. One study by Kuhl and Meltzoff (1982) suggests that young infants have knowledge of the relation between how the articulators move and the sounds they produce. 4 to 5 months of age infants are found to be aware of the correspondence between two static faces illustrating the production of the vowels [i] and [a] respectively and the sounds [i] and [a] heard from a loudspeaker. They are

reported to look longer at the picture depicting the articulation of the sound matching the one that they heard from the loudspeaker.

[5] These abstract principles may not be dedicated to language alone and may arise in other modalities as well, as pointed out by Chomsky himself at a talk given at Boğaziçi University in November 2002.

[6] A statistical mechanism for identifying word boundaries was also hinted by Chomsky (1975, chap. 6, fn. 18), as mentioned in Guasti, 2002:72).

[7] As the anonymous reviewer suggests, we have to point out that linguists have different views about what parameters are and some even avoid using the term parameter or implement other means with different connotations (cf. Baker, 2001:68-84 on this issue and also for some discussion on the OT (Optimality Theory) account of parameters and the prevailing lexical parameter approach which is originally proposed by Borer (1984)). The head parameter also assumes a dubious place in current syntactic theorizing. In the Minimalist Program (Chomsky, 1995), for example, there is no X-bar theory or phrase structure rules: the only structural relations invoked are those that are induced by computation, particularly by the operation Merge (Chomsky, 2000:11). When Merge is adopted the necessity for assuming the independent existence of tree structures disappears, therefore Merge renders the parameter of head direction useless with its flexible nature.

References

Aslin, R. N., Saffran, J. R., Newport, E. (1999). Statistical learning in linguistic and nonlinguistic domains. In B. Mac Whinney (ed.), *The Emergence of Language*, 359-415. Hillsdale, NJ: Lawrence Earlbaum Associates.

Baker, M. C. (2001). *The Atoms of Language*. New York: Basic Books.

Bates, E. (1997). *On the nature and nurture of language*. [On-line]. Available: http://crl.ucsd.edu/~bates/papers/pdf/bates-inpress.pdf

Bates, E. & Goodman, J. (1999). On the emergence of grammar from the lexicon. In B. Mac Whinney (ed.). *The Emergence of Language*, 29-78. Hillsdale, NJ: Lawrence Earlbaum Associates.

Bates, E., Thal, D., Finlay, B., Clancy, B. (2001). Early language development and its neural correlates. In I. Rapin & S. Segalowitz (eds.). *Handbook of Neuropsychology*, Vol. 6: *Child Neurology*. Amsterdam: Elsevier.

Blumstein, S. E. (1995). The neurobiology of the sound structure of language. In M. S. Gazzaniga (ed.), *The Cognitive Neurosciences*, 915-929.

Borer, H. (1984). *Parametric Syntax: Case Studies in Semitic and Romance Languages*. Dordrecht: Foris.

Calvin, W. H. & Bickerton, D. (2000). *Lingua ex Machina: Reconciling Darwin and Chomsky with the Human Brain*. Cambridge, MA: MIT Press.

Chi, J. G., Dooling, E. C. & Gilles, F. H. (1977). Left right asymmetries of the temporal speech areas of the human brain. *Architectural Neurology*, *34*, 346-348.

Chomsky, N. (1957). *Syntactic Structures*. The Hague: Mouton.

__________. (1959). A review of B. F. Skinner's *Verbal Behaviour*. *Language*, *35*(1), 26-58.

Chomsky, N. (1975). *The Logical Structure of Linguistic Theory*. Chicago: The University of Chicago Press.

__________. (1988). *Language and Problems of Knowledge. The Managua Lectures*. Cambridge, MA: MIT Press.

__________. (2000). *New Horizons in the Study of Language and Mind*. Cambridge, UK: Cambridge University Press.

Deacon, T. W. (1997). *The Symbolic Species*. New York, London: W. W. Norton & Company.

Elman, J., Bates, E., Johnson, M., Karmiloff-Smith, A., Parisi, D., Plunkett, K. (1996). *Rethinking Innateness: A Connectionist perspective on Development*. Cambridge, MA: The MIT Press.

Elman, J. (1999). The emergence of language: A conspiracy theory. In B. Mac Whinney (ed.), *The Emergence of Language*, 1-27. Hillsdale, NJ: Lawrence Erlbaum Associates.

Gopnik, M. (1990). Feature-blindness. A case study. *Language Acquisition, 1*, 139-164.

__________. (1999). Some evidence for impaired grammars. In R. Jackendoff, P. Bloom and K. Wynn (eds.), *Language, Logic and Concepts*, 264-283. Cambridge, MA: The MIT Press.

Guasti, M. T. (2002). *Language Acquisition: The Growth of Grammar*. Cambridge, MA: The MIT Press.

Jenkins, L. (2000). *Biolinguistics*. Cambridge, UK: Cambridge University Press.

Karmiloff, K. & Karmiloff-Smith, A. (2001). *Pathways to Language: From Fetus to Adolescent*. Cambridge, MA: Harvard University Press.

Kirby, S. (1999). *Function, Selection and Innateness*. Oxford: Oxford University Press.

Knight, C., Studdert-Kennedy, M. & Hurford, J. (2000). *The Evolutionary Emergence of Language: Social Function and the Origins of Linguistic Form*. Cambridge: Cambridge University Press.

Kuhl, P. K., & Metzoff, A. N. (1982). The bimodal perception of speech in infancy. *Science, 218*, 1138-1141.

Kuhl, P. K. & Miller, J. D. (1975). Speech perception by the chinchilla: voiced-voiceless distinctions in alveaolar, plosive consonants. *Science, 190*(4209), 69-72.

Lenneberg, E. H. (1967). *The Biological Foundations of Language*. New York: Wiley.

Mehler, J., Dupoux E., Nazzi, T., & Dehaene-Lambertz, G. (1996). Coping with linguistic diversity: The infant's viewpoint. In J. L. Morgan and K. Demuth, (eds.). *Signal to Syntax*. Mahwah, N.J.: Lawrence Erlbaum.

Mehler, J., Christophe, A. and Ramus, F. (2000). How infants acquire language: Some preliminary observations. In Marantz et al. (eds.), *Image, Language and Brain. Papers from the First Mind Articulation Project Symposium*, 51-77. Cambridge, MA: MIT Press.

Miller, J. (1990). Speech Perception. In D. N. Osherson & H. Lasnik (eds.) *An Invitation to Cognitive Science: Language*, Vol.1, 69-93.

Nazzi, T., Bertoncini, J., & Mehler, J. (1998). Language Discrimination by newborns: Towards an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance, 24*, 756-766.

Nespor, M., Guasti, M. T. & Christophe, A. (1996). Selecting word order: The Rhythmic Activation principle. In U. Kleinhenz (ed.), *Interfaces in Phonology*, 1-26. Berlin: Akademie Verlag.

Pettito, L. A., Zatorre, R. J, Gauna, K., Nikelski, E. J., Dostie, D. and Evans, A. C. (2000). Speech-like cerebral activity in profoundly deaf people processing signed languages: implications for the neural basis of human language. *PNAS*, Vol. 97-25, 13961-13966.

Pinker, S. (1994). *The Language Instinct*. New York: William Morrow.

__________. (1998). Rules of Language. In P. Thagard (ed.), *Mind Readings*, 77-92. Cambridge, MA: MIT Press.

Place, U. (2000). The role of hand in the evolution of language. *Psycoloquy, 11*(7): *Language and Gesture (2)*.

Pujol, J., Deus, J., Losilla, J. M., & Capdevila, A. (1999). Cerebral lateralization of language in normal left-handed people studied by fMRI. *Neurology, 52*, 1038-43.

Ramus, F., Mehler, J., Hauser, M. D., Miller, C. & Moris, D. (2000). Language discrimination by newborns and cotton-top tamarin monkeys. *Science, 288*, 349-351.

Skoyles, J. (2000). Gesture, language origins and right handedness. *Psycholoquy, 11*(24): *Language Gesture (2)*.

Smith, N. & Tsimpli, I. (1995). *The Mind of a Savant*. Oxford: Blackwell.

Stromswold, K. (1995). The cognitive and neural bases of language acquisition. In M. S. Gazzaniga (ed.), *The Cognitive Neurosciences*, 855-870. Cambridge, MA: MIT Press.

__________. (1999). Cognitive and neural aspects of language acqusition. In E. Lepore & Z. Pylyshyn (eds.), *What is Cognitive Science?*, 356-399. Oxford: Blackwell.

Wada, J. A., Clarke, R. & Hamm, A. (1975). Cerebral hemispheric asymmetry in humans. *Archives of Neurology, 32*, 239-246.