What Studies of the Brain Can Tell Us About Language (if anything) and Vice Versa

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I. Introduction

Despite great advances made in the understanding of brain structure, brain mechanisms, and neural nets, particularly in the recent years due to technological developments such as MRI's (Magnetic Resonance Imaging), Positron Emission Tomography (PET), Event Related Potentials (ERPS), computer simulation programs and connection machines, studies of the brain still cannot tell us whether X-Bar Theory or the Verb-Internal Subject Hypothesis is correct, whether G-B or HPSG, or LFG is a viable theory of language, or whether stages in the acquisition of language reveal a continuity or maturation of UG. We have unfortunately no more to add to John Marshall's observations in 1980:

> 'Biologists...have accumulated a vast body of knowledge concerning the gross anatomy of those parts of the central and peripheral nervous system which seem to be implicated in the acquisition and exercise of linguistic abilities. Some knowledge is even available about the slightly less gross physiology of the relevant brain areas....(P)sycholinguists...have amassed alarming amounts of data of the progression from the birth cry to the multiply embedded relative clause. The problem is...found in the simple fact that no one .. has the slightest idea how to relate these two domains of inquiry to each other....We have so far failed ... to construct ... models ...that could mediate between noun phrases and neurons.'

Yet, despite the seemingly discouraging picture, many of us keep looking for a way to relate noun phrases to neurons in our attempts to answer a question posed by Chomsky (1988):

> 'What are the physical mechanisms that serve as the material basis for (the) system of (linguistic knowledge) and for the use of this knowledge? (p 3)
> 'In the study of language we proceed abstractly, at the level of mind, and we also hope to be able to gain understanding of how the entities constructed at this abstract level and their properties and the principles that govern them can be accounted for in terms of properties of the brain.' (p 8)

Although we have not yet been able to delineate the neural structures underlying linguistic structures, there is evidence from studies of the brain and language that bear on a number of issues of interest to linguistics. One such issue which this paper will consider is currently being debated among linguists and other cognitive scientists; it concerns the question of whether the human mind and the brain which serves as its neural base is 'modular'.

Simply stated, the question is whether human language ability is a genetically determined, autonomous system, independent of other cognitive systems with which it interacts, or whether it is derivative of more general cognitive ability. It is of course possible that language is acquired on the basis of non-linguistic general cognitive abilities and in the course of its development becomes independent. Thus one can accept the notion of modularity and reject that of innateness, but they are related issues. With some small changes in Fodor's (1983) definition, we can ask whether the language system is domain-specific, informationally encapsulated, subserved by specific neural architecture and subject to idiosyncratic pathological breakdown. As we can see from Figure 1[2], according to at least one historical view, language does indeed constitute such a module.

Since I doubt that anyone today will accept the phrenological head as 'proof' of a modular brain, I will attempt in the remainder of this paper to provide some more viable empirical evidence for this claim.

A second related but independent question is whether the components of the mental grammar are themselves modular units. Given the size limitations of the paper, I will be able to do no more than mention some aphasia data on differential breakdown of linguistic abilities which suggests that such modules do exist.

Finally, again because of size limitations, I will deal only briefly with a third related issue which concerns the relationship between language and non-linguistic conceptual knowledge in the mature brain.

II.. Historical Overview

The interest in the neural basis of language and cognition goes back at least 2000 years. In fact, evidence for the independence or modularity of language has been accumulating over thousands of years and did not spring full grown Medusa like out of the minds of either Chomsky or Fodor.

Since it is becoming fashionable to quote the scriptures given the rise of fundamentalism throughout the world, it may be of interest to note that in the 135th Psalm , one finds an implicit recognition of the left brain / language interface (although contralateral brain function was of course not understood). The verse states: 'If I will forget thee, Jerusalem, let my right hand die -- let my tongue stick to the roof of my mouth.' That is, they observed a relationship between disfunctions of the right side of the body which we now know is controlled by the left cerebral hemisphere and the ability to speak which we now know is also controlled by the left brain.

In the New Testament, St. Luke reports that Zacharias could not speak but could write, predating the modern observations of the independence of linguistic components by two millennia.

Observations of language loss with intact general intelligence are found in the medical records written on papyrus in 1700 B.C.E. by Egyptian surgeons, long before the philosophers of ancient Greece speculated about the brain/mind relationships. (Breasted 1930) Although neither Plato nor Aristotle recognized thbrain's crucial function in cognition or memory as shown by Aristotle's suggestion that the brain is a cold sponge whose function is to cool the blood, in the same period, the Graeco-Roman physicians' Hippocratic Treatises (written from 400 BCE to 135 CE) reveal their understanding of the role of the brain in cognition noting that language and speech disorders result from cerebral trauma or brain disease and that loss of speech often occurred simultaneously with paralysis of the right side of the body. They also showed an understanding of the separation of linguistic competence and performance in their observation that language loss may occur without the loss of speech and vice versa.

Other writers and scholars of the ancient classical world and the mediaeval period provide us with a wealth of information on aphasia -- the loss of distinct linguistic abilities -- with a preservation of nonlinguistic cognitive functions, as well as differential impairment and preservation of different linguistic abilities. Over 2000 years ago Valerius Maximus and Pliny described the Athenian scholar who in the words of Pliny '...with the stroke of a stone, fell presently to forget his letters

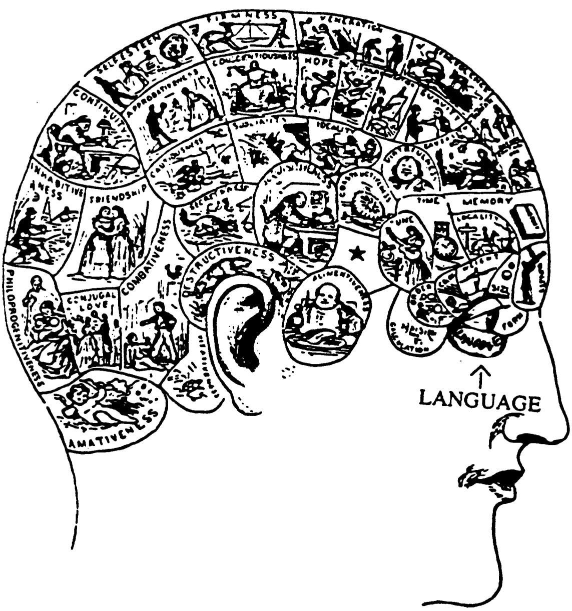

Figure 1. Phrenology skull model

only, and could read no more; otherwise his memory served him well enough.'

Numerous clinical descriptions of patients with language deficits and preserved non- linguistic cognitive systems were published from the 15th to the 18th century. And as we can see from this drawing of Albertus Magnus in 1506 shown in Figure 2, the view that the brain was modular is not a new one.

Other reports describe patients suffering from acquired dyslexia (loss of ability to read) who nevertheless preserved their ability to write, and patients who could "write to dictation but could not read back what they had written" (Arbib et al. 1982).

Carl Linnaeus in 1745 published a case study of a man suffering from jargon aphasia, who spoke "as it were a foreign language, having his own names for all words" revealing either a disruption of the phonological representation of words or a breakdown in the phonemic to articulatory mapping. (Benton and Joynt 1960) An important observation regarding word substitution errors was made by Ryklof Michel von Goens in 1789 in his reference to a patient which he described as follows: "After an illness, she was suddenly afflicted with a forgetting, or, rather, an incapacity or confusion of speech...If she desired a chair, she would ask for a table... Sometimes she herself perceived that she misnamed objects; at other times, she was annoyed when a *fan*, which she had asked for, was brought to her, instead of the *bonnet*, which she thought she had requested." (Crichton 1798; Winslow 1868)

The description of this and other similarly afflicted patients reveals that they substituted words that were semantically or phonologically similar to the intended ones, producing errors similar to normal word substitution errors (cf. Fromkin 1980) or to those produced by the agnosia patient of the Drs. Damasio in Iowa who called Ronald Reagan 'John Wayne'. (Damasio, personal communication).

In 1770 Johann Gesner described a case of jargon aphasia in which the patient not only produced neologisms but in writing words used orthography which reflected the phonology of the jargon, showing his use of phoneme-to-orthographic rules. He also discussed bilingual asymmetry in which, for example, an abbot, following brain damage, retained his ability to read Latin but not German.

Another case was of a patient who, in reading aloud, substituted semantically similar words, like a patient mentioned who made such errors in spontaneous speech. Such errors are again similar to what we find today like the patient who reads 'cake' for *bun*, 'poison' for *arsenic* and 'pixie' for *gnome*.

Gesner did not attribute these language difficulties to either general intellectual deficits or loss of memory "in general" but instead to a specific impairment to language memory, stating: "just as some verbal powers can become weakened without injury to others, memory also can be specifically impaired to a greater or lesser degree with respect to only certain classes of ideas." (Benton 1981)

Because of such asymmetries in the breakdown of distinct cognitive abilities, Franz Joseph Gall (1791) argued against the majority view of his time that the brain was an unstructured organ and in favor of discrete anatomical areas (or cortical organs) which were directly responsible for specific cognitive functions (or faculties), including language.

It was not until 1861 that language was specifically related to the left side of the brain. In the seminal paper which has now become part of linguistic as well as

Figure 2. The three ventricles of the brain as drawn by Albertus Magnus in *De Anima* 1506

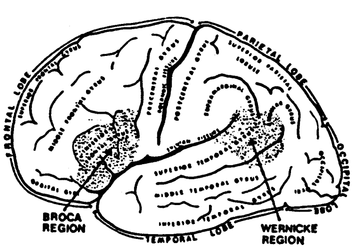

Figure 3. Lateral (external) view of the left hemisphere of the human brain showing the position of Broca and Wernicke regions.

neurological common knowledge, Paul Broca (1861) presented autopsy evidence showing that a localized (anterior) left hemisphere lesion resulted in a loss of ability to speak, whereas focal lesions in similar parts of the right brain did not. He managed to convince his Parisian audience (and most of neurology) that "On parle avec l'hemisphere gauche".

In 1874, Carl Wernicke (1874), however, pointed out that damage in the posterior portion of the left temporal lobe results in a different form of language breakdown than that occurring after damage to the frontal cortex (now called Broca's area). These different kinds of acquired language loss -- aphasias -- continue to be corroborated.

These localized areas for different kinds of language breakdown are shown in Figure 3.

The years which followed Broca's and Wernicke's discoveries stimulated neurologists throughout the world such as Broadbent (1879) and Bastian (1887) in Britain, Pick (1913) and Salomon (1914) in Germany, and Moutier (1908) in France to apply linguistic analyses to aphasia data.

Jakobson (1940, 1955, 1964) was the first linguist to apply linguistic theory to aphasia research, following up on the insights of de Courtenay in 1885 and Saussure in 1879 who had expressed the belief that a study of language pathology could contribute to linguistics.

Except for Jakobson, few linguists followed up the early interest in linguistics by neurologists who drew on linguistic concepts in their investigations of aphasia. There was the pioneering study of Blumstein (1977), a student of Jakobson, but it is only in the last two or three decades, possibly because of the dominant ideology of behaviorism in the period prior to Chomsky, that serious linguistic work on the brain/language interface has been conducted.

Many of us who now work in the area of neurolinguistic research were spurred on by Chomsky's notion of the language faculty and by the seminal work on the biological basis of language by Lenenberg (1967).

As to his views on modularity, Chomsky (1988) states that '...there seems to be little reason to insist that the brain is unique in the biological world in that it is unstructured and undifferentiated' referring to David Hubel 's work on the physical basis for mammalian vision.

III. Aphasia Evidence for Modularity

The current linguistic interest in aphasia is partially due to the fact that focal injuries to different parts of the brain not only lead to selective cognitive disorders, but may also lead to damage of distinct components of language or of specific linguistic processing mechanisms.

Following damage to different parts of the left hemisphere, syntax may be impaired with phonology retained, for example, or vice versa as is the case of jargon aphasics who while producing many neologisms, properly inflect them as shown in the following examples from Buckingham (1981).

1. The leg vilted from here down.
2. This is the krebekacks where the frejes get out after the chew.

The aphasic disorder referred to as agrammatism -- a term first used by Pick in 1918 -- has been of particular interest in the attempts to understand the nature of abnormal as well as normal language. Pick noted that the sentences produced by some Broca's aphasics were ungrammatical although the patients seemed to be aware of their 'intended preverbal meaning'

Pick also showed linguistic sophistication when he distinguished between lexical and grammatical formatives. This distinction has been revealed in certain patients after brain damage as shown in the different reading responses to lexical and grammatical words of a patient of Newcome and Marshall (1985), shown in 3. The patient suffered from acquired dyslexia -- the loss of the abililty to read by a former literate individual.

3.

STIMULUS	RESPONSE	STIMULUS	RESPONSE
witch	'witch'	*bean*	'soup'
which	'No!'	*been*	'No!'
hour	'time'	*eye*	'eyes'
our	'No!'	*I*	'No!'
hymn	'Bible'	*wood*	'wood'
him	'A Boy? No!'	*would*	'I hate those little words'
four	four	*moor*	'mist--fog?'
for	'No!'	*more*	'No!'

Note that GR while making semantically similar substitution errors in reading the content word in lexical/grammatical homophone pairs, is unable to read the grammatical formatives at all.

Agrammatism was originally considered to be a disorder of speech production in which some Broca's aphasic patients delete such grammatical formatives like auxiliaries, pronouns, determiners and some prepositions, and inflectional affixes.

Up until the 1970's, it was believed that the comprehension of these patients was intact, thus suggesting that the disorder was due to a problem in processing grammatical formatives during speech production. However, controlled experimental studies showed that where comprehension depends on the syntactic structure of sentences, syntactic comprehension deficits (also referred to as asyntactic comprehension) also arise in these patients (Caramazza and Zurif 1976; Heilman and Scholes 1976; Kean 1985)

The observation that asyntactic comprehension occurs with agrammatical production led to the view that agrammatism is a central deficit of the syntactic component of the grammar (Linebarger et al. 1983; Linebarger 1989; Luketela et al. 1986; Shankweiler et al. 1989). More recently, less global theories of the deficit have been proposed, which focus on some particular aspect of syntactic processing as the locus of failure (Cornell et al. 1993; Mauner et al. 1993; Grodzinsky 1984, 1986, 1990; Hickock 1992)

While linguists may not be interested in which specific lesion sites produce different aphasic symptoms, the fact that there are such sites and that they are correlated with different linguistic difficulties is of interest. The neural architecture is revealed by Magnetic Resonant Imaging techniques and the templates processed by Hanna Damasio showing the different lesions sites of a Broca's aphasic and a Wernicke's aphasic, as in Figures 4 and 5.

IV. Genetic evidence

There is mounting evidence to support a genetic basis for language acquisi-

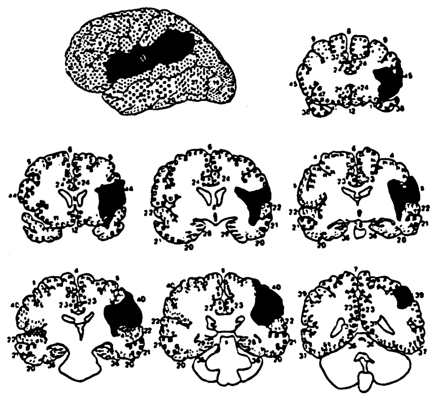

Figure 4. Templates taken from weighted MR images of a 67-year old women with Broca's aphasia, i.e. nonfluent, effortful speech, severe word-finding difficulty, and paraphasic (both semantic and phonemic) word substitutions. Comprehension of grammatically complex sentences was severely defective. The black areas show the site of the lesion. Each diagram represents a brain 'slice'. (Damasio and Damasio 1989. p 53)

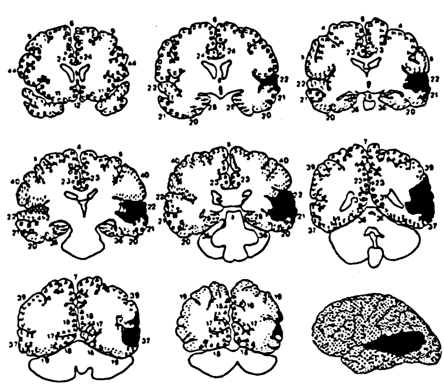

Figure 5. Templates taken from MRI's of a 63 year old woman with Wernicke's aphasia. Her speech was marred by neologisms, but was grammatical and well articulated. Comprehension of words and sentences was severely defective. (Damasio and Damasio 1989. p 107)

tion and a structured and differentiated brain. The new evidence extends the historical findings that localized brain damage effects different cognitive functions selectively, for example, language versus non-language.

In a recent article, Gopnik and Crago (1991) reported on a study of a family in which, of 30 members across three generations, 16 suffered from the inability to acquire syntactic rules. Otherwise, the 16 were normal as were the unaffected family members. She suggests that this reflects a genetic based syntactic ability, which some linguists would refer to as Universal Grammar.

Whether one looks at the selective impairment or preservation of language abilities in child development or in the mature brain one can find little to support the view of language as derivative of some general intellectual capacity.

A. **Evidence from Childhood hemiplegics and hemidecorticates**

Children who have suffered prenatal, perinatal, or childhood left hemisphere lesions provide evidence that the brain is differentiated in regard to language and non-language abilities. Children with acquired unilateral lesions of the brain, and who retain both hemispheres (one normal and one diseased) -- called hemiplegic -- were studied by Dennis and Whitaker (1976). The children with left damaged hemispheres showed deficiency in language acquisition and performance, with the greatest impairments in their syntactic ability.

In studies of hemidecorticate children, those with left hemispheres removed either within the first year of life or later in childhood, Dennis and her colleagues (1980a,b) found that the IQ. and cognitive skills were equivalent in both left and right hemidecorticates, but in visual-spatial function, the left-hemidecorticates outperform the right, and in language, the right-hemidecorticates outstrip the left. In addition, both hemispheres appear to be equivalent in the ability to acquire the use of the sense and referential structure of common words, but the right hemisphere again shows syntactic deficits.

B. **Asymmetry of abilities**

The psychological literature documents numerous cases of intellectually handicapped individuals, traditionally, known as 'idiot savants' (but more recently simply called 'savants') who, despite their disabilities in certain spheres show remarkable talents in others. The classic cases include individuals who, without the required ability to take care of themselves, are superb musicians, or artists, or draftsmen. Some of the most famous savants are human calculators who can perform complex arithmetic processes at phenomenal speed.

Until recently, most of the savants have been reported to be linguistically handicapped. While such cases strongly argue for domain specific abilities and suggest that certain talents do not require general intelligence, they do not decisively respond to the suggestion that language is one ability that is derivative of general cognitive abilities, if such individuals show little linguistic knowledge.

A more telling case can be made if there are individuals who have acquired the highly complex system which we call grammar, without parallel abilities of equal complexity. There are now a number of such studies of children who have few cognitive skills and virtually no ability to utilize language in sustained meaningful communication and yet have extensive mastery of linguistic structure. Yamada (1990) reports on one severely retarded young woman, named Laura with a non-verbal IQ of 41-44, lacking almost all number concepts including basic counting principles, drawing at a preschool level, and processing an auditory memory span limited to three units, who at the age of 16 produced syntactically complex sentences like 'She does paintings, this really good friend of the kids who I went to school with last year and really loved.'

Although Laura produces sentences with multiple embeddings, can conjoin verb phrases, produce passives, inflect verbs for number and person to agree with the grammatical subject, and forms past tenses when the time adverbial structurally refers to a previous time, she can not add 2 + 2, read nor write nor tell time. She does not know who the president of the US is or what country she lives in and does not know her own age. Her drawing of humans resemble potatoes with stick arms and legs. Yet, in a sentence imitation task she both detected and corrected surface syntactic and morphological errors, but is unable to tie her shoes.

Laura is but one of many examples of children who display well-developed phonological, morphological and syntactic linguistic abilities, seemingly less developed lexical, semantic, or referential aspects of language, and deficits in non-linguistic cognitive development. A number of such cases, studied at UCLA by Curtiss (1982) and others, have been reported in the literature.

Any notion that linguistic ability results simply from communicative abilities or develops to serve communication functions is also negated by studies of Blank, Gessner, and Esposito (1979) which concern a child with fully developed structural linguistic knowledge but with almost a total absence of communicative skills and by Cromer who showed a dissociation between pragmatic and syntactic abilities. Similar cases of schizophrenic and autistic children are also reported. It thus seems clear that the ability to communicate in a social setting depends on different cognitive skills than the acquisition of language.

Interesting studies of genetic disorders such as Turners syndrome and Williams syndrome also reveal domain specificity. Five out of six children with Turner's syndrome (a chromosomal anomaly) studied by Curtiss and Yamada (1981) and Curtiss and Kempler (1982) revealed normal or advanced language simultaneous with serious non- linguistic cognitive deficits. Similarly, the studies by Bellugi and her colleagues (1988) of the language development in Williams syndrome children reveal a unique, behavioral profile in which there appears to be a selective preservation of linguistic functions in the face of severe general cognitive deficits.

A similar and perhaps even more dramatic case is being studied by Smith and Tsimpli (1991) of a 29 year old man, named Christopher, investigated first by O'Connor and Hermelin. Christopher has a non-verbal IQ between 60 and 70 and is institutionalized because he is unable to take care of himself. As Smith and Tsimpli report, he finds the tasks of buttoning a shirt, cutting his finger-nails or vacuuming the carpet too difficult. Yet when given written texts in some 15 or 16 languages he translates them immediately into English. The languages include Germanic languages like Danish, Dutch, and German, Romance languages like French, Italian, Portuguese, Spanish, as well as Polish, Finnish, Greek, Hindi, Turkish, and Welsh.

Christopher's conversation is quite laconic, repetitive and 'full of snatches that appear to have been memorized from textbooks'. Smith and Tsimpli therefore conducted controlled experiments to test his command of English syntax and pragmatics and syntax of other languages.

Smith and Tsimpli point out that while it is still too early to draw complete conclusions about Christopher's remarkable ability, 'it is clear that his talent for learning languages is remarkable, ... and that, despite his handicap, his command of English is essentially normal'. His knowledge of other languages varies from very good to 'so-so'.

Smith and Tsimpli also conclude that 'Christopher's linguistic ability (is) independent of his general cognition and could operate in the absence of "central" control', supporting the notion of encapsulation of the language module.

Such cases argue against the view that linguistic ability derives from more general cognitive 'intelligence', since in these cases language develops against a background of deficits in general, non-linguistic intellectual abilities.

C. **Sign language studies.**

Perhaps the most telling findings on the brain/ language relationship which supports the conception of the brain and mind as consisting of neurological and cognitive interactive but autonomous modules is revealed by the exciting research on sign language conducted by Bellugi and her colleagues (Bellugi et al. 1988). The linguistic study of sign language over the last 25 years has already revealed that these languages of the deaf have all the crucial properties common to all spoken languages, including highly abstract underlying grammatical and formal principles.

Since the same abstract linguistic principles underlie all human languages -- spoken or signed -- regardless of the motor and perceptual mechanisms which are used in their expression, it is not surprising that deaf patients show aphasia for sign language similar to the language breakdown in hearing aphasics following damage to the left hemisphere. Furthermore, while these patients show marked sign language deficits, they can correctly process non-language visual-spatial relationships. The left cerebral hemisphere is thus not dominant for speech, as had been suggested, but for language, the cognitive system underlying both speech and sign. Hearing and speech are not necessary for the development of left hemispheric specialization for language.

This has been a crucial point in determining that the left hemisphere specialization in language acquisition is not due to its capacity for fine auditory analysis, but for language analysis per se. As long as linguists concerned themselves only with spoken languages, there was no way to separate what is essential to the linguistic cognitive system from the constraints imposed, productively and perceptually, by the auditory- vocal modality, that is, to discover what the genetically, biologically determined linguistic ability of the human brain is.

D. **Agnosia and Prosopagnosia**

Further evidence for the separation of cognitive modules is provided by the neurological and behavioral findings that auditory agnosia (inability to recognize sounds), color agnosia, prosopagnosia (loss of the ability to recognize familiar faces) can all be distinguished from visual object agnosia. (Damasio et al 1988; Warrington and Shallice 1984) Even within a specific agnosia we find evidence of distinct category loss. One agnosia patient at the Radcliffe Infirmary in Oxford, shows particular difficulty in recognizing animals and less difficulty with non-animate objects.

At the University of Iowa, the Drs. Damasio and their colleagues have found that 'together with data from patients with surgical ablations, or selective neuronal loss due to Alzheimer's or Pick's diseases, the retrieval of items from a previously learned lexicon depends on the integrity of neural systems located in left temporal cortices, namely in the inferotemporal region and in the polar temporal region. One component of this system, i.e. area 38, appears to be especially dedicated to the retrieval of proper nouns, as opposed to common nouns. These systems do not appear necessary for phonemic and syntactic levels of language operation'. They state (Damasio & Damasio 1989) that 'Patients possess the generic information about a given animal or object. They are aware of its visual and functional properties. But they cannot access the unique name label.' Were they linguists, they would say they can not access the lexical entry.

Further support for the dissociation of linguistic and conceptual knowledge is provided by a patient of the Damasios, named Boswell. When given the name of a well known city, e.g. Denver, and asked to say what state it is in he replies 'Denver Colorado'. If he is asked to name a city in Colorado, however, he is unable to do so. Nor is he able to give any information about Denver, or Los Angeles (which he will say is 'Los Angeles, California') without being able to give the name of a city in California. He responds similarly when asked what football team plays in Los Angeles -- saying 'Los Angeles Rams' -- but if asked in what city the Rams play he cannot tell you.

[Denver, Colorado] appears to be a single lexical item, with a semantic representation something like {city, state}. Boswell can access the item or the entry [Colorado], which is also in his lexicon, but the pathway between the lexical representations of these items and conceptual knowledge about their references seems to be blocked if not destroyed.

Boswell also suffers from prosopagnosia, the inability to recognize familiar faces. There are cases where patients who do not seem to have trouble with naming other visual stimuli suffer from this problem. Yet, again through meticulously controlled experimentation the Damasio group have shown that prosopagnosia patients have the same differential physiological skin responses to familiar and unfamiliar faces as do normals. In other words, these patients suffer from an accessing rather than a representation loss. Some prosopagnosia patients can't quite get to the name but make interesting substitutions. One patient recognized a picture of Judy Garland as Liza Minelli, referred to a picture of Ronald Reagan as 'John Wayne' and when shown a picture of Kruschev said on the first day of testing 'I don't know but I think it's a Russian' and on the second day of testing responded 'Lenin', Vladimir that is, not John.

V. Conclusions

There is more evidence. One additional example of the separation of language from non-linguistic abilities will have to suffice for this paper. Campbell conducted lip reading studies in which she found that the ability to process faces for verbal information can be maintained despite inability to process faces for emotional or gestural interpretation. The same perceptual processes are used for the two tasks and therefore the difficulty cannot be due to non-linguistic factors. It is language processing that is independent of other cognitive processing.

The more we look, whether at studies of neonates or development or lesions, the more we find that knowledge and processing of language is separate from the ability to acquire and process other kinds of knowledge, that the asymmetry between general knowledge and linguistic knowledge shows language to be independent of general intellectual ability, and that language itself, as well as other cognitive systems, is distinct both anatomically and functionally.

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[1] Sections of this paper were previously discussed in Fromkin 1990 and 1991

[2] The picture of the phrenology head and the idea of it being used as 'proof' for a language module was provided by Lila Gleitman.

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