Of marks and meaning : a palaeographic, semiotic-cognitive, and comparative analysis of the identity marks from Deir el-Medina.

Moezel, K.V.J. van der

Author: Moezel, K.V.J. van der
Title: Of marks and meaning : a palaeographic, semiotic-cognitive, and comparative analysis of the identity marks from Deir el-Medina
Issue Date: 2016-09-07

3

THE ROLE OF THE COGNITIVE SCIENCES

The previous chapter discussed how semiotic theories and models can be useful in analyzing the structure of signs and in mapping the generation of meanings. However, the semiotic approach covers only part of the search for meaning. Since the end of the 19th century it had studied signs as the products of communicative behavior, but it had not related the creation and generation of meaning to its actual origin in the human brain: it is there, where all forms of human communication and expression are produced, processed and interpreted. The patterns, structures and rules that communication systems manifest are 'grounded, indeed, embodied in the brain'.[1] Therefore, anyone who wishes to analyze any system of human communication must take into account the functional organization of the brain. In this chapter we want to investigate whether the cognitive sciences can offer support to the previous semiotic account especially in regard of two questions:

1. Can we find support for the metaphoric and metonymic processes of semiosis as cognitive patterns of thought and conceptualization in the human brain?;
2. How do cognitive models explain and visualize processes of thought, and (how) can they be helpful in explaining and visualizing the semiosis of the identity marks?

To answer these questions we will first briefly familiarize ourselves with the nature and focus of the 'cognitive sciences' (section 1). Thereafter, we look into the organization of communication in the human brain (section 2). Finally, we look at connectionism and activation theory, which are currently popular theories in the cognitive sciences that offer models to analyze and visualize the processing of information in the brain (section 3).

1 COGNITIVE SCIENCES IN A NUTSHELL

'Cognitive sciences' is a collective term by which is meant a relatively recently developed multidisciplinary approach to the study of the human mind and brain.[2] Its beginnings can be traced back to the mid-20th century when psychology and linguistics were both redefining themselves, resulting in their combination into psycholinguistics: the study of language processing in the human mind. This development was much due to the work of the linguist Chomsky. Before the 1960s the dominant trend in psychology had been behaviorism, which concerned itself with the observable natural behavior of humans and other animals, but neglected mental events. Behaviorists argued that events taking place in the mind are unobservable and that the only objective evidence for the study of psychology is therefore behavior. Human communication was examined as natural behavior just like any other sort, without

[1] Obler & Gjerlow, *Language and the Brain*, xv.
[2] The difference between 'mind' and 'brain' will become clear below, but generally comprises a psychological approach (mind) and a neurological approach (brain).

consideration of mental processes.[3] The behavioral approach to psychology reached its acme in the publication of the book *Verbal Behavior* (1957) by the psychologist Skinner. The downfall of behaviorism was brought about by Chomsky's devastating review of it in 1959.[4] Chomsky argued that defining psychology as the science of behavior was like defining physics as the science of meter reading. If scientific psychology were to succeed, mentalistic concepts would have to be integrated to explain the behavioral data.[5] It is impossible to distinguish behavior from mental events since the latter cause and stimulate behavior; behavior must be observed, but analyzed as a result of mental events. Chomsky described a new type of linguistic theory called transformational grammar that provided both an account of the underlying structure of language and of people's knowledge and consciousness of their linguistic behavior. His theory explained the cognitive processes that were responsible for the structural aspects of human language. The idea that grammatical rules which govern phrases and sentences are not behavior but mentalistic hypotheses about the cognitive processes responsible for the verbal behavior we observe was received and tested enthusiastically among psychologists throughout the 1960s and the 1970s: psycholinguistics was born.

The cooperation of psychology and linguistics and their new mental approach inspired developments in other disciplines, such as artificial intelligence studies, which viewed the human mind as a computer and used computer modeling to understand language performance and stimulate mental processes. Neuroscience developed to seek a way to bridge the gap between 'brain' in a biological and neurological sense and 'mind' in a psychological sense. In anthropology scholars began to focus on differences and commonalities in the way people of different cultures perceive the world. They studied how thought works in different cultural settings.[6] The study of cultural differences in metaphor and metonymy as rhetoric tropes through which the world can be expressed is the result of combined cognitive psycholinguistic and anthropological research.[7] In philosophy the necessity was felt to deal with questions such as the relation of mind and body and how people think and behave, or should think and behave.[8] In the late 1970s, six disciplines had included a study of mental processes and each had progressed far enough to recognize that the solution to some of its problems depended on collaboration with the other disciplines. The six disciplines were combined in the hexagon of cognitive sciences, usually presented as in fig. II3-1. The disciplines are linked in that they all contribute theories, methodologies and research tools such as models to study 'the representational and computational capacities of the human mind and their structural and functional realization in the human brain'.[9]

---

[3] Skinner argued that the standard methods and techniques to study the verbal behavior of animals were 'surprisingly free of species restrictions' and could be 'extended to human behavior without serious modification'. Skinner, *Verbal Behavior*, 3. See also Miller, 'The cognitive revolution: a historical perspective' in *TRENDS in Cognitive Sciences* 7 (3) (2003), 141; Harley, *The Psychology of Language*, 10.

[4] Chomsky, 'A Review of B.F. Skinner's Verbal Behavior' in *Language* 35.1 (1959), 26-58.

[5] Miller, 'The cognitive revolution: a historical perspective' in *TRENDS in Cognitive Sciences* 7 (3) (2003), 142.

[6] Thagard, 'Cognitive Science' in *Standford Encyclopedia of Philosophy* (2014) (http://plato.stanford.edu/entries/cognitive-science/).

[7] See, for instance, the study on metaphor and metonymy by Lakoff & Johnson, *Metaphors We Live By* (2003), referred to already in the previous chapter.

[8] *Ibid*..

[9] Miller, 'The cognitive revolution: a historical perspective' in *TRENDS in Cognitive Sciences* 7 (3) (2003), 143-144.

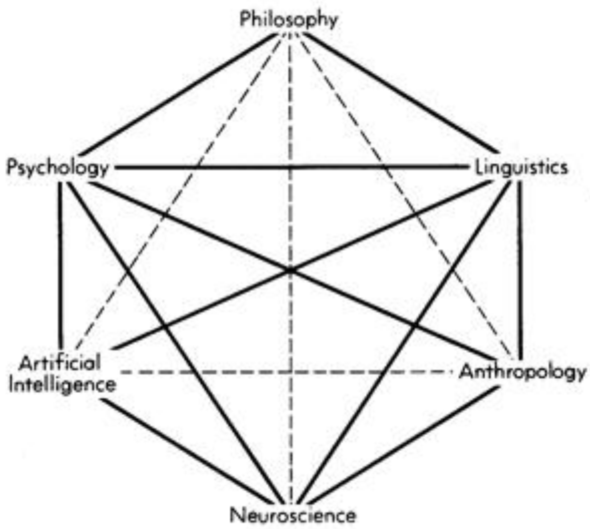


Fig. II3-1 The hexagon of cognitive sciences. Gardner, *The Mind's New Science*, 37.

Semiotics is not universally considered a separate discipline and as such has no position in the hexagon. However, it is indirectly included in the collective of cognitive sciences. The previous chapter showed its close ties with linguistics, but also brought semiotics in connection to psychological and anthropological questions concerning culturally determined patterns of thought.[10] In this chapter we focus more on neuroscience and artificial intelligence in order to link the semiotic processes of meaning-making to the human brain and to represent them in a neurological model. We begin the next section with a neuroscientific account of the organization of communication in the human brain. Neuroscience comprises study of the nature and organization of the brain and nervous system, and of how brain and behavior are related. Neuroscientists who work with human subjects use various techniques such as magnetic and positron scanning to observe what is happening in different parts of the brain while people are doing various mental tasks. As a result, they have been able to identify regions of the brain that are involved in the mental processing and interpretation of visual, auditory and other forms of input.[11] In close cooperation with psycholinguistics neuroscience is referred to as neurolinguistics. As such, it has especially focused on the localization of brain regions involved in linguistic information processing in healthy individuals as well as in patients who have suffered brain damage and therewith loss of cognitive abilities.[12] The focus on linguistic information processing has, however, been biased, both in psycholinguistics and in neurolinguistics: with respect to spoken language it has concentrated on subjects who speak at least one modern Western language (primarily English, German, French or Dutch), and with respect to written language it has concentrated on subjects who are able to read and write the modern Western alphabet.[13] Other languages and scripts are underrepresented; other systems of communication even more so. Thus, questions on how the human brain processes

[10] In particular sections 1.c-d and section 3.

[11] Thagard, 'Cognitive Science' in *Standford Encyclopedia of Philosophy* (2014) (http://plato.stanford.edu/entries/cognitive-science/). See also section 2 below.

[12] Obler & Gjerlow, *Language and the Brain*, 1-2; Harley, *The Psychology of Language*, 14; Wolters & Groenewegen, *Neurologie*, especially chapter 34 on the higher cerebral functions and dysfunctions.

[13] Harley, *The Psychology of Language*, 14. Most information provided by Harley is based on studies done on monolingual English-speaking subjects, with contributions particularly of studies on Dutch-speaking subjects (e.g. by the psycholinguist Levelt). Earlier psycholinguistic and neuroscientific studies were carried out on French and German speaking subjects (e.g. by the physician and anatomist Broca and by the neurologist Wernicke).

information from drawings, paintings, photographs, pictograms or other marking systems, and how it interprets these data as meaningful, have not been given full attention. Consequently, models on human communicative behavior have focused on modern Western linguistic behavior as well, for instance on the lexical, semantic, syntactic and phonological processes of speech production or word recognition. Figs. II3-2 and 3 provide two examples that are well-known in psycholinguistics. Yet, these models make use of an approach that is derived from artificial intelligence and which has the potential to be more generally applicable: it is called connectionism or activation theory and it models mental or behavioral phenomena as processes of interconnected networks of nodes (processing units). We will argue that it can be used to visually explain the processes of semiosis that underlie the identity marks.

Whereas semiotics has lacked in connecting the generation of meaning to the organization of the brain as the origin of all human communication, the cognitive sciences have stayed behind in including a more universal perspective as regards the various natures of *communicative* instead of merely verbal signs by which humans express themselves. It is our goal to find out to what extent the semiotic account from the previous chapter is reconcilable with neuroscientific accounts on the organization of brain functions involved in communicative behavior and to what extent we can accommodate the processes of semiosis in a connectionist modeling of the communicative brain.

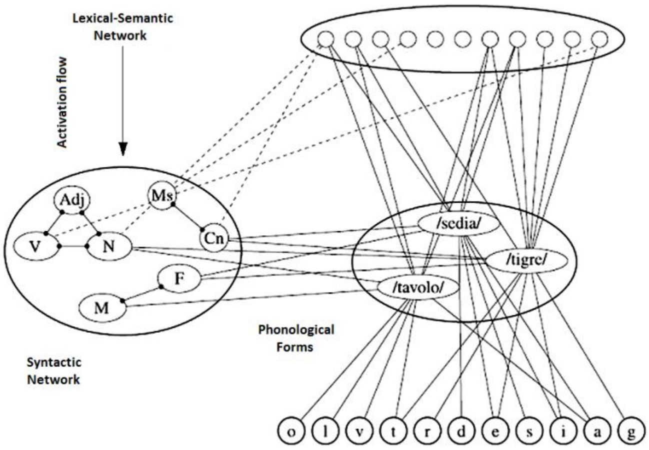


Fig. II3-2 Model of lexicalization by the psycholinguist Caramazza. The flow of information is from semantic to lexeme and syntactic networks. N = Noun; V = Verb; Adj = Adjective; M = Masculine; F = Feminne; Cn = Count noun; Ms = Mass noun. Dotted lines indicate weak activation. Harley, *The Psychology of Language*, 419 (fig. 13.5).

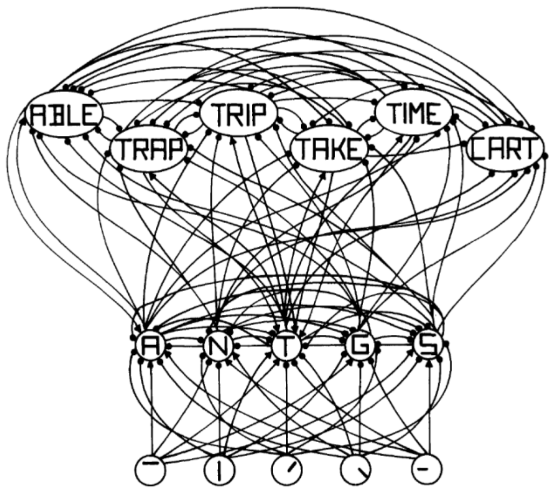


Fig. II3-3 Interactive activation network of letter recognition. It shows how letters are recognized and identified on the basis of visual input features as well as in the context of words. McClelland & Rumelhart in *Psychological Review* 88.5 (1981), p. 380 (fig. 3).

2 THE ORGANIZATION OF COMMUNICATION IN THE HUMAN BRAIN

a. The structure of the brain

Before anything can be said on the operation of communicative functions in the brain it is necessary to identify those parts of the brain that have important roles in complex cognitive processes, in particular communication. Therefore, we begin this section with a basic account on the brain's neuroanatomy.[14]

The human brain, together with the spinal cord, forms the central nervous system. It controls the muscular activity in the human body as well as our conscious thought. The anatomical and functional organization of the brain is extremely difficult to grasp because of the complicated clustering of nuclei (collections of neuron and glial cell bodies, which form the functional units of the nervous system) and the intricate pathways of their axons (long processes extending from the neuron cell bodies to form connections with other neuron cells in the brain).[15] Details of the organization and operation of the brain are therefore not entirely clear; despite anatomical studies and neurological experiments since the 1800s and improvement of scanning and imaging techniques especially in the second half of the 20th century the exact processes of the brain's mediation between thought and expression is still not completely understood, and we have yet to learn how individual cells behave and contribute in the processes of communication.[16]

We are, however, not completely lost. The human brain can be described according to different anatomical and/or functional areas, or according to its phylogenetic development.[17] We will here present a simple functional-anatomic picture of the brain consisting of the cerebellum or the small brains, which serve to coordinate and refine movement; and of the cerebrum, home to the large brains, which form the functional-anatomic basis for our conscious experience of sensory perceptions, including vision and hearing, as well as for the planning and execution of complex motor actions (fig. II3-4).

[14] Two notes must be made. First, I am aware that the following account lacks many details about the neurological organization and operation of the human brain. It is by far not a detailed neurological account, which I cannot provide as I have no scientific background in this field. I have only introduced myself to the cognitive sciences taking classes on Psycholinguistics and Language and Cognition (prof. dr. N. Schiller, Leiden University) and familiarizing myself with relevant scientific literature from these classes, complemented with literature on neurology kindly provided by dr. A.M. van Sijl (Diakonessehuis Utrecht). From these classes and from the literature I extracted those basic, primary structures and operations relevant to the processing of communication. Finer differentiation of cortical and subcortical structures, details about brain architecture (cellular distribution) and the transmission of neural impulses related to complex cognitive processes must be sought in expert literature.

Second, one may ask whether it is justified to study the brain and communicative behavior of modern man and compare it with the communicative behavior of the ancient Egyptians, living approximately 3500 years ago. Yet, 3500 years is only a small time frame compared to the 35.000 years in which man has not changed morphologically. Structures that are concerned with the processing of communication are present in the brain since at least some two million years. Anatomically, the brain of an ancient Egyptian man is therefore comparable to the brain of modern man. Of course, there will have been functional differences, due among others to culture, experience and level of knowledge, but since we can no longer subdue ancient Egyptians to psycho- and neurolinguistic tests, study of the modern brain is the closest we can get to an interpretation of their neuro-communicative behavior. Kolb & Whishaw, *Fundamentals of Human Neuropsychology*, chapter 4; Harley, *The Psychology of Language*, 51-54.

[15] Kolb & Whishaw, *Fundamentals*, 4-5, 8-9; Wolters & Groenewegen, *Neurologie*, 5-8.

[16] Obler & Gjerlov, *Language and the Brain*, 8, 13.

[17] The latter concerns a description according to evolutionary development; see Kolb & Whishaw, *Fundamentals*, 8-10.

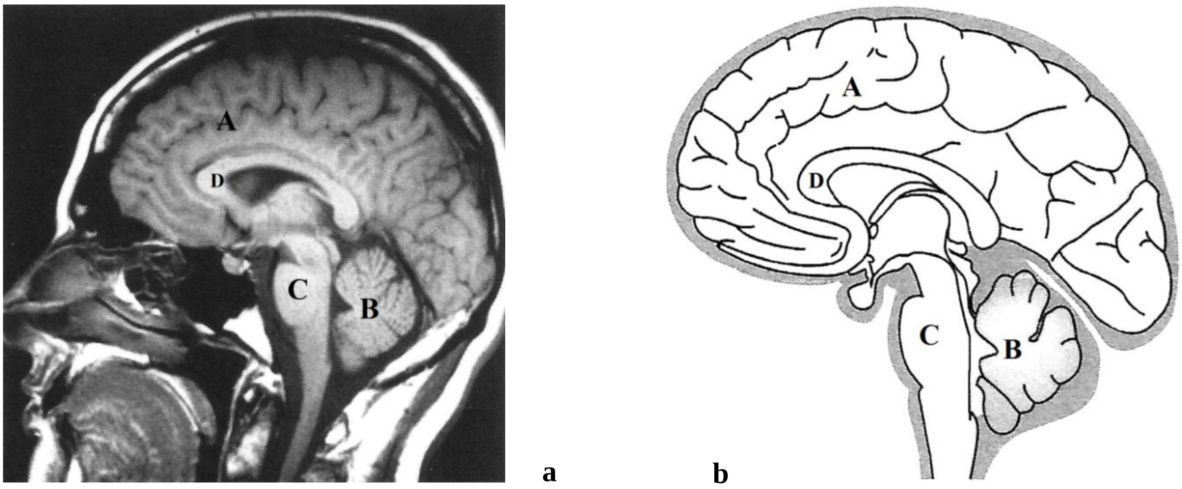


Fig. II3-4 MRI-scan of the human brain (**a**) and drawing (**b**) indicating A: cerebrum, B: cerebellum, C: brain stem, and D: corpus callosum. Wolters & Groenewegen, *Neurologie*, 33, 43.

Since higher cognitive functions including the processing of communication are accommodated in the cerebrum, it is this part of the brain that concerns us further. The cerebrum consists of the neocortex, or (cerebral) cortex, as its largest and dominant area, and of several subcortical areas including the thalamus, basal ganglia and the limbic system.[18] Brain functions that concern communication cannot be directly explained by looking at the functional-anatomic organization of the cerebrum; yet, the structure of this region and the connections between the neocortex with subcortical areas at least provides insight into cognitive function and dysfunction. The cerebrum is divided into a right and left hemisphere by a medial longitudinal fissure (fig. II3-5). These hemispheres are symmetrical to a large extent.[19] Each is subsequently divided into four main areas called lobes: the frontal, parietal, occipital and temporal lobe (fig. II3-6).[20] The lobes are not functional, but anatomical regions. Nevertheless, there are functional differences between them, and their designations are often used in a loose and descriptive way to indicate different functional regions.[21]

---

[18] Kolb & Whishaw, *Fundamentals*, 11 (Table 1-2), 16-26; Wolters & Groenewegen, *Neurologie*, 415-427.

[19] That is, there are functional differences, for which see below (section 2.b). Anatomically the hemispheres are symmetrical to a large extent, although there are differences. For instance, the area lying deep in the posterior part of the superior temporal lobe, the ‘planum temporale’, is larger in the left hemisphere for 65% of the human population, while it is larger in the right hemisphere for 10% of the population. In 25% there is symmetry. Because of the fact that this area is often larger in the left hemisphere Obler & Gjerlov consider it important for language, a brain function for which the left hemisphere is dominant in 90-95% of the population; see *Language and the Brain*, 25 and section 2.b below. Wolters & Groenewegen, however, argue that a connection between this feature of anatomical dissimilarity and the function of language is unclear; *Neurologie*, 416, 427.

[20] Deep within a large sulcus that separates the frontal, parietal and temporal lobes (the sulcus lateralis) lies the insular cortex, which is sometimes considered to be a fifth lobe in the cerebrum. Wolters & Groenewegen, *Neurologie*, 415-6. The lobes are separated from each other by convolutions in the form of hills (gyri) or valleys (sulci). Obler & Gjerlov, *Language and the Brain*, 18.

[21] Kolb & Whishaw, *Fundamentals*, 17.

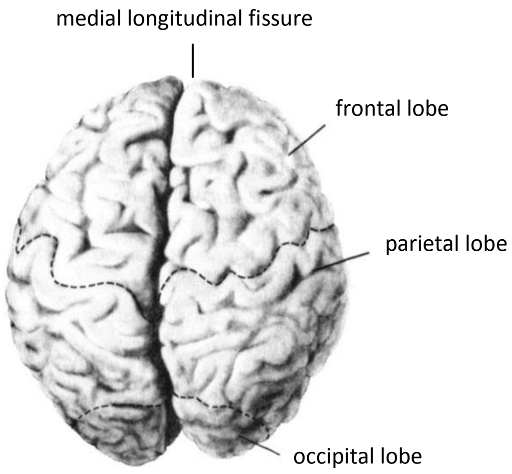


Fig. II3-5 Dorsal view of the brain showing the medial longitudinal fissure. Adapted from Kolb & Whishaw, *Fundamentals*, 18.

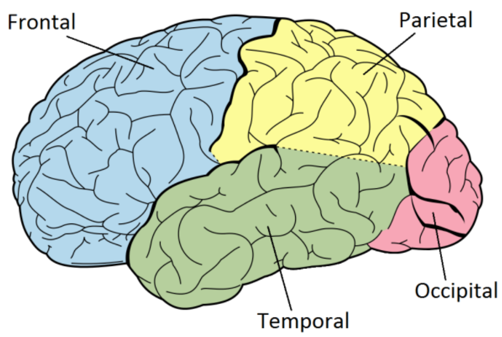


Fig. II3-6 Lateral view of the brain showing the lobes in one hemisphere (here left). Adapted from Gray, *Anatomy of the Human Body*, 728.

The topography of the neocortex and the four lobes can be mapped on the basis of information obtained by the application of various research techniques. Fig. II3-7 shows a projection map based on a tracing of the connections between neuron cells from the sensory systems (vision, audition and the somatosensory system, i.e. touch) and the motor system (movement) to the neocortex and subcortical areas. The dark grey zones in the map are the primary projection areas, which receive input in the case of vision, audition and touch, and send out information in the case of body movements. The map shows that vision primarily projects to the posterior occipital lobe, audition to a superior area in the temporal lobe and touch to the parietal lobe, while movement appears to be processed in the frontal lobe. The zones in light grey and white are secondary respectively tertiary projection areas: adjacent areas that, to lesser extent, are also involved in sensory and motor activities. Certainly, such a map is a much simplified description of the neocortex; it reflects only the main concentrations of activity when we see, hear, feel and move.[22]

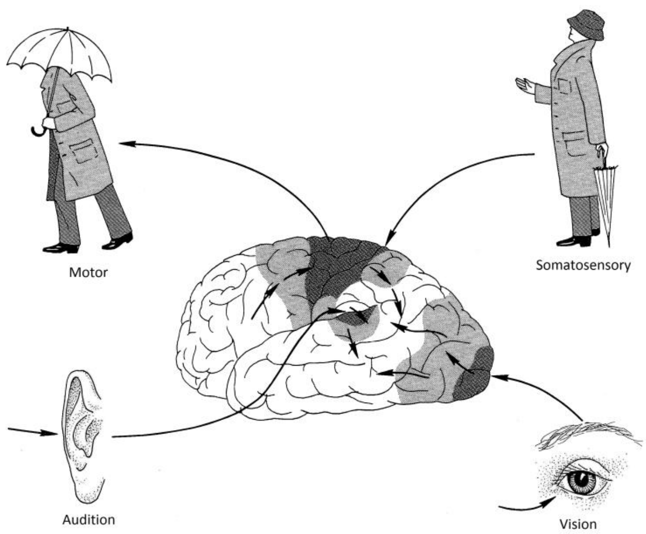
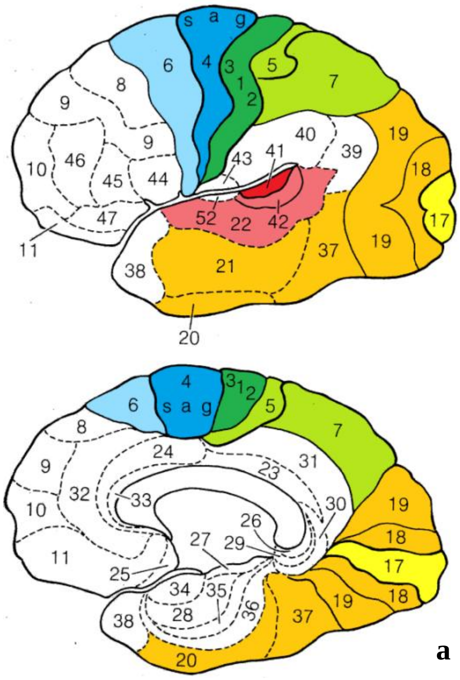


Fig. II3-7 Projection map. The dark areas indicate primary projection zones, which receive input from the sensory systems or project to the motor system. The light grey areas are adjacent secondary projection zones. The white areas are tertiary, or association, projection zones**.** Kolb & Whishaw (1985), 19.

[22] Kolb & Whishaw, *Fundamentals*, 18-19.

A different kind of map, the cytoarchitectonic map, provides more specific information. Cytoarchitectonic maps are based on study of differences in cell distribution and in cell sizes and shapes throughout the cerebrum; in other words, they are based on the different architectonic structures of cells.[23] The most influential cytoarchitectonic map has been Brodmann's map (fig. II3-8a).



a

b

Functional areas and Brodmann cytoarchitectonic areas

Function	Brodmann area
Vision	
primary	17
secondary	18, 19, 20, 21, 37
Auditory	
primary	41
secondary	22, 42
Body senses	
primary	1, 2, 3
secondary	5, 7
Sensory, tertiary	7, 22, 37, 39, 40
Motor	
primary	4
secondary	6
eye movement	8
speech	44
Motor, tertiary	9, 10, 11, 45, 46, 47

Fig. II3-8a Brodmann's anatomically different areas of the cerebrum. The upper picture shows the visible surface of a hemisphere; the lower picture shows the inner part that faces the other hemisphere. Kolb & Whishaw, *Fundamentals*, 21; **b** Table indicating the relations between some of the known areas of brain function and Brodmann's anatomical areas. Adapted from Kolb & Whishaw, *Fundamentals*, 22.

In numbering the areas with cells that differ in structure, the map is solely based on anatomical information. Yet, as it turns out, the relation between anatomical structure and brain function is stunning.[24] Knowledge on the localization of brain function had been based on study of the effects of brain lesions (aphasia) since the 19th century, but in the 20th century more accurate 'human brain imaging'-techniques became possible: EEG, CAT, PET, MRI and particularly fMRI and TMS are techniques that measure and map the brain's activity.[25] The table in fig. II3-8b shows some of the relations between the known locality of *brain functions* and anatomical areas numbered by Brodmann. The primary and secondary areas of brain function are colored in the map. We gain from it a similar, but slightly more accurate picture as from fig. II3-7, with the secondary areas of vision now extending into the temporal lobe (18-21, 37), and specific areas for eye movement and articulated speech localized in the frontal lobe (9 resp. 44).

Certainly, in any act of movement or communication there is not just one lobe or brain area involved. Thus, vision involves not only the processing of visual input in the occipital lobe, but also

[23] Kolb & Whishaw, *Fundamentals*, 8, 20-22.

[24] *Ibid*., 22; Wolters & Groenewegen, *Neurologie*, 418-419.

[25] For these techniques, see Harley, *The Psychology of Language*, 16-19; Wolters & Groenewegen, *Neurology*, 424-425; Obler & Gjerlov, *Language and the Brain*, 9-10.

movement of the eyes regulated in the frontal lobe. The topographical maps simply show that, anatomically as well as functionally, input received visually is processed primarily in the occipital lobe; input received auditorily is processed primarily in the temporal lobe; input received via touch is processed primarily in the parietal lobe; and movement is regulated in the frontal lobe.

Communication between the different areas within a lobe, as well as between the lobes and the two hemispheres in general takes place via various connections, or 'pathways', which are bundles of nerve fibers that transport information. There are relatively short connections within a lobe, longer connections between lobes, and interhemispheric connections called commissures.[26] The largest commissure is the corpus callosum, which connects almost all parts of the two hemispheres (the curved area indicated 'D' in fig. II3-4 above).[27] Because of the fact that different brain functions are not only concentrated in different areas within one hemisphere, but the two hemispheres are also, at least in part, specialized in different functions, the commissures are essential for the integration of processes that take place in each hemisphere.[28]

b. Lateralization of brain functions

The functional asymmetry of the right and left hemispheres is called lateralization of brain functions: the two hemispheres are in part specialized for different tasks. For instance, more than 80% of the human population is better skilled with the right rather than the left hand. Because of the fact that the brain is cross wired and each hemisphere responds to, and controls the contralateral side of the body, this means that the motor skills for hand movement are dominant in the left hemisphere.[29] The left hemisphere appears furthermore to be dominant for intellectual, rational, verbal, analytical and time-based processing, while the right hemisphere accommodates especially nonverbal and intuitive processes, for instance musicality, artistry and spatial orientation.[30] The processing of grammar, syntactic structures, and linguistic communication in general appears to take place especially in the left hemisphere with 90-95% of the population.[31] This is apparent from lesion and stimulation studies. Lesion studies are the oldest approach and provided much of the 19th and early 20th century knowledge on the localization of language functions. They examined the effects of brain damage (resulting from head injury, vascular accidents, tumor or brain surgery in circumscribed regions of the brain) on verbal language production and comprehension on the basis of behavioral tests, the results of which were compared to verbal language production and comprehension in normal control subjects.[32] The healthy subjects provided the norm, the patients with brain damage the deviation. On the basis of both norm and deviation, the French physician Bouillard in 1825 was the first to propose an asymmetry of brain functions, suggesting that the left hemisphere had a special role in complex movements such as fencing, writing, and speech. His proposal found a little bit of support from scholars who observed that the left

[26] Kolb & Whishaw, *Fundamentals*, 22-23; Wolters & Groenewegen, *Neurologie*, 422-423.
[27] *Ibid*., 423; Obler & Gjerlov, *Language and the Brain*, 18, 24.
[28] Wolters & Groenewegen, *Neurologie*, 415, 427-428.
[29] *Ibid*., 427. For the cross wired operation of the brain see also Obler & Gjerlov, *Language and the Brain*, 22-25.
[30] Wolters & Groenewegen, *Neurologie*, 427; Harley, *The Psychology of Language*, 68.
[31] Wolters & Groenewegen, *Neurologie*, 427; Obler & Gjerlov, *Language and the Brain*, 28 give a percentage of 97% with left hemispheric dominance for linguistic processing, while in 3% of the population the right hemisphere appears to be dominant; Harley, *The Psychology of Language*, 68.
[32] Kolb & Whishaw, *Fundamentals*, 66-79.

hemisphere appeared to be more crucially linked to language, since damage to the right hemisphere seemed to have very few consequences for the production or comprehension of linguistic communication.[33] More definite proof came in 1836, when both the Scottish physician Abercrombie and the French neurologist Dax published data which demonstrated that disorders of language were consistently associated with lesions of the left hemisphere.[34] Finally, in 1865, the French neurologist Broca provided the decisive anatomical evidence. In his paper he argued that language loss after brain injury was far more common after left-sided injury than after right-sided injury, and he was able to localize one specific area, damage to which resulted in a defect of speech production: Broca's area in front of the primary motor area in the frontal lobe of the left hemisphere (nr. 44 in fig. II3-8a).[35] Ten years later, the German neurologist Wernicke identified another area, also in the left hemisphere, damage to which caused disturbance especially in language comprehension: Wernicke's area in the back of the left temporal lobe (nrs. 41-42, 22 in fig. II3-8a).[36] Various other regions of the brain, all in the left hemisphere, that appeared to be somehow connected to the function of language, were identified in the years thereafter.[37]

The results from the early lesion studies could be supported by stimulation tests that were developed in the second half of the 20th century. In stimulation tests specific parts of the brain are stimulated by chemical or electrical means and the resulting behavior is studied. In a technique called the Wada test, for instance, the anesthetic sodium amytal is injected into the artery leading to one or the other side of the brain. If the drug is delivered to the left side of the brain, a temporary paralysis of verbal language function is experienced. The patient cannot speak at all for several minutes and in the minutes thereafter language sounds aphasic. Of the people who have undergone this test, 95% of those whose left hemisphere is dominant in motor skills have left hemispheric dominance for language processing as well; 70% of those whose right hemisphere is dominant in motor skills appear to have left hemispheric dominance for language processing.[38] This means that in general for the majority of people the left hemisphere is dominant for verbal language production. In another test, tachistoscopic presentation, visual stimuli are briefly presented selectively to one hemisphere or the other in normal individuals with uninjured brains in order to learn about which hemisphere is involved in processing them. When a

---

[33] *Ibid*., 9; Kolb & Whishaw, *Fundamentals*, 513.
[34] *Ibid*.; Obler & Gjerlov, *Language and the Brain*, 28.
[35] *Ibid*.; Kolb & Whishaw, *Fundamentals*, 514.
[36] *Ibid*.; Obler & Gjerlov, *Language and the Brain*, 9.
[37] *Ibid*.; Kolb & Whishaw, *Fundamentals*, 514ff. A remark must be made here: the early lesion studies all followed a localizationist approach. This was criticized by those who rather followed a holist approach. Holists argued that localizationism was a false compartmentalization of language abilities that in fact are supported by larger parts of the brain. They focused on the questions how areas of the brain are interconnected and how any language is dependent on other cognitive abilities such as memory and thinking. The neuropsychiatrist Goldstein, for instance, to whom Jakobson often referred, argued that our ability to think in abstract terms is lost in any sort of brain damage and will necessarily influence language as a result. Holists thought not in terms of individual syndromes linked to specific areas in the brain; rather, they saw aphasia as a single phenomenon with patients only being more or less severely impaired. Indeed, pure localization of speech and language functions has little meaning. The 19th century neurologist Jackson pointed out that 'to locate the damage which destroys speech and to locate speech are two different things' (quoted by Obler & Gjerlov, *Language and the Brain*, 33). But, even if we ignore the exact localizations of brain functions, at least the localizationist approach in the early lesion studies indicated a clear left hemisphere dominance for linguistic communication functions in general. Obler & Gjerlov, *Language and the Brain*, 10.
[38] Obler & Gjerlov, *Language and the Brain*, 29. The authors note that the Wada test is used primarily as a method of determining which hemisphere is dominant for language in patients who must undergo brain surgery. The brains of these patients, frequently epileptics for whom medications have not worked, while not acutely injured, by definition have some neurological problem. They expect the percentages for left hemispheric dominance in language processing to be even higher in neurologically normal populations.

person looks at a random point in space everything to the right of that point is in the right visual field, and everything to the left of that point is in the left visual field. Due to the crossed wiring of the brain, information about the right visual field is sent by the eyes to our left hemisphere, while information about the left visual field is sent by the eyes to our right hemisphere. In normal individuals the hemispheres communicate through the corpus callosum; that is, information is ultimately processed regardless of the visual field in which it is presented. However, the test of tachistoscopic presentation shows that *linguistic stimuli are initially processed more quickly and more accurately when they are presented to the right visual field, that is to the left hemisphere*.[39] A similar test can be carried out with auditory instead of visual stimuli: the dichotic listening technique relies on the fact that the right ear has stronger connections to the left hemisphere than it does to the right, and the left ear has stronger connections to the right hemisphere than it does to the left. It appears to be the case that verbal or numeral stimuli are better processed when heard with the right ear, i.e. in the left hemisphere, while nonverbal sounds and noises are rather processed better with the left ear, i.e. in the right hemisphere.[40] A third example of stimulation tests is cortical stimulation. In this test, specific regions in the neocortex of the brains are stimulated by electric currents, while the patient remains conscious and carries out various tasks such as reading a sentence, naming objects shown in a picture, or listening and responding to a question or message. The results from this test present the same left hemispheric dominance for processing linguistic communication.[41]

While these tests can all be conducted on healthy subjects as well as on brain damaged patients, similar tests developed specifically for split brain patients are particularly interesting. Split brain patients are former heavy epileptic patients of whom the commissures between the two hemispheres have been cut in order for them to live a life free of epilepsy, and whose hemispheres thus no longer communicate. In one test, the split brain patient sits at a table onto which several objects lie, the view of which is blocked by a screen. When the patient holds an object in his left hand, tactile information about the object is conveyed only to the right hemisphere. The patient has a mental image of the form of the object, but is unable to name it. When the patient holds an object in his right hand, information is conveyed to the left hemisphere and the object is readily named.[42] This strongly suggests that tactile visual-spatial information, or mental images, are processed in the right hemisphere, while verbal processing takes place in the left hemisphere.

c. Metaphor and metonymy in terms of the organization of communication in the brain

On the basis of lesion and stimulation studies and with help of neuroimaging techniques such as EEG, CAT and fMRI a more detailed account and visualization of the organization of communication in the brain can now be presented. The areas of Broca and Wernicke in the left hemisphere appear to have central, albeit not exclusive, roles in the reception, comprehension and expression of information. Broca's area is known to have a motor planning function specific for speech and syntactic structure. It is responsible for verbal language production and expression, and together with other areas in both right and left frontal lobes, in the left parietal lobe, in the basal ganglia and the cerebellum it forms a brain

[39] Obler & Gjerlov, *Language and the Brain*, 29-30.
[40] *Ibid*., 30-31.
[41] *Ibid*., 34; Harley, *The Psychology of Language*, 68.
[42] Obler & Gjerlov, *Language and the Brain*, 31-32.

system called the ‘mental grammar’.[43] Wernicke’s area is nowadays known to be responsible for the reception and comprehension of incoming auditory and visual information. It makes sense out of auditory and visual stimuli and cooperates with the primary auditory and visual areas to interpret them as meaningful sounds or patterns.[44] Wernicke’s area is part of the brain system called the ‘mental dictionary’ or ‘lexicon’, based mainly in the temporal lobe, where representations of all known words, objects, beings, and so forth are stored.[45] Basically, the distinction between the brain systems of which Broca’s and Wernicke’s areas are part is one between conceiving input (mental dictionary) and producing and articulating output (mental grammar); a distinction that is also explained in terms of a declarative function of Wernicke’s area as against a procedural function of Broca’s area.[46]

Fig. II3-9 shows the activation of Broca’s and Wernicke’s areas in the left hemisphere when we hear, see, speak or think.

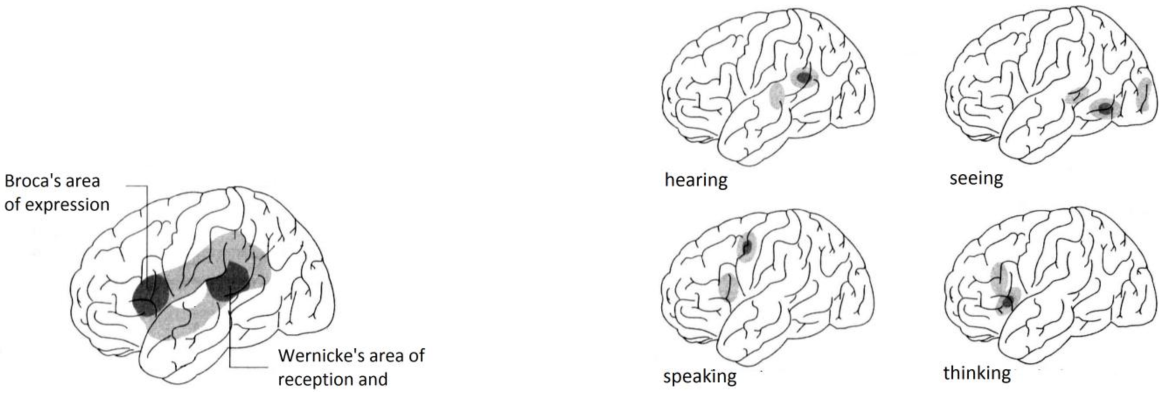


Fig. II3-9 The activation of Broca’s and Wernicke’s areas when we hear, see, speak or think. Adapted from Wolters & Groenewegen, *Neurologie*, 454.

Fig. II3-10, then, shows what happens when we receive auditory or visual input and translate it into verbal expression.

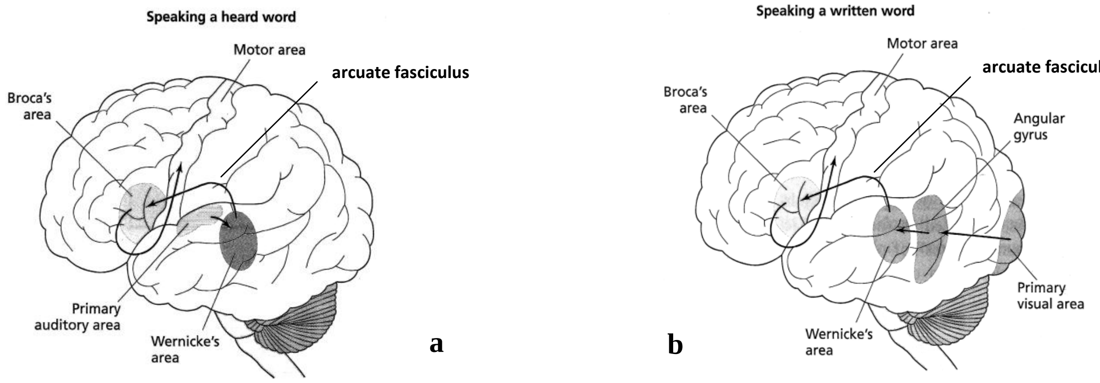


Fig. II3-10 The Wernicke-Geschwind model that shows the sequence of events when a word is presented in auditorily (**a**) or visual form (**b**) to someone who repeats or responds to it in spoken form. Harley, *The Psychology of Language*, 70.

---

[43] Ullman, referred to in Harley, *The Psychology of Language*, 71.
[44] What is interpreted as meaningful is based on culture, experience and education.
[45] The memory system is also involved. Harley, *The Psychology of Language*, 71. When the identity marks of abstract linear form appear merely geometric to us, the Egyptians may have stored a representation of an object or being for it; they were then able to translate the form into that object or being. As outsiders to their culture, we do not have the same mental dictionary.
[46] Ullman, referred to in Harley, *The Psychology of Language*, 71.

The model of fig. II3-10 is based on an idea put forward already by Wernicke at the end of the 19th century, and elaborated upon by the neurologist Geschwind in 1972. Wernicke had argued that the 'sound images' of words, objects and beings are stored in the mental dictionary of Wernicke's area.[47] The model shows that, when we plan to speak, information from the mental dictionary is sent along a pathway of fibres called the *arcuate fasciculus* to Broca's area, where the sound images are translated into the movements needed for controlled speech and articulation. Thus, when we receive auditorily input (fig. II3-10 a), this information is transmitted from the primary auditory area to Wernicke's area; if we then plan to respond to it verbally, the information flows to Broca's area where articulatory information is activated and passed on the primary motor area responsible for speech. When we receive visual input (fig. II3-10b), this information is transmitted from the primary visual area, via an area called the *angular gyrus*, to Wernicke's area; if we then plan to respond, the information flows further to Broca's area where again the necessary motor functions are activated. The exact function of the angular gyrus is not well understood, but it at least appears to play a central role in mediating between visual and auditory language.[48]

The Wernicke-Geschwind model is a much simplified presentation of how language-processes are organized in the brain. Although more recent theories essentially still follow it, they do present a more complicated picture, involving other brain regions throughout both left and right hemispheres that are believed to contribute in one way or another to the processing of communication. Thus, stimulation tests demonstrate that the inability to use synonyms and antonyms on the basis of relations of (dis)similarity results from stimulation of areas throughout the anterior and posterior regions of the brain.[49] In particular, the whole of the superior temporal gyrus, of which Wernicke's area is just one part, seems to be important; in the left, and to lesser extent in the right hemisphere.[50] The right hemisphere is also active in visual word recognition[51] and the spatial organization of incoming or outgoing messages, both of verbal and of nonverbal nature. Subcortical areas as well play a significant, although poorly understood role (fig. II3-11). Especially specific areas of the thalamus and the hypothalamus, as well as the temporal isthmus are implicated in the processing of communication.[52] Furthermore, tests show that the right cerebellum, the small brains, also become active when we process the meaning of words.[53] Finally, the connections and pathways between all these areas are implicated as well.[54] All these regions were neither considered in the Wernicke-Geschwind model, nor by Jakobson, who linked the patterns of metaphor and metonymy to the areas of Broca and Wernicke.

[47] Harley, *The Psychology of Language*, 69. As we know, De Saussure later used the same term in his semiological description of the psychological signifier.
[48] Harley, *The Psychology of Language*, 69.
[49] Kolb & Whishaw, *Fundamentals*, 515-516. Specific zones include the sensory and motor facial areas and the supplementary motor area, stimulation of which interferes with the muscles necessary for language production.
[50] Harley referring to a study by Hickok & Poppel (2004) in *The Psychology of Language*, 70-71
[51] Harley, *The Psychology of Language*, 69.
[52] Harley, *The Psychology of Language*, 69; Kolb & Whishaw, *Fundamentals*, 517-518, 527; Obler & Gjerlov, *Language and the Brain*, 21.
[53] Harley, *The Psychology of Language*, 70.
[54] Kolb & Whishaw, *Fundamentals*, 22-23.

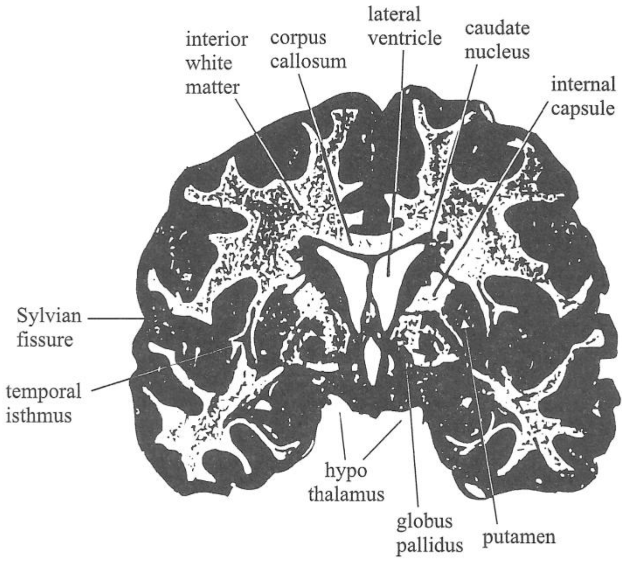


Fig. II3-11 Subcortical areas that also play a significant role in the processing of communication. Obler & Gjerlov, *Language and the Brain*, 21.

In section 1.d of the previous chapter we saw that Jakobson had linked a contiguity disorder and the production of metaphoric speech to Broca's area, and a similarity disorder and the production of metonymic speech to Wernicke's area. Indeed, patients with damage to Broca's area present non-fluent speech characterized by a failure to sequence units of language (agrammatism) and to produce and articulate coherent speech. They usually describe objects or beings in telegraphic manner on the basis of objects or beings to which they have a relation of resemblance.[55] Patients with damage to Wernicke's area have fluent speech characterized by well-formed sentences through which they are able to describe objects or beings in context, but their speech generally makes little sense as the processing of meaning is disrupted. They have difficulties in comprehending language and cannot perceive relations of (dis)similarity.[56] But the distinctions are not that clear-cut. Aphasiologists rarely find these characteristics as a result of damage either to Broca's or to Wernicke's area. Thus, patients with damage to Broca's area may have difficulty with understanding and comprehension as well, and virtually all patients with aphasia have difficulty in finding and selecting words, regardless of the site of damage and the involvement of metaphoric or metonymic processes.[57] The severity of the disorder is also something to take into account: a lesion in Wernicke's area does not straightforwardly lead to difficulty with selection of words, and a lesion in Broca's area does not immediately result in difficulty with syntactic patterns. Stimulation of the anterior region of the brain where Broca's area is located, and of the posterior region of the brain where Wernicke's area is located, has remarkably similar effects on language functions; when the stimulation interrupts language, this interruption is often of the same type in both regions.[58] Fig. II3-12 shows that the same regions of the brain may be affected by both Broca's and Wernicke's types of aphasia. This, as well as the fact that many more brain regions are involved, suggests that we cannot simply link a contiguity disorder resulting in metaphoric style exclusively to Broca's area, and a similarity disorder resulting in descriptive style of metonymic nature to Wernicke's area.

---

[55] Cf. Part II, chapter 2, section 1.d.2; Harley, *The Psychology of Language*, 435, 437-439, 492; Obler & Gjerlov, *Language and the Brain*, 39-41.
[56] Cf. Part II, chapter 2, section 1.d.2; Harley, *The Psychology of Language*, 68-69, 436, 499; Obler & Gjerlov, *Language and the Brain*, 41-43.
[57] Harley, *The Psychology of Language*, 70-71.
[58] Kolb & Whishaw, *Fundamentals*, 516, 526; Harley, *The Psychology of Language*, 71.

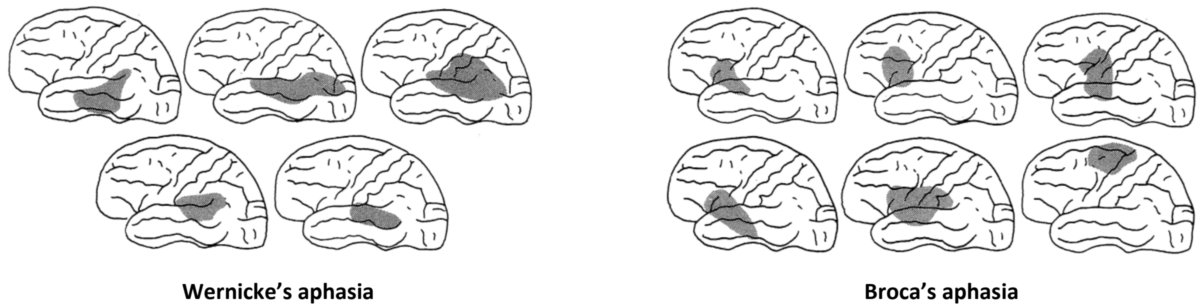


Fig. II3-12 Maps of lesions of individual cases of Wernicke's and Broca's aphasia. Kolb & Whishaw, *Fundamentals*, 526.

Because the symptoms of aphasia cannot be clearly related to either Broca's or Wernicke's area, nowadays a different classification of language disorders is used. Although there is disagreement on the exact number of aphasic disorders, aphasiologists generally distinguish between fluent and non-fluent forms.[59] Fluent forms of aphasia include the traditional Broca's aphasia, but several forms of comprehension disorders as well. They are further divided into 'conduction' and 'transcortical sensory' aphasias, in which the repetition and/or comprehension and/or phonological encoding of language may be impaired. Non-fluent forms of aphasia include the traditional Wernicke's aphasia, but are further divided into 'global' and 'transcortical motor' aphasias, in which the spontaneous use of language, grammar and naming objects is impaired.[60] No classification scheme for neuropsychological language disorders is, however, perfect; there are always exceptions and patients who cut across categories.[61]

To summarize, lesion and stimulation studies demonstrate that much more and larger areas of the brain are involved in the processing of communication than was once thought. Multiple areas and routes are involved, but it is difficult to localize them exactly in combination with specific processes, patterns, behaviors or aphasic symptoms. Although neurologists and aphasiologists can point roughly to specific regions that play important roles in the production and comprehension of verbal language, particularly the left frontal and temporal lobes, the neural systems underlying communication in general are in fact distributed over many cortical and subcortical regions of the brain. Jakobson's proposal, in which he linked the inability to combine units into correct syntactical forms of communication and the ability to select units on the basis of metaphoric relations of resemblance to Broca's area, and the inability to conceive and produce relations of resemblance as against the ability to conceive and produce relations in metonymic context to Wernicke's area is therefore too simplistic. Metaphor and metonymy cannot be that simply localized as cognitive patterns in the processing of communication.

Yet, although metaphor and metonymy cannot be neuro-anatomically linked to the organization of communication in the brain, our communicative behavior can clearly be of metaphoric or metonymic nature. Instead of localizing the generation of the tropes, they are nowadays rather included in a new paradigm used for conceiving how information might be processed and represented in the brain. This new paradigm does not search for language centers *per se*, but rather focuses on the activation of meanings in a network of nodes and relations between them: connectionism theory.

[59] Harley, *The Psychology of Language*, 436-437; Kolb & Whishaw, *Fundamentals*, 520-523.
[60] Kolb & Whishaw, *Fundamentals*, 521-523.
[61] Harley, *The Psychology of Language*, 436-437.

3 CONNECTIONISM THEORY

a. The principles of connection and activation

Connectionism is a popular theory in the cognitive sciences that derives from artificial intelligence studies. It is used to explain intellectual abilities and complex cognitive behavior as processes that occur through the interaction of interconnected units, or nodes, in a network. Connectionist networks are based on a metaphor of the brain as a structure made up out of many interconnected neurons that are joined in patterns of synapses (connections). Connectionist networks are therefore also known as neural networks, and they are considered to represent a faithful picture of the nature of cognitive and neurological sensory processing in the human brain.[62] There are many types and forms of connectionist networks, among which are simple tree-structured hierarchies, unstructured mind-maps and so-called 'small-world' graphs,[63] but a very basic example is presented in fig. II3-13:

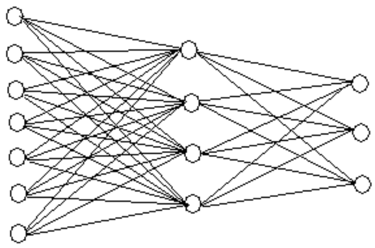


Fig. II3-13 Example of a connectionist network. Input units, or nodes, sent activation along connections to output nodes via intermediate nodes. This principle can be used to explain and visualize the processing of various intellectual abilities, from word recognition and speech production to semantics and classification theory. Adapted from Garson, 'Connectionism' in the *Stanford Encyclopedia of Philosophy* (2015).

The network in fig. II3-13 shows three levels of processing that are represented by input nodes, hidden or intermediate nodes, and output nodes. The input-nodes contain incoming information, which may be visual, auditory or sensory in nature. Via connections they activate the other nodes in the network, which are called 'hidden' in that they represent intermediate levels of processing between input and output. They allow for non-linear and indirect processing. Via the intermediate levels activation is sent to output nodes, which represent the outcome of the information processed. The number of nodes and connections, as well as the number of intermediate levels, depends on the kind and complexity of the cognitive behavior a network is intended to visualize and explain. All connectionist networks, however, depart from three basic concepts that summarize connectionism theory in a nutshell:[64]

- The prime concept that there are many processing nodes that, in analogy to neurons in the brain, are all connected (wired) together;

[62] Harley, *The Psychology of Language*, 23, 481; Garson, 'Connectionism' in the *Stanford Encyclopedia of Philosophy* (2015), introduction and section 1. Consultable online: http://plato.stanford.edu/entries/connectionism/. Harley warns not to get too carried away with the metaphor, but at least it comes closer to the brain than traditional models discussed by him on pp. 10-11. See also Steyvers & Tenenbaum, 'The Large-Scale Structure of Semantic Networks', *Cognitive Science* 29 (2005), 72-73; Burk et al., 'Pattern Discovery Using Semantic Network Analysis', *3rd International Workshop on Cognitive Information Processing* (2012), 1-6. For criticism on connectionism networks as maps of the brain, see Garson, *ibid*., section 4.

[63] Steyvers & Tenenbaum, 'The Large-Scale Structure of Semantic Networks', *Cognitive Science* 29 (2005), 42-43.

[64] Harley, *The Psychology of Language*, 485.

- The concept that activation spreads from node to node throughout the network in a way that is determined by the strengths of the connections between the nodes;
- The concept that high-level, complex intelligent behavior emerges from the interaction and cooperation of the nodes and the strength of their connections.

The concept of activation is central to connectionism theory. Psycholinguist Harley explains it as energy or electricity flowing around a circuit board:[65] it fires quickly in all directions, activating nodes that themselves activate other nodes throughout the network. Activation starts with the input nodes. However, they do not activate all intermediate nodes to equal extent. This is seen in fig. II3-14:

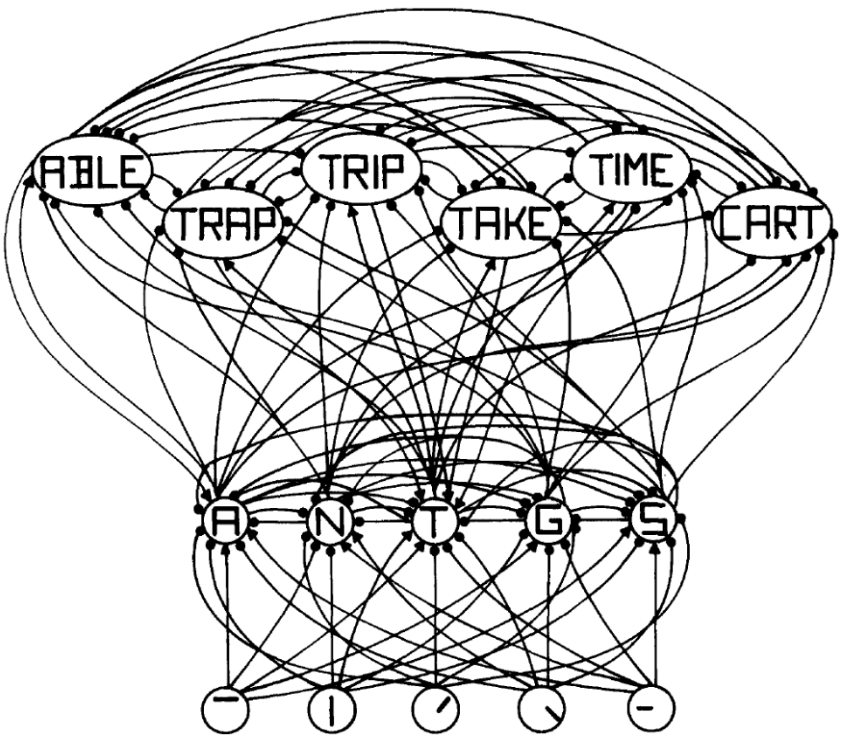


Fig. II3-14 A connectionist network that shows interactive activation between the input, intermediate and output nodes. It was developed to explain visual word recognition and identification: visual input features activate certain letters, which themselves activate certain words as output nodes. McClelland & Rumelhart in *Psychological Review* 88.5 (1981), p. 380 (fig. 3).

Fig. II3-14 shows a connectionist network that was developed by the psychologists McClelland and Rumelhart to account for visual word recognition on the basis of letter identification.[66] The first level at the bottom is the input level. It shows visual feature units; elements that may feature in the composition of the letters of our alphabet.[67] The nodes in the intermediate level correspond to individual letters, and the nodes in the outcome level correspond to words that begin with the intermediate level letters. This is, of course, a simplification of the situation in reality. McClelland and Rumelhart note that in reading

[65] Harley, *The Psychology of Language*, 13.
[66] McClelland & Rumelhart, 'An Interactive Activation Model of Context Effects in Letter Perception', *Psychological Review* 88.5 (1981), 375-407; Harley, *The Psychology of Language*, 197-198, 485-486.
[67] The breaking up of signs into minimal feature units that have in themselves no meaning, and functional units such as words that do carry meaning is precisely what semiotics has called *double articulation*. See the previous chapter, section 1.d. The levels of articulation are here used to show how the brain makes sense out of them: it recognizes words by identifying how they are built up from minimal units that compose meaningful units.

and perception normally many more levels are important. Yet for the sake of comprehension only three levels and a small amount of exemplary nodes are given here.[68]

Starting from the input level, not all of the feature units in fact feature in the letters of the intermediate nodes. That is, although in analogy to neurons in the brain all nodes are in principle connected, for some intermediate nodes this connection is of an *excitatory* (positive) nature and for others it is of *inhibitory* (negative) nature. Thus, when a person NN, who is familiar with the English language and Western alphabet, is presented with a stimulus word a process is initiated in which certain features are extracted from each letter in the stimulus word, and excitatory and inhibitory pressures begin to act upon the intermediate and output-level nodes in order to identify the letters and ultimately the word. Assume that the stimulus word is 'TAKE'. As regards the first letter, the visual feature '|' may be extracted, which has an excitatory connection to the letter 'T', because '|' is a feature of 'T'. The letter 'T' is activated, because it is consistent with the visual input.[69] But the same feature unit '|' establishes an inhibitory connection to the letter 'S', because '|' is not a feature of 'S'. The inhibitory connection makes the letter 'S' inactive in the network.[70] The network indicates activation through excitatory connections by means of an arrow, and deactivation through inhibitory connections by means of a circle.

The excitatory connections that go out from the input level make certain pathways through the network highly active, and therewith certain outputs highly possible, while the inhibitory connections make other pathways end. Thus, all connections from S to the output level are inhibitory; they all end in circles. The conclusion is as follows: it is highly unlikely that person NN, after having been presented with the visual stimulus 'TAKE' and after having extracted the visual feature units of the first letter, will arrive at an output node that starts with the letter 'S'. In contrast, it is very likely that he arrives at an output node that starts with the letter 'T', of which four examples are given in the model: excitatory connections from 'T' arrive at the output nodes 'TRAP', 'TRIP', 'TAKE' and 'TIME'.

The next letter in the stimulus word is processed in similar manner. Thus, the visual feature unit '¯' may be extracted, which establishes excitatory connections with the letters 'A', 'T', 'G', and 'S'; and an inhibitory connection with the letter 'N'. However, although 'A', 'T', 'G', and 'S' are thus all activated, the latter three will receive less activation, since in the context of the previous identification of 'T' the letter 'A' makes most sense in the English language.[71] In activating 'A', the pathway to the output word 'TAKE' (or other words that begin with 'T' and 'A', such as 'TASK' or 'TANK') becomes highly active, while those leading to 'TRAP', 'TRIP' and 'TIME' are inhibited.[72]

Thus, each letter in a stimulus word is identified and visual word recognition is built up from feature-, letter- and word-level processing. But McClelland and Rumelhart warn against considering these processes as taking place stepwise from one level to another. Although their model has the appearance of being built up of three successive stages, McClelland and Rumelhart note that 'processing

---

[68] McClelland & Rumelhart, 'An Interactive Activation Model of Context Effects in Letter Perception', *Psychological Review* 88.5 (1981), 378-379.
[69] *Ibid*., 376.
[70] Note that the exact position of visual feature units in the circle is significant; the unit '|' does not establish an excitatory connection to N, a letter which contains two long vertical lines, but not at its centre. This means that we recognize and identify letters not only on the basis of formal resemblance with compositional features, but also on the basis of the spatial arrangement of these features.
[71] This effect is called the word superiority effect: the phenomenon that people have better recognition of letters presented within words as compared to isolated letters. Harley, *The Psychology of Language*, 197.
[72] *Ibid*., 198.

at the letter level presumably occurs simultaneously with processing at the word level and with processing at the feature level'.[73] It is through feedback that the levels communicate with each other, and strengthen and affirm activations in the lower and higher levels. McClelland and Rumelhart call this *interactive activation* along two-way connections between nodes: a stimulus at once fires activation throughout the network, but only when the letter 'T' has found affirmation in the lower level of visual feature units and the word 'TAKE' has found affirmation in the lower level activation of 'T' and 'A' do their connections become excitatory or inhibitory.[74] The eventual output word is truly a result of processing and communication taking place at once between the feature-, letter- and word-levels.

To summarize briefly, the connectionist network of visual word recognition shows the pathways that become active when a stimulus in the form of a visually written word is presented. These pathways lead to potential outcomes, or interpretations, of the initial visual input. As such, the network highlights patterns that are created in the brain and visualizes the processes that take place to make sense out of the visual input.

It must be stressed that this is an incomplete and simplified account of McClelland's and Rumelhart's network that we have used to explain the basic idea of connectionism and its central concept of activation. The theory of visual word recognition on which the model is based implies, of course, much more,[75] but we would like to focus merely on one aspect: the *nature of the excitatory connections* that can exist between the nodes of the input, intermediate and output levels. The nature of the excitatory connection between the nodes in fig. II3-14 was of one kind only: visual, formal resemblance between '|' and '¯' as features of 'T' and 'A', and 'T' and 'A' as the first letters in 'TAKE'. Harley mentions that the scope of the network is consequently limited as it gives no account of the various roles semantics and sound can have in establishing excitatory connections.[76] Psycholinguistic studies that made use of picture-word interference tests, in which participants see pictures that they have to name as quickly as possible, have demonstrated that after the presentation of visual input *semantically as well as phonetically related nodes* may receive activation.[77] Thus, one experiment found that the presentation of the picture of a couch activated the word 'sofa' (semantic relation) as well as the word 'soda' (phonetic relation to 'sofa');[78] and the picture of a sheep may activate 'goat' (semantic relation), and also 'sheet' (phonetic relation);[79] and Harley explains that when we hear the word 'ghost', words related in meaning (e.g. 'vampire') can become activated, but words

[73] McClelland & Rumelhart, 'An Interactive Activation Model of Context Effects in Letter Perception', *Psychological Review* 88.5 (1981), 377.

[74] Interactive activation implies that the processing of visual input does not take place bottom-up from feature level to word, but simultaneously top-down. The top-down processing codetermines and affirms the activation of the nodes. Thus, as soon as 'T' is activated, it affirms its own activation by communicating feedback to the input level. While the activation of 'T' is affirmed also in communication with the processing simultaneously taking place at the word-level, the activation of the other nodes in the letter-level is decreased. See pp. 377-378 of their paper in *Psychological Review* 88.5.

[75] For further information, see the papers by McClelland and Rumelhart 'An Interactive Activation Model of Context Effects in Letter Perception', parts I and II, *Psychological Review* 88.5 (1981), 375-407 and 89.1 (1982), pp. 60-94; as well as further and more recent studies on visual word recognition in Harley, *The Psychology of Language*, chapter 6.

[76] *Ibid*., 198.

[77] *Ibid*., 414-415, 421. A debate in psycholinguistic studies has been the question whether semantic nodes are activated first and independently from a secondary activation of phonetic nodes (discrete models), or whether there is overlap in the activation of both semantic and phonetic nodes (cascade models). The evidence supports the latter hypothesis: although the accessing of semantic and phonetic information is generally a two-stage process, the stages overlap in that the presentation of visual input activates nodes that have a semantic relation to the input, while simultaneously nodes with a phonetic relation are activated at least partially (420-425).

[78] Peterson & Savoy (1998), referred to in Harley, *The Psychology of Language*, 421.

[79] Levelt et al. referred to in *ibid*., 421.

related in sound (e.g. ‘goal’) will also receive an amount of activation.[80] As for the words related in sound, they are precisely what Goldwasser called *phonetic metaphors*: different words that sound similar to the target word depicted in the picture. Phonetic metaphors should thus be reckoned with as possibly activated nodes in a connectionist network. As for the words related in meaning, they may show a variety of semantic relations to the target word.

b. Semantic Network Analysis

A focus on semantics in the question of how the brain processes meaning led to Semantic Network Analysis (SNA) and the development of semantic networks based on connectionism theory and the principle of spreading activation.[81] Semantic connectionist networks are based on the idea that meaning is given by how it is embedded within a network of *semantic features*. It presents these semantic features as nodes in a network structure, within which they are associated on the basis of connections that have themselves meaning.[82] Two of the most common connections between nodes are the ‘IS-A’ (or ‘verification’) association and the ‘HAS-A’ (or ‘property inheritance’) association. The first kind of association was mentioned in section 1.b of the previous chapter with respect to classification theory. It indicates that a node in the network is a type of another node. The second association describes a node’s differentiating features, such as ‘a bird HAS wings’ whereas ‘fish HAVE fins’. Indeed, classification theory makes use of the same idea of spreading activation. Two examples are given below: fig. II3-15 shows a general tree-structured hierarchical classification, while fig. II3-16 shows associations of a classificatory kind between nodes in a spreading activation model.

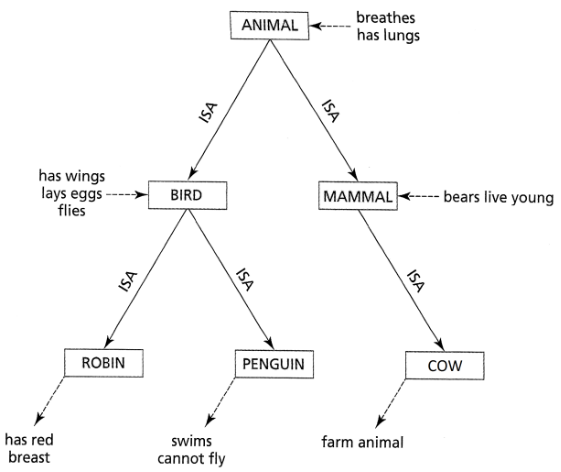


Fig. II3-15 Hierarchical tree-structure based on IS-A connections between semantic nodes. Adapted from Harley, *The Psychology of Language*, 326 (fig. 11.1).

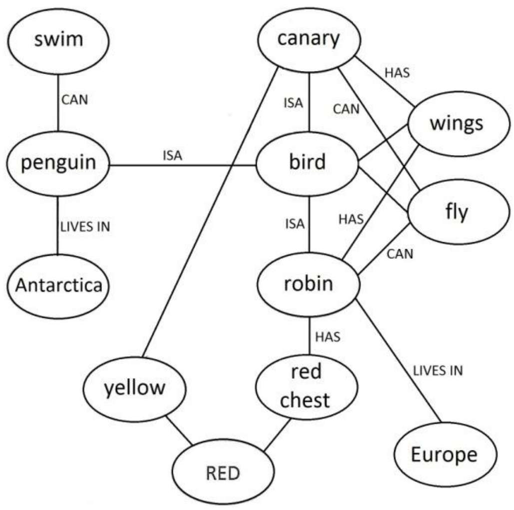


Fig. II3-16 Spreading activation network based on IS-A, HAS-A and other kinds of connections between semantic nodes. Adapted from Harley, *The Psychology of Language*, 328 (fig. 11.2).

[80] Harley, *The Psychology of Language*, 13.
[81] *Ibid*., 325-328.
[82] This feature distinguishes a semantic network from a simpler association network, where there is no structure and no relation between the nodes. *Ibid*.,325.

The disadvantage of the tree-structured model is that the processing of meaning in the brain often does not reflect the hierarchical steps of the categorical structure. For instance, whereas in processing the meaning of 'robin', the node 'bird' ('robin IS-A bird') is indeed activated at an earlier stage than the node 'animal' ('robin IS-AN animal'), in processing the meaning of 'cow' the node 'animal' is rather directly activated, skipping the node 'mammal'.[83] In other words, tree-structured hierarchies present a linear successive process that does not always reflect the manner in which meaning is processed in the brain. Tree-structured hierarchies are furthermore considered limited as models of semantic structure in that they place constraints on the possible extensions of predicates; that is, on the kinds of knowledge and excitatory connections that are possible. They are mainly appropriate for certain taxonomically organized concepts.[84]

In fig. II3-16, which concentrates on the processing of 'robin' only, the thought processes are visualized in a connectionist model in a meaningful, non-hierarchical, structure. The relative lengths of the connections between nodes are significant: short connections indicate quick activations, longer connections indicate later activations and those that take place via multiple intermediate nodes. Thus, the connection between 'robin' and 'bird' is fairly short on the basis of the 'robin IS-A bird' association. The connections with 'wings' and 'red chest' are also fairly short on the basis of the associations 'robin HAS wings' and 'robin HAS-A red chest'. The connection between 'penguin' and 'bird' is longer because, in contrast to 'robin', 'penguin' is considered less of a prototypical example of 'bird';[85] the idea that 'penguin IS-A bird' takes longer to process.

The reader will notice that Fig. II3-16 includes also semantic nodes that are based on other than 'IS-A' and 'HAS-A' associations: there is a functional association that connects the node 'robin' to 'fly' ('a robin CAN fly'), and what has been called an encyclopaedic relation that connects the node 'robin' to 'Europe' ('robins LIVE IN Europe').[86] Other associations on the basis of which nodes may become active in the processing of meaning have been found by the cognitive psychologist Hinton and the neuropsychologist Shallice in a study on a reading disorder, in which the patients cannot retrieve words except on the basis of semantic associations (deep dyslexia).[87] They mention among others association on the basis of:[88]

- size;
- color;
- material, hardness or softness;
- location (indoors, outdoors);
- pars-pro-toto;
- source or derivation;
- a made-of association;
- or a used-for association.

[83] The conceptualization 'cow IS-AN animal' is encountered more often than the conceptualization 'cow IS-A mammal'. Harley, *The Psychology of Language*, 326-327 (referring to a study by Collins and Quillian (1969)).
[84] Steyvers & Tenenbaum, 'The Large-Scale Structure of Semantic Networks', *Cognitive Science* 29 (2005), 42.
[85] It may be called a fuzzy member of the class of birds. Goldwasser, *Prophets, Lovers and Giraffes*, 19-24; Harley, *The Psychology of Language*, 327-328, 335-337. For prototype theory, see also section 1.b.1 of the previous chapter.
[86] Rogers et al., referred to by Harley, *The Psychology of Language*, 357-358.
[87] Hinton & Shallice, 'Lesioning an Attractor Network', *Psychological Review* 98.1 (1998), 74-95.
[88] Listed in Hinton & Shallice, 'Lesioning an Attractor Network', *Psychological Review* 98.1 (1998), Appendix B. See also Harley, *The Psychology of Language* (2008), 236-239; Steyvers & Tenenbaum, 'The Large-Scale Structure of Semantic Networks', *Cognitive Science* 29 (2005), 51.

If we translate these semantic associations as well as the phonetic and the classificatory associations mentioned before into semiotic terms, we are in fact dealing with a variety of metaphoric and metonymic associations in meaning.[89] Two associated nodes A and B may be metaphors for one another on the basis of similarity in sound (phonetic metaphors), or on the basis of similarity in size, color, material, function, location of usage or occurrence and so forth (semantic metaphors), while these metaphors are framed or supported by connections of metonymic kind; function, habitat, source, material or usage stand for the two concepts that are associated in nodes A and B.

c. The marking system from Deir el-Medina

It now becomes tempting to ask ourselves whether a connectionist activation network can be used to visualize and explain the different processes through which the identity marks generate meaning. But before we attempt to do so, a final aspect of connectionism theory must be explained. In computational cognitive science a connection is not simply excitatory or inhibitory; it is so to a precise calculated degree. Connections have weights, or strengths, that determine how much activation spreads along them, and hence how quickly activation builds up in the node at the other end of the connection.[90] The higher the activation of the connection is, the more likely the node at the other end is to become the output of the network.[91] Meaning is therewith not stored in nodes, or semantic and phonetic features, but precisely in the connections and their weights.[92] The question of meaning and of the motivation for a specific sign is, then, a matter of *degree*;[93] a sign as input node may have several meanings as output nodes that are all motivated to greater or lesser degree.

This is an important point. Although the issue of various degrees of motivation was emphasized in the field of semiotics already by Barthes as well as by Peirce in his sign-varieties (the degree to which a sign is iconic, indexical or symbolic), an essential contribution of the cognitive sciences to the question of the generation of meaning is the provision of algorithms to calculate the degree of motivation. These algorithms, however, require outstanding knowledge of mathematics and we have neither the knowledge, nor the time and space, to include them in our present study.[94] Yet, we can at least consider the visual presentation of a spreading activation network to show how the marks are connected to the workmen and at the same time how the workmen identified through their marks are connected to each other. Let us consider the example of :

[89] See section 1.d.1 of the previous chapter.
[90] Harley, *The Psychology of Language*, 486.
[91] *Ibid*., 13.
[92] Garson, 'Connectionism' in the *Stanford Encyclopedia of Philosophy* (2015), section 5. Consultable online: http://plato.stanford.edu/entries/connectionism/.
[93] *Ibid*., section 6.
[94] Harley, *The Psychology of Language*, 486 offers examples and a brief explanation.

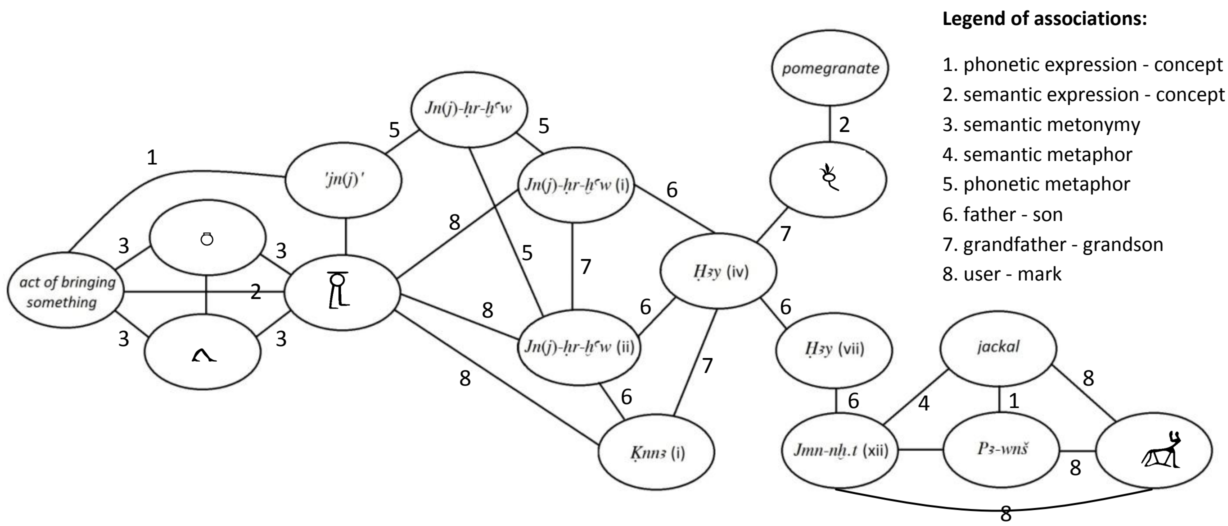


Fig. II3-17 The mark as visual input in a spreading activation network including the meanings along the pictorial and phonetic trails that were suggested in the synthesis of the previous chapter, now as semantic nodes in a non-hierarchical structure spreading toward both *Ḥꜣy* (iv) with the mark and *Jmn-nḫt* (xii) with the mark . NB: associations on the basis of great-grandfather – great-grandson relations are not indicated as this would not enhance the clarity of the network.

In the previous chapter we saw that the mark consists of and and pictorially depicts *the act of bringing something*. Both and are in metonymic relation to the expression as well as to *the act of bringing something* which is the concept, because they are parts representing the whole. They are semantic nodes that are activated by on the basis of semantic metonymy. In addition, as a phonetic sign, conveys the sound pattern '*jn*(*j*)'. This phonetic node is connected to *the act of bringing something* as the ancient Egyptian expression for this act, but on the basis of phonetic similarity (i.e. metaphor) it is furthermore connected to the name *Jn*(*j*)-*ḥr*-*ḫꜥw*. This name is in turn connected on the basis of phonetic metaphor to both names *Jn*(*j*)-*ḥr*-*ḫꜥw* (i) and *Jn*(*j*)-*ḥr*-*ḫꜥw* (ii) and the persons who were called by these names. As such, *Jn*(*j*)-*ḥr*-*ḫꜥw* (i) and *Jn*(*j*)-*ḥr*-*ḫꜥw* (ii) are indirectly connected to the mark on the basis of phonetic metaphor through the intermediate nodes of '*jn*(*j*)' and *Jn*(*j*)-*ḥr*-*ḫꜥw*, but both also have a direct user-mark connection, as they were both direct users of the mark within the system of Deir el-Medina for a certain period of time. *Ḳnnꜣ* (i) is connected to *Jn*(*j*)-*ḥr*-*ḫꜥw* (i) and *Jn*(*j*)-*ḥr*-*ḫꜥw* (ii) on the basis of family relations, and thus also has an indirect connection with the mark through intermediate nodes (whether via '*jnj*' and the name *Jn*(*j*)-*ḥr*-*ḫꜥw*, or via his great-grandfather *Jn*(*j*)-*ḥr*-*ḫꜥw* (i) and/or father *Jn*(*j*)-*ḥr*-*ḫꜥw* (ii)). Yet, he too has a direct user-mark connection as he was also a direct user of for a certain period of time. *Ḥꜣy* (iv), in contrast, does not have a direct connection to ; he is not attested with this mark. Rather, he used the mark , which pictorially represents a *pomegranate*. Still, he is indirectly connected to via family relations. In further spreading its activation, the network comes to include another workman, *Jmn-nḫt* (xii), whom we have encountered in the previous chapter with the mark , representing a *jackal*. His connection to this mark, we assumed, was on the basis of his nickname *Pꜣ-wnš*, a name that presumably came forth from some aspect of similarity between *Jmn-nḫt* and the animal: a case of semantic animalistic metaphor. *Jmn-nḫt* was the son of *Ḥꜣy* (vii), who was in turn a son of *Ḥꜣy* (iv). As such, he was a nephew of *Ḳnnꜣ* and a great-grandson of *Jn*(*j*)-*ḥr*-*ḫꜥw* (i), the first known user of .

The big advantage of such a representation in comparison with the model presented in the synthesis of chapter 2 is that it is *not linear*. Therefore, it does not imply that every individual went through the same linear process to get from to, for instance, *Ḳnnꜣ* (i). Some, especially contemporaries of *Ḳnnꜣ* (i), will have made the connection between and *Ḳnnꜣ* directly; others, such as elderly who knew *Ḳnnꜣ's* father or lineage, may have made the connection through *Jn*(*j*)-*ḥr*-*ḫꜥw* (ii), or perhaps even through *Jn*(*j*)-*ḥr*-*ḫꜥw* (i). Furthermore, those with better knowledge of script may have made the connection through '*jn*(*i*)' and the family name *Jn*(*j*)-*ḥr*-*ḫꜥw*, while others without knowledge of script may again have followed a direct connection. Inherent to this advantage is another advantage, namely that *Ḫꜣy* (iv) does not necessarily have to be included in the process from to *Ḳnnꜣ*. In the previous chapter he was included in the linear process as *Ḳnnꜣ*'s grandfather, but by not using the mark he in fact represents an interruption. In the network of fig. II3-17 one can quite literally get around him and still follow the process from to *Ḳnnꜣ*.

In other words, a representation of the semantic and phonetic knowledge connected to the mark such as in fig. II3-17 shows which nodes have the potential to receive excitatory activation, but it does not imply that one specific path needed to be followed. Although we can never be certain what exactly the ancient Egyptians thought when they saw the mark , or any other of the identity marks, and which semantic and phonetic features may have been activated to greater or lesser degree, we can assume that there were personal differences depending on, among others, age and degree of literacy. The meaning of may have been *conceived differently* by someone who made a phonetic connection through '*jn*(*j*)', *Jn*(*j*)-*ḥr*-*ḫꜥw* and the family connections, than by someone who made the connections more directly. As such, the meaning of the mark in fig. II3-17 is indeed found in the connections, and not in the nodes themselves.

In sum, connectionism theory and the principle of spreading activation are important contributions in the search for meaning generated by the signs and markings of visual communication. The strength of connectionism networks lies in the fact that they visualize meaning through a pattern of activation distribution over many potential semantic and phonetic feature nodes in a non-hierarchical structure that approaches the nature of cognitive and neurological sensory processing in the human brain better than traditional models have done.

Unfortunately, we have merely been able to suggest the potential of connectionism theory to the analysis of the Deir el-Medina identity marks. We would have liked to apply the marking system to the theory in more detail, including its computational aspects in calculating the weights of potential connections. The semantic and phonetic nodes to be included in such a connectionist network between the marks as input nodes and the workmen as output nodes, as well as the weights of their connections should be based on a thorough study of ancient Egyptian sources: which semantic and phonetic, metonymic and metaphoric associations do we find in Egyptian sources connected to the marks that were selected to convey the identity of the Deir el-Medina workmen, and how often do these associations occur; that is, how integrated were they? Frequently encountered associations will receive a higher degree of activation as they theoretically have more potential to lead to the output. Such study, however, must be left for a future interdisciplinary undertaking with specialists in the field of (computational) cognitive science.