

Semantics and Neurology: *Neuronal Man* and Linguistics

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I. The Linguists' Silence

Jean-Pierre Changeux's *Neuronal Man*¹ attempts to define mental activity, that is thought, with respect to the neurophysiology of the brain.*

Since antiquity, the historical account of these problems has undergone the examination of classical notions: what is a mental image, a concept, a representation? Changeux, who accepts these traditional points of departure, as well as the notion of signification, aims to clarify the physical, neurophysiological counterparts of these notions, in order to arrive at less simplistic terms: *image de mémoire* "memory image," later – *objet mental* "mental object," and still later – *objet de mémoire* "memory object." Behind these terms lies transition to neurophysiology, with the notion of engram, and finally with the notion of *trace*, a notion which is precise but very general, since the substantive reality of these traces, their anatomy and physiology in the brain has yet to be determined.

Changeux's hypothesis proposes that these traces – indispensable to an explanation of memory proceeding, without which there could be no thought – are linked to a system of electrical circuits conducting from the perceptive interceptors to the neurons, then to

1. Jean-Pierre Changeux, *L'Homme Neuronal*, Paris, Fayard 1983. This work has been translated into Italian (Milan, Feltrinelli 1984); German (Reinbek, Rowholt 1984); English (New York, Pantheon 1985); Spanish (Madrid, Espasa Calpe 1985); Portuguese (Lisbon, Dom Quixotte 1985); Serbo-Croatian (Belgrade, Nolit 1987); Japanese (Tokyo, Misuzu Shobo 1990). It is also forthcoming in Dutch (Elsevier).

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their extensions, axons and dendrites; these electrical circuits are then transported from one neuron to another by chemical transmitters. In short, these neuronal branches constitute networks.

Perhaps cerebral localizations do not exist in the meaning that was ascribed to this term a hundred years ago. Nevertheless each network has a topology that can extend over several areas, indeed across several levels of the brain. The traces are stored via quick repetitions of neurological messages which in the long run construct preferred routes of transmission. This is memory – the persistent trace – which Changeux calls epigenesis (not constructed within the genes) through the selective stabilization of the most frequently traced circuits. This theory is not incompatible with research which aims to explain the great variability in individual cerebral performance. Consider, for instance, child musicians, or mathematical prodigies.

It seems that Jean-Pierre Changeux's book did not provoke much reaction among linguists. It is true that, at first glance, the work appears not to concern linguists at all. With respect to language in general, the book contains only brief allusions to the "symbolism of linguistic signs"²; otherwise, as early as the preface, the author sets forth his quite precise opinion that "where the brain is concerned, linguistics has, with little exception, reached a total impasse."³

There is little mention of linguists. Chomsky's thesis on the innateness of language is – with good reason – dismissed in passing.⁴ Jakobson is cited only for his minor work *Kindersprache* (1941), updated in English in 1968.⁵ It is not Bloomfield, but rather J. B. Watson (1913)⁶ whose work is noted in the discussion of physicalism. Lacan's thesis – that "dream, and likewise the unconscious mind, is structured like language" – is presented, also with good reason, in a doubting light⁷. Saussure is represented only in the bibliography.

For the linguist, this fact is all the more notable as Changeux often avails himself of formulas resembling those of Saussure, but which he borrows, less felicitously, from Wittgenstein: "Mental objects do not generally exist in a free state. They appear simulta-

2. Jean-Pierre Changeux, *Neuronal Man*, New York, Pantheon 1985, p. 217.

3. *Ibid.*, p. 8.

4. *Ibid.*, p. 293, and implicitly, p. 273.

5. *Ibid.*, p. 320.

6. *Ibid.*, pp. 9, 53, 133.

7. *Ibid.*, p. 206.

neously independent and dependent in the sense that we cannot imagine any object without also imagining the possibility of its connection with other objects."⁸ In spite of their being limited to the language,⁹ one might prefer the clearer and more traditional statements made in the *Course* regarding the fact that "the conceptual part of the value [of a linguistic unit] is comprised exclusively of the similarities to and differences from other terms of the language," and the fact that the signifying values of a system correspond to concepts [or rather to the signified, which is not synonymous with concept, G. M.] "suggests that these concepts are purely differential . . . [and that] their most precise characteristic lies in being what others are not."

The Saussurian influence is even more apparent in what Changeux offers as the generally accepted notion of "concept," when he examines the opposing values inherent in a *coquetteuse Renaissance* "Renaissance folding chair," compared to a *chaise Louis XIII* "high-backed Louis XIII chair," and a *ponteuse Louis XVI* "Louis XVI upholstered chair," when compared with *siège* "seat," *chaise* "chair," and *fauteuil* "armchair."¹⁰ This example almost certainly originates in the work of Bernard Pottier, but it is so common that we might speculate that, like Saussure's thought, it is known to Changeux via second hand transmission.

Certainly, it is equally possible that Changeux's analysis, based on opposing and defining "traces" of meaning, owes just as much to Leibniz's *requisits* and even to Aristotle as it does to Saussure, especially since the text of the *Neuronal Man* remains rather loose with regard to its use of such central linguistic concepts as "language, with its arbitrary system of signs and symbols," or its mention of the "alphabet, in which the letters represent not ideas, but rather sounds, or *phonemes*."¹¹

It is probably in its discussion of writing that *Neuronal Man* is most progressive – although the standard literature on this problem has undoubtedly been adapted from the *Catalogue d'exposition Naissance de l'écriture – Cunéiformes et hiéroglyphes* (1982), by André-Leicknam and Ziegler – because the problems associated with hieroglyphs, as opposed to phonetic alphabets, provide impetus

8. *Ibid.*, p. 181.

9. *Ibid.*, p. 98, and especially p. 162.

10. *Ibid.*, pp. 178, 179.

11. *Ibid.*, p. 181 or 368–369; see also the mention of the "phonemes" [ra] and [la] in Japanese, p. 323.

for neurophysiological research into probable distinct localization in the brain.

Naturally, *Neuronal Man* pays careful attention to all that concerns the relationship between language, and neurophysiology and cerebral pathology, from Broca (1863) and his predecessors to the most recent works. In general, linguists are familiar with these works only to the extent to which they explore areas of linguistic concern such as aphasia.* Moreover, this linguistic interest is limited to a narrow and very specialized discipline within the field of psycholinguistics. The impact of this area of study on research in general linguistic theory has always been, without doubt unjustly, rather inconsequential.

This introduction to *Neuronal Man* and its relationship with linguistics should under no circumstances be read as flawed by the contempt or by the narrowness of a specialist's point of view. On the contrary, I seek to determine the reasons why such an important work as *Neuronal Man* has not provoked more response in the domain of language. Its thirty-page bibliography suggests to the linguist how difficult it is to keep oneself up-to-date on issues of current scholarship. From this point of view, Jean-Pierre Changeux's work certainly deserves the keenest attention, even aside from its rich historical perspective and its commendable presentation of recent works on the subject of cerebral neurophysiology.

II. Are the Representations Equivalent to Images?

In addition to the two theses outlined above, *Neuronal Man* also offers a new approach to one of the central questions of general linguistics: the problem of the formation and the cerebral storing of what we call *signification*, or *meaning*.

As mentioned above, Changeux uses little conventional linguistic terminology, and furthermore, when he does, his usage is not in accord with any strict or rigorous definition. Let us repeat here that Changeux twice, in passing, mentions "signs and symbols"¹², seemingly without recognizing that these two terms refer to quite distinct concepts which, moreover, are not identical from the viewpoint of different philosophies. Changeux's mention of "signs" and

* See *Diogène*, no. 150, April – June 1990: Edwin Alexander, "Auto-observation of an Aphasic Philosopher"; Georges Lantéri-Laura, "Aphasies and Internal Language."

12. *Ibid.*, pp. 181, 320.

“speech” or “the arbitrary nature of the system of signs”¹³ of a language is brief. The only linguistic concept which Changeux truly exploits – in the example of the significata of the chairs – is that of the “relevant characteristic features of the significatum.” However, he employs only the concept of “characteristic features,” while the concepts of “relevance” and “significatum” are implicit in his treatment of the example.

The center of the theoretical analysis is therefore the concept of *signification, meaning*, with respect to which Changeux emphasizes that “we are gradually leaving physiology to enter the domain of psychology and linguistics.”¹⁴ Changeux’s intervention is quite welcome and justified because the notion of meaning and its analysis, that is, the analysis of the *significatum* of a unit, of its *meaning*, etc., remain the central and as yet unresolved problems of semantic analysis. Nevertheless, here as well, Changeux’s hesitant approach, while eminently respectable, is that of a highly specialized scholar who attempts a multidisciplinary approach all by himself, using a personal background extending from Aristotle to Descartes, from Leibniz to, probably, Saussure, and from classical psychologists to recent behaviorists and cognitivists.

This long work, which is at once an investigation and a search for hypotheses, focuses on two terms: image and representation. At the outset, Changeux does not question the reasons behind Epicurus’ – and later Aristotle’s – affirmation that “the soul never thinks without images.” Changeux himself talks about “inner vision,”¹⁵ and asserts that “the existence of *mental* images is no longer doubted” (a sentence in which the adjective merits a closer scrutiny),¹⁶ or that “the material nature of these representations is illustrated in a striking manner” (here, again, the word *representation* requires discussion). The experiments he recalls, such as the memory of the Mona Lisa, the identification of the same object from different perspectives, the game of the desert island, and the experience of an imaginary tomato,¹⁷ are more than ingenious, and they are certainly significant from the point of view of the function of the brain. But do they in fact prove the “materiality” of the “images” in question? I am not convinced, by my own experience,

13. *Ibid.*, pp. 188, 189.

14. *Ibid.*, p. 178.

15. *Ibid.*, in quotes, p. 173.

16. *Ibid.*, pp. 174.

17. *Ibid.*, pp. 173–177.

that "mental images . . . arise spontaneously [or] voluntarily when the object is not physically present."¹⁸ On one hand, as far as the reproduction of memory is concerned – whether of rather complex objects or of pictures – it would undoubtedly prove necessary to devise a methodical test of the probable great variability among the subjects, because the mental process of *reproducing* does not appear to be identical to *imagining* in its literal sense, or to *recognizing*. On the other hand, I have often been struck by the difficulty, which undoubtedly also varies among subjects, in truly evoking a mental image (for example, a face, a place, a house) in the literal sense. Finally, one may be surprised to learn that the concept of *image*, presented at length in Changeux's book, appeals only very late¹⁹ to true isolated mental images which we all, or almost all, have experienced internally: the hypnagogic images preceding sleep, the images of dreams, and the images of hallucination, whether spontaneous or induced. I continue to maintain the thought that the single term *image* cannot adequately embrace such diverse phenomena as those just mentioned, from the more or less precise memory of the Mona Lisa to the memory of a dream at the moment of awakening, when compared to the genuine images of the dream itself.

I insist once again that my exposition should not be regarded as the maniacal philological ranting of a purist and a specialist, for behind all these terms there lies their signification – that is their definition. If a term is polysemous it has multiple definitions, often within the scope of the same discipline. Such terms, then, cease to be functional even – and perhaps especially – in discussion; an "epistemology of inconsistencies in the humanities," which will undoubtedly be written at some point, would find here one of its most obvious sources. Differences among national cultures, among academic backgrounds, among scientific information, among schools, etc., almost always arise of and result in what is essentially a terminological "tower of Babel," that is, an inventory of terminology that can be translated internationally across time and space, but that renders terms' meanings – which ought to be their definitions – partially or totally heterogeneous.

I would like to cite another example of the risk involved in the use of terminology. Changeux describes very well, I believe, the outcome of the areas on the surface on the cortex where the senso-

18. *Ibid.*, p. 176.

19. *Ibid.*, pp. 196, 197, 204.

ry, visual, acoustic, olfactory, tactile, and motor receptors or effectors are localized. These areas, when pictured together, appear to resemble the being (human or ape) which is the object of this exploration.²⁰ This type of picture is called *homoncule sensoriel* "sensorial homunculus," and *homoncule moteur* "motor homunculus." Changeux, however, in order to describe this phenomenon more clearly, compares these homunculi to *cartes* "maps," then to *figurines*, finally to *hiéroglyphes*.²¹ All these metaphors are subsumed under the more abstract and neutral term *representation*, which is especially precise when he writes about "anatomical representation,"²² or "cortical representations."²³ Nevertheless, it seems to me that all these terms precipitate perceptible shifts in meaning, although the word *image* does not appear. The cortical homunculus "resembles" an organism, which is itself "a representation of its environment";²⁴ a statement which undoubtedly is not imprecise, if the word *representation* is properly defined. As a result of Changeux's multiple metaphorical approaches, Chapter IX of *Neuronal Man* is entitled however "The Brain – Representation of the World." This is a risky formulation, even if it is qualified in the chapter itself by an entirely acceptable sentence: "The human brain contains or produces three major representational categories of the world."²⁵

Of course, reflection on the concept or on the notion of image is only the starting point for Changeux's analyses. He never repudiates it, but rather constructs transitions. He adopts Aristotle's term "copies,"²⁶ Epicurus's and Lucretius's term "simulacri,"²⁷ terms which emphasize the first meaning of the word "image." He also revives Aristotle's term, *imprint* (*ibid.*, note 27). This term is very concrete, referring to the imprint "of a seal in wax." Changeux evokes the relationship between the image and the perceptum – the thing perceived – a relationship which is evident according to the author and which is in fact a "neural relationship, a material congruence between the perceptum and the image in the memo-

20. *Ibid.*, pp. 156–161.

21. *Ibid.*, pp. 157, 158, 160, 162, 168.

22. *Ibid.*, p. 156.

23. *Ibid.*, p. 160.

24. *Ibid.*, p. 156.

25. *Ibid.*, p. 367.

26. *Ibid.*, p. 173.

27. *Ibid.*, p. 173.

ry."²⁸ Changeux also emphasizes "the identity of form, or *isomorphy*, between the perceptum and the external object. . . ." ²⁹ But the use of the word *carte* "map," which is already more abstract, constitutes a semantic shift from the literal to other, very different meanings,³⁰ which suggest the homunculi. Page 188 is the most relevant. Starting with an isomorphic "Aristotelian" image of the "external object" and of the perceptum – an isomorphy which will be discussed later – Changeux seeks transition to more abstract forms of storage in the brain, "a 'photograph' of the characteristic *features* of the object," which involves a "pruning of the sensory component," accompanied by a "loss of 'vividness' of the image" and an "attenuation of its realism." Thus, he concludes, "the isomorphy [between the image and the perceptum relative to] the external object can disappear altogether." In that way, we obtain a transition from the image to the perceptum to the concept, "which gradually becomes abstract."

Before discussing the notions of "representation" and "concept" in detail, I must emphasize the fact that, in my opinion, Changeux passes too quickly over a question that ought to constitute the focus of his argument. Contrary to his own thesis, he evokes "a rationalist approach, which denies the importance of images."³¹ He mentions the Würzburg school from the beginning of the century, and cites Descartes who correctly observed that "signs and speech . . . in no way resemble the things they signify." I remember that in the 1950s Marcel Cohen demonstrated – without rejecting the old Aristotelian formula – that in its most abstract forms, thought without images exists. Cohen had in mind mathematics, physics, and undoubtedly also chemistry. André Martinet reflects the same view when he writes: "It must be pointed out that the sight of a house does not automatically initiate the linguistic process associated with the object; similarly, the use of word *house* does not necessarily entail the memory of a real experience. It is even probable that, in the majority of cases, no connection of that sort occurs, and that, generally, an utterance is not accompanied by a series of recollections or realizations corresponding to each successive unit of meaning. This would be completely incompatible with the speed of discourse. But it is not for a linguist to issue a verdict on this sub-

28. *Ibid.*, pp. 177, 178.

29. *Ibid.*, p. 188.

30. *Ibid.*, compare also pp. 175, 184, 186.

31. *Ibid.*, p. 180.

ject.”³² The experiments cited by Changeux do not respond to this fundamental and sound objection. The above remark serves only to open the matter for discussion, for I do not believe that Changeux’s neuronal theses require for their acceptance the Aristotelian theory – “thought impossible without images” – in its literal sense.³³

III. Concepts or Signifieds

As for the use of the term *concept*, Changeux will always appear to the non-linguist as an orthodox Saussurian, as he uses the term *concept* synonymously with *signification*, just as Saussure does, explicitly, at a few instances in his *Course*. But we must not forget that, throughout the *Course*, Saussure’s research revolves tentatively around the two terms, *concept* (which is soon preferred to *idea*) and *signified*. Saussure himself seems to prefer the second of these terms for purely linguistic reasons, adopted and developed by his followers. While I do not wish to embark on an exegesis of a term which is highly polysemous even among philosophers, it must be noted that it is in fact impossible to talk about a concept except within intellectual and scientific domains which define their technical terms explicitly and specifically. In such cases definitions are always based on a certain number of necessary and sufficient characteristic features – the *requisits* of Leibniz – in order to affirm that a given reality belongs to an extensional class of realities defined by one particular concept or another.

As soon as the linguists began to discover the possible structural arrangements of the signifieds (the semantic structures), they realized that this domain offered resistance to their analyses. Except in scientific and technical disciplines where every term is linked to a definite concept, the signifieds of a language are far from being equivalent to the definitions offered in dictionaries. Indeed, one cannot learn the signified of a term by consulting a dictionary. The signified takes shape slowly, during the process of acquiring the primary language, and is based simultaneously on the referential features (which concern the facts or objects of perception), the situational features (linked to the circumstances in which a given term appears) and on the contextual features (the utterances or figures

32. André Martinet, *Eléments de linguistique générale*, Paris; Payot 1960; 2nd edition 1980.

33. Jean-Pierre Changeux, *op. cit.*, p. 180.

of speech in which the word is used by all speakers). Thus, by trial and error, a nucleus of characteristic features common to all speakers is constructed. This nucleus facilitates social communication – without offering any assurance that there exists behind every term a concept in the literal sense, composed of relevant semantic features which are both *stable* and *common* to all the speakers. This is the point of Martinet's statement discussed above. On the other hand, Buysens, writing at the same time, had already proven that the structure of any given lexicon is inevitably individual. The concepts of a speaker who has at his disposal only the signifieds *pine, fir, juniper, box, holly*, for example, cannot be the same as those of a speaker who, in addition, is conversant with the signifieds of *cedar, yew, bald cypress, parasol pine, Laricio pine, Aleppo pine, picea, fragon*, etc. The socialized structure of the lexicon of a spoken language consists only of the intersections of a small inventory of common features, intersections which, moreover, vary according to the pairs of interlocutors involved in the speech event.

It is this fact that led Martinet to assert that the "relevant features of the signified" are not a *sine qua non* condition for linguistic communication. Therefore, the accepted notion of "concept" (*stable* and *common* for all speakers), such as has been developed in the philosophical tradition (and, in a much less rigorous way, by lexicographers), turns out to be only a convenient but fragile and simplistic hypothesis serving to explain cerebral formation and storage of what we all call *sense* or *meaning*, and what linguists refer to as signifieds of units (lexical or non-lexical) of a language. We can therefore dispense with this hypothesis altogether.

IV. Mental Object, Memory Object, Engram, or Trace?

As a scholar, Jean-Pierre Changeux is too concerned with furthering knowledge in his field merely to organize and synthesize all that has already been written on the *image* and the *concept*. The term *representation*, so important to a description of brain functioning and thought, could not be omitted from his theoretical construct. Of course, the word *representation* is tricky as it suggests – in all languages in which its Latin or Germanic (*vorstellen, vertreten*) etymology is transparent – a cerebral process via which the image of an absent object or being is conjured up in the mind. This term, nevertheless, offers one advantage in that it makes no claims as to physical, physiological or formal nature of whatever it is in the

brain that produces, recognizes or controls our so-called mental activity, and another in that it allows for the gradual separation of the most unrefined forms of the so-called *mental image*. Psychologists have in fact come to describe as "the representation of an object" (this term taken here in its broadest sense) any other object, fact, or phenomenon "that stands in for" that object in its absence, be it by analogy, association or convention. Changeux himself, starting with *representation* which term he does not find satisfactory although he never repudiates its feeble synonymy with *image*, multiplies terms which are even more neutral when compared to the old vocabulary.

For example, he uses the concept of *prototype* proposed by Rosch in 1975, a very interesting illustration of the geographical and academic distribution of knowledge, as well as an instance of rediscovering an already extensively charted America by creating a neologism. Rosch's "prototype" is in fact nothing other than Leibniz's "signification" along with his necessary and sufficient *requisits*, which itself is nothing more than the Saussurian "signified," the more so as it is constructed, in Changeux's work, on the basis of the relevant semantic features of Bloomfield and many of the post-Saussurians.

Furthermore, Changeux speaks even more freely in my opinion of a *mental image*,³⁴ or, *mental object*,³⁵ better as a result of its greater neutrality. Finally, Changeux designates what he previously called *images*, *concepts*, *prototypes*, and *representations*, by a term that is even more neutral with regard to its physiological foundation – that is, *images de mémoire*, "memory images." This term affords even greater precision, since the adjective *mental* is derived from Latin *mens*, "mind" which in turn is derived from the verb *memini* "I remember, I recall" Changeux thus proceeds from the still debatable *images de mémoire*,³⁶ to *objets de mémoire*.³⁷ The latter term is far more satisfying, since it preserves the very general term, *object*, and dispenses with the adjective (*mental*) overburdened by theses concerning the "mind," and by the traditional, dangerous approximation between *image* and *representation*. For that matter, the word *memory* introduces the central problem of storage. . . . Later on, Changeux discusses the *engram*, yet another metaphorical term.

34. *Ibid.*, pp. 173–175.

35. *Ibid.*, pp. 171, 179, 180, 187, 218, 226, which provides the title for Chapter V.

36. *Ibid.*, pp. 176, 179.

37. *Ibid.*, pp. 182, 183, 186, 187, 188, 194.

This term too is tricky, as it has for a long time concealed our ignorance of the physiological substratum underlying images, concepts, or representations themselves through the analogy it offers with the wax phonographic recordings.³⁸ Finally, Changeux introduces a word associated with memory, which presents the central problem in a perfectly clear manner. The word is *trace*. It appears almost without introduction³⁹ and is manifest, in association with the word *engram*,⁴⁰ in the conclusion of chapter V ("Mental objects"); by the end of the work, it occurs alone.⁴¹

I do not claim that Changeux was conscious of this evolution in his terminology, but the evolution itself can be traced in the text. Changeux himself, and all the predecessors (especially of the last twenty years) whom he cites have identified these purely biological and physiological "traces" with increasing precision. Researchers have defined these traces as electric circuits connecting neurons to axons, or to other neurons, as chemical transmission via neuro-transmitters, and most recently finally (a hypothesis strongly supported today), as the geography or topology of "a large population or 'assembly' of neurons distributed over several specific areas of the cortex";⁴² these comprise the "graph"⁴³ which is responsible for the existence of a given "memory object." This description, which indeed seems to be the most insightful and the most acceptable in light of our present knowledge on the subject, resolves, at least for the short term, the old problem of the cerebral form in which received, constructed or "calculated" by the brain information is recorded. This problem of cerebral form of recording seems to have been resolved for a long time via the terms of *image* and *mental representation*.

Changeux also proposes a solution to the problem of memory – the fixing, the preservation, and the subsequent retrieval, after a time, of what has been stored – a problem as yet unresolved in spite of the growth of our knowledge on the subject of cognitive function. Changeux proposes the following theory: the existence of an autonomous and transient "memory object," the evocation of which does not require any direct interaction with circumstances,

38. *Ibid.*, pp. 223, 224.

39. *Ibid.*, pp. 152, 191.

40. *Ibid.*, pp. 223, 224.

41. *Ibid.*, p. 372.

42. *Ibid.*, p. 186.

43. *Ibid.*, p. 155, 167, 181, 186, and *passim*.

implies that "this autonomy can be conceived only if there is a *temporally stable connection* between neurons of the graph, which exists prior to the recollection."⁴⁴ The thesis involves the stabilization,⁴⁵ then the often permanent stability⁴⁶ of the cluster of neurons which constitute the biological substratum of a graph of an object of memory. Moreover, this stabilization suggests the hypothesis that the operation of the human brain, strongly conditioned as it is by the genetic data which have become progressively better understood, is established by an epigenetic development linked to actual experiences, resulting in a "combinatorial mechanism . . . which does not involve any modification of genetic material," but instead involves the existence of traces, the persistence of which stabilizes the networks related to our most common experiences.⁴⁷ This is the theory – expounded in the Chapter VII of *Neuronal Man* – of the "epigenesis by selective stabilization"⁴⁸ of topological graphs, electrical and chemical, which lend material support to what we refer to as memory and thought.

Therefore, the brain is neither an extraordinary sort of phonograph which engraves engrammes into the cells, as Jean-Marie Guyau imagined (by analogy, he claimed),⁴⁹ nor is it a miniature library of microfilms which store "images" and their substitutes, as it has been conceived at least since Aristotle. The only fundamental representations which merit this name are the masses of electrical and chemical signals, stabilized in the networks of neurons, axons and dendrites. Whatever their point of origin in the external or internal world, all the objects of memory must culminate in those signals which "stand in for them," that is, which represent or symbolize them. The objects must, in turn, start in their signal form in order to *again become* the objects of our thought, in the way that they appear to us when we think. The true mental problem no longer concerns the points of origin (percepta, concepts, etc.) or the points of arrival (*objets de mémoire* "memory objects," *objets mentaux* "mental objects," but rather the transformations undergone at every stage of these round trips. It is because we begin with neuronal "equivalents" that we are able to recognize a person from

44. *Ibid.*, pp. 185, 186.

45. *Ibid.*, pp. 190, 191, 194, 195, 224.

46. *Ibid.*, pp. 195, 205.

47. *Ibid.*, p. 276.

48. *Ibid.*, pp. 301, 311.

49. Jean-Marie Guyau, *La Genèse de l'idée du temps*, 1890, IV, 1, pp. 49–57.

behind, that we can envision the Mona Lisa "in our mind's eye," that we can recall a word that we've been looking for or a name which we appear to have forgotten, that we can talk and think. Changeux is not mistaken when he writes that mental man is neuronal man first, foremost, and everywhere, throughout his development via all environmental and psychosociological conditioning during the long period of epigenesis by selective stabilization.

A close and competent friend of mine has observed that epigenesis by selective stabilization is an affidavit, not an explanation. He may be right. Nevertheless, I do not pretend, on one hand, to have assimilated, or even understood, all that *Neuronal Man* has to offer; on the other hand, I do hope to explain what this affidavit – indeed this hypothesis – brings to bear, or may bring to bear, on the existing reflection in some of the most subtle and delicate areas in linguistics.

Before embarking on this last point, I would like to highlight yet one more terminological problem which may impede communication among the neurobiologists – especially cognitivists – and linguists. Changeux talks in several places about the "language of thought."⁵⁰ Regardless of the content attributed to this expression, it is *a priori* infelicitous, as it suggests that the function and structure of thought processes are patterned after the same models which have been extracted for language itself – that is after the model of natural human language. During the last few decades, different attempts to construe "the language of the painting," "the language of the cinema," "the language of music," etc., on the basis of the models derived from the language proper have undergone various metamorphoses which demonstrate the dangers inherent in unqualified use of the tricky word "language." Let us talk instead of "symbolic function," as it is observed in the human species; let us talk of mental function and mental activity, and of the structure generated by this function. Let us talk, like Piaget and his school, of the "production of sensory-motoric models, antecedent to all language acquisition, which already constitute operational logical behaviors." Let us consider the case of very young deaf-mutes, not yet reeducated, among whom it is possible to observe the development of operational schemas, attesting both to the analyses of reality, and to the stable internalized models of behavior, established on the basis of these analyses, the presence of which is tantamount to both intelligence and thought. Let us also

50. Jean-Pierre Changeux, *op. cit.*, pp. 181, 189, 217.

consider the development of symbolic function in the normal child, through the percepta and behaviors evoked by these percepta, as well as the persistence *in absentia* of some of these percepta – since, for example, in the presence of an unpeeled banana, there may ensue the behavior directed towards the acquisition of a peeled banana. Let us not, however, talk of the “language of thought,” as this is an expression which may lure the uninitiated reader, and even the reader who considers himself to be better informed, into accepting as answered a question that has perhaps not even been posed correctly.

V. Memory and Semantic Fields

Having dealt with these lengthy but indispensable terminological rectifications, I will now proceed to a discussion of those aspects of *Neuronal Man* which may be of interest to linguists. First of all, I will explore the aspects which concern the domain of meaning, that is, semantics. In spite of the efforts initiated almost half a century ago by Hjelmslev, the area of semantics is viewed as a domain where the structure of the facts – that is the organization of the body of facts about a given language – did and still does encounter obstacles which appear insurmountable. It has proved possible to structure small and well delineated semantic fields, such as, for example, the Romanian color terms, investigated by Angela Bidu Vranceanu. It was not difficult neither to demonstrate the structure inherent in scientific and technical terminologies (among them, the chemical nomenclature, already shown to be more complicated than was generally thought, cf. Renée Mestrallet). Nevertheless, the crux of the matter still abounds in impenetrable – or, as was demonstrated above – very questionable facts. American theories which propose to define meaning as a description of the referents of a term, fail when confronted by, among other obstacles, the mass of vocables lacking objectively and universally manifest referents. We have just discussed the value inherent in the theories which for a long time associated meanings with “mental images.” The same criticism applies to theories which do not distinguish meaning from concept.

The old theory propounded by scholars investigating dead languages, which consists in reconstructing the meaning of vocables through the totality (whenever possible) of contexts in which they occur (cf. biblical concordances) is still viable in its diachronic

domain. This theory, however, is not well adapted to a synchronic perspective, where each speaker has only his own set of contexts. I myself, at one point, encountered the word *chablis* more than ten times in my readings, without being able to discern its meaning, before I took recourse to a dictionary; and in sixty years I have probably only twice encountered the word *procrastination* in a text. The "meaning from context" theory is applicable only to high-frequency words which are, in addition, associated with favorable situations.

The theory of "relevant characteristic features of the signified" as a way of reconstructing the meaning of a lexical unit, was introduced by Bloomfield in 1933 and by Hjelmslev in 1943. This theory appealed to many of us, as a fully linguistic hypothesis, an elegant parallel to our approach to phonology. Nevertheless, its success too did not endure. As we saw before, Buysens demonstrated around 1960 that the semantic value of a given lexical item is dependent on its opposition to all the other items in all contexts possible for this item. Thus, the same word (*outarde* "bustard" or *bernache* "barnacle," for example) does not have the same "value" (or the same opposing and relevant "characteristic features") for the speaker who has 4,000 words at his disposal, as for the speaker who has command of 40,000 words. Tulli de Mauro (1971) has proven it is theoretically impossible to ascertain a single structure for the entire vocabulary as this would demand, for a given language, a finite set of relevant semantic features – Leibniz's *primitives*. However, language, and especially its lexicon, are permanently open structures. Moreover, if we exclude morphology (declension and conjugation) and word formation (prefixation, suffixation, infixation, composition), in which the structure is transparent, the rest of the lexicon – that is, at least 75 percent – is composed entirely of elements for which it is possible to find – according to actual usage – only one distinctive feature. Let us consider for example words like *banane* (banana), *ortie* (nettle), *ficelle* (string), *tarte* (pie), etc. One can describe the signifieds of these terms, but (with the exception of botanists, and perhaps cooks, textile engineers, and logicians) it is impossible to integrate them into a sub-system – a field of opposing features. Now, if the number of characteristic features in a system is equal to, or even greater than, the number of items construed with these features, the structure is not economical, and probably does not exist either in the speakers'

brain, or in lexicographers' definitions. Linguists, psychologists, and neurophysiologists are interested in discovering the true functional organization of the lexicon in the head of a speaker – not in the definitional and classificatory artifacts of nomenclators and lexicographers, regardless of how useful we find the tools they provide.

The most severe argument, however, against the comprehensive structuring of a given lexicon on the basis of an analysis relying on relevant opposing and distinctive "features" concerns both linguists and psychologists. The relevant "features" that a speaker may try to isolate for a given lexical item are almost never identical for two speakers, in spite of the fact that they attribute the same "value" (the same signified) to a given sign. Martinet offers many examples of this phenomenon: "Is it necessary for a schoolboy or an uneducated adult, faced with a (kitchen) *table* on one hand and a (multiplication) *table* on the other, to identify these two tables by contrasting their relevant characteristic features, e. g., 'plane surface' + 'x' and 'plane surface' + 'y'? Of course not." There is no objective linguistic or psychological procedure that enables us to derive a structure for a given signified on the basis of relevant characteristic features which are both stable and common to all the speakers of a language. What is true for one speaker is not for another, even if we leave aside the arbitrary nature of the delimitation of referents, standard examples of which abound: a *lake* in one language is a *sea* in another; a *river* in one, is a *stream* in another, etc.

In the eyes of many linguists, this is the state of research in semantics, in spite of efforts to find solutions in the fields of computer science and artificial intelligence. But Changeux's description of the structural and functional model of the brain (neurons, axons, and dendrites traversed by flow of electrical currents, synapses set in action by neurotransmitters, circuits, or networks connecting the multiple cerebral zones at different levels) accounts for the facts observed by linguists, especially with regard to "epigenesis by selective stabilization," which hypothesis Changeux himself proposes. The author insists on that account that these "topologically defined clusters of nerve cells"⁵¹ are formed gradually, in different ways depending on the individual, his personal experiences, and his behavioral responses. Thus, for instance, several neurological "routes" can correspond, in different individuals,

51. *Ibid.*, p. 363.

to the same perceptum, and the constructed model enables us to understand the diversity among the cellular routes which lead to the principal organs of an adult.⁵²

It is rather surprising that the observable facts about the memory lapses and the recollection do not occur more often either in linguistics or in discussions devoted to Changeux's model. A few simple examples will be more revealing than a long abstract explanation. I read in the newspaper of an incident in Grenoble about someone named Navel. I am at once reminded of someone I knew in Grenoble in 1944–1946. I do not recall his name at the moment, but I do remember a certain number of characteristic features which define it in my memory: he was a leader of the Resistance movement, he was elected county councillor at the end of the war, I have met him several times in public and privately. I also recall several characteristic features which are less easy to verbalize, the shape of his face, his build, etc. As I think about all this again, it strikes me that his name begins with an *n*. As I often do, I look for the second syllable, having found the beginning of the first. I test all the consonants of the alphabet in succession. When I get to *m*, I suddenly remember the name: it was Naime. And I realize that I did not think at all about the writer who is the namesake of the individual about whom I had read in the paper – Georges Navel, whose *Works* I had read more than forty years before.

This type of memory lapse is not specific to proper names. I shall offer another example: from the time I learned it more than half a century ago, I have always had trouble remembering the word *capillaire*, "maidenhair," which fact, as well as my hesitation in determining the gender of the word (masculine or feminine), may indicate faulty memorization of the word at the time when it was first learned. Certainly, I know immediately that the word refers to a rather short, decorative fern, which is cultivated for this latter purpose. But the first words which come spontaneously to my mind are *scolopendra* and *polypod*, which I reject. Almost always, I am only able to find the word via an association, which I have made for a long time, with two other plants rhyming in *aire*: *vulnéraire*, "woundwort" and *salicaire*, "saltwort." Then I retrieve it: *capillaire*. And I observe the following: in spite of periodic efforts on my part to engrain this word in my memory via its etymology (which I know [*capillaris* < *capillus*, "hair"]), I never automatically take this "route" to find the word. Perhaps this is because, uncon-

52. *Ibid.*, p. 257.

sciously, I have never been satisfied with the image, in which the leafstalks of the fern are likened to the delicacy of hair.

Everybody can attest to an experience of this sort, and, with a moment's thought, even through an analysis which is only intuitive and summary, can trace all the stages which led him to the "missing" word. It would be difficult to find a domain more important to the two theses which I propose to unite here: first, that the meaning of a lexical unit, for a given speaker, is not limited to what linguists call its signified, a term which – with or without the "relevant characteristic features" – purports to delimit a small number of features necessary and sufficient to distinguish a given item from others. In fact, we discover that for a given speaker the meaning of a given lexical item is a cluster of referents, contexts, and situations which go well beyond the signified. We also discover that this cluster is psychologically relevant, since the observable mechanisms for remembering always attest to the items of a particular cluster, peculiar to a given speaker.

Second, it seems difficult, in any discussion of the epigenesis theory, not to take into consideration those analyses of mechanisms for remembering that are totally independent from Changeux's theory. His theory of epigenesis of the totality of brain processes that comprise what we think of as memory involves the selective stabilization of neuronal routes. These routes, at first very diverse, transitory, and redundant, and finally stable, facilitate the recovery of a lexical item after a momentary "blank" through processes which vary from speaker to speaker. (The only domain which offers material that might permit the verification of Changeux's theory would be the free associations of Jung and Freud. The meaning of a lexical item, or a statement, is the sum of the free associations which were formed during the time that the item or statement was acquired and subsequently used by the speaker. Unfortunately, the Freudian interpretation of these associations is overly dogmatic, too unilateral, at least in his best known text, the *Third Lecture on Psychoanalysis*. Moreover, these associations have never really been analyzed for themselves, but rather only, initially, as data, and, finally, as symptoms).

VI. "Associations" and Connotations

Changeux's hypothesis also merits close examination from the point of view of stylistics. It is especially worthwhile for linguists,

who – unconsciously or not – consider stylistics a matter very close to semantics, since stylistics is concerned with the study of special, surprising effects of meaning, efficacious precisely because they are not yet adopted into the standard idiom. Changeux writes⁵³ that an experience always varies from one individual to another, and that this variability in the phenotype [...] is the result of the precise *history* of cell division and migration, of the growth cone's navigation and its division, of regressive phenomena and of selective stabilization, which cannot be identical from one individual to another, even if they are otherwise genetically identical. This statement is equally applicable to semantics. Changeux describes here, in neurophysiological terms, why we encounter enormous difficulties when we attempt to define the hypothetical set of "semantically relevant characteristic features" of a lexical item, shared by all the speakers of a language. Changeux adds that adequate mathematical formalism enables us to demonstrate in no uncertain terms that "different (cerebral) inputs during the course of learning may produce different connective organizations and functional neuronal capacity, but the *same* behavioral capacity." This assessment accounts, in neurophysiological terms, for a phenomenon already acknowledged by the linguists, that two speakers do not need to identify the same (supposed) relevant features of a lexical item to be able to use that lexical item so as to afford mutual comprehension and communication (for example when the speakers discuss *yews* and *cypresses*).

This part of Changeux's thesis is equally relevant to understanding the stylistic function (poetic, aesthetic, artistic, etc.) of language. In fact, if we accept that the meaning of a lexical item or an utterance is equal to the sum of the associations connected with it in the usage of a given speaker, then the hypothesis of epigenesis by selective stabilization accounts, on the neuronal level, for the intertwining that linguists have observed between the denotation and the connotation of a given signified. If the denotation of a given signified corresponds to the sum of the distinctive characteristic features of a class of objects sufficiently common and stable as to allow for mutual comprehension and communication, the connotations are, according to André Martinet's definition, the entirety of all the associations of which this utterance constitutes the center, that is all that the term in question may recall, suggest, stimulate, implicate, be it distinctly or vaguely, for any given speaker. Thus,

53. *Ibid.*, p. 327.

the connotations of a term, even within the scope of the same language, can vary greatly from one speaker to another. They imply emotional associations which depending on the individual may be either positive or negative. They often elude verbal expression as they are often "private," occupying a position at the extreme limits of the conscience. Hence the aesthetic use of language, which so often reveals, by exploring the limits of the code, this expression of the inexpressible, the unutterable, and the ineffable, which constitutes such an important aspect to the experience of the individual. For a long time, from Bally to Bloomfield and Hjelmslev – linguists were so aware of this emotive aspect of the signified, that they defined indistinctly as *connotations* the affective nuances of the signifieds, even if these nuances were part of the idiom, that is, thoroughly lexicalized (for example, *banger* and *jalopy* for *car*, whence, the connotations qualified as jargon, provincial, vulgar, academic, etc.). Simultaneously, the label *connotations* was used to refer to other nuances – affective or emotive, varying from one individual to another, inexpressible or elusive of verbal expression. Thus, for example, almost every association that the word *cèpes* has for me is very personal. I saw these mushrooms for the first time in 1929, in a third class omnibus car, among the baskets of produce that peasant women in black scarves were bringing to town from Agen and Montauban. As for the smell of *cepes*, which I had never before encountered, I cannot even now find words quite adequate to describe it. I had a dish of sautéed *cepes* for the first time a few days later at an inn in a small town in Cevennes. About thirty years later, I picked a dozen of *cepes* in the wood for the first time. All these connotations are connected by a core of similar or close characteristic features which I share with other speakers, as well as by other characteristic features, much more marginal, which endow the word *cepe*, in certain contexts and in certain situations, with a resonance and coloration which are peculiar to me, owing to the associations that this word evokes, and which serve to revive my memory. Proust's little madeleine is an unparalleled example of an analysis of connotations, an analysis which was carried out independently, before the concept itself had been well defined by the linguists.

Also independent of linguistic research, Changeux offers further confirmation of the validity of certain concepts developed in linguistics. One example of such confirmation lies in his neurophysiological description, after Harlow, of the intertwining of conscious

facts, developed and stabilized at the cortical level, with the emotions which relate to the hypothalamic and limbic neurons. Another confirmation lies in Changeux's very plausible hypothesis, which states that "the resonance of a mental object at the cognitive level is communicated to the neighboring emotional receptor of the frontal cortex, releasing bursts of impulses that travel to the limbic system and to the hypothalamus where they evoke a positive, pleasurable effect, or, in the case of dissonance, a depressive effect." Thus we are able to understand, Changeux maintains, the severity of emotional disturbance sustained by a delirious person when these resonances are not, or are inadequately, produced. Finally, in conclusion there is a sentence which resumes, from a neurological point of view, André Martinet's reflection on connotations: "We can thus understand how *a single word* can provoke resonance or dissonance with a memory image (and occasion joy or distress)."⁵⁴

This mutual confirmation of neurology by linguistics is made even more convincing by other points that complement the reciprocity. For example, Changeux, still relying on Harlow, emphasizes that "passing through the channel of attitudes and gestures, and even more importantly through facial expressions, emotions are communicated within a social group *without necessarily calling upon the power of the words.*"⁵⁵ This explains and legitimates the perpetual effort of all artists, and especially writers, to enhance "the power of the word," to adopt Paul Éluard's phrase, in order to express something devoid of any idiomatic meaning that has been standardized by language at some point in its history: the pre-linguistic, the private, the ineffable experience.

In every brain, each cell is unique, differing from the others by the exact repertory of connections it establishes and has established, through information or stimulation, over the course of the unending learning process. The uniqueness of each cell results in the unique memorization of an individual's life experiences; each experience is memorized in accord with the individual's own networks, circuits, and distinct neuronal passages, not to mention the deterioration of transitory circuits, the regression of neuronal branches which prove to be redundant,⁵⁶ etc. In the face of such a description, we are almost amazed that human communication

54. *Ibid.*, p. 216.

55. *Ibid.*, p. 212.

56. *Ibid.*, pp. 290, 293.

among individuals as we know it could ever become possible; and we are not far – neurologically speaking – from Martinet's famous sentence: "(An individual's) experience is *incommunicable in its uniqueness*."

Nevertheless, Changeux, paradoxically, supports both the views of his adversaries the psychologists, who maintain that "superior organisms achieve a given psychological end by a great variety of neurological means," as well as those of the linguists who insist on the possibility of inter-personal communication in spite of all this diversity. According to Changeux, even if we find, after examining them in details, that the mental objects are assembled in neurologically different ways, the "resulting *behavioral* manifestations will nevertheless be quasi-identical."⁵⁷ Here Changeux approaches Martinet's linguistic analyses: it is the linguistic contexts and the extra-linguistic circumstances that occasion the mutually satisfactory use of a given linguistic element, regardless of the structure of meaning that the signifieds hold for each speaker individually.

VII. Remaining Problems

In the conclusion, I do not claim – as true interdisciplinary work is difficult far from laboratories or enduring teams of researchers – to have understood all that I gleaned from *Neuronal Man*. This book cannot possibly be, and never pretends to be, the final statement on the subject of cerebral neurology. On the other hand, I can testify that the author does indeed always "carefully differentiate his data from his theoretical discourse."⁵⁸ This he does by offering numerous caveats (which are not simply rhetorical precautions) as to the hypothetical status of his propositions.⁵⁹ Personally, I was very attentive and sensible to Changeux's nearly fifty very moderate formulations, where the author insists, in my opinion quite honestly, that he is "proposing" a theory that must be further tested and verified by his colleagues.

From another perspective, I think that if *Neuronal Man* has offended humanistic scholars, psychologists, sociologists, and per-

57. *Ibid.*, p. 366.

58. *Ibid.*, p. 362.

59. *Ibid.* We could set forth here dozens of references to activities where (among other formulas) Changeux draws attention to the fact that the details "are yet imperfectly known," p. 82, that a reaction "is not yet entirely clear," p. 118, that "there is not enough data to describe precisely," p. 356.

haps linguists, it is because they are concentrating on some formulas which are, undoubtedly, rather excessive. Nevertheless, it seems to me that any work that is riddled with such words as *learning, behavior, environment*, deserves a philological reading that takes into account all the contexts where the humanities are again introduced. The book deserves such a reading all the more since Changeux repeats that epigenesis by selective stabilization always implies the interaction between biology and the "social link," social "cooperation," "cooperative comprehension among individuals";⁶⁰ and, furthermore, aside from genetic heritage, "the cultural imprint," transmitted to each generation,⁶¹ through some "extra-cerebral memory" of the social culture.

Neuronal Man has irritated psychologists and philosophers because a fast reading can give the impression that it claims to destroy and replace the mental man – that is, two or three thousands years of philosophical and psychological reflection on the nature and function of thought.

The objections raised concern the fact that epigenesis by selective stabilization is not a specific definitory characteristic with the capacity to separate *homo sapiens sapiens* from all other species, since all species capable of learning (and this ability can be found very low in the animal hierarchy) seem to possess the same characteristic. Nevertheless, there is nothing in Changeux's book that claims or even suggests that he maintains such a theoretical position.

It is also alleged that some of the experiments on which Changeux relies cannot be interpreted as he claims, or are questionable in and of themselves. Nevertheless, it seems to me, although I am not a specialist, that this objection does not weaken the solidity of all the other experimental evidence offered by Changeux in support of his primary thesis. Furthermore, as we saw above, Changeux does not claim any license, and is happy to submit his hypothesis to the examination of his colleagues.

There are many concise definitions of the human species: *homo habilis, homo erectus, homo loquens, homo sapiens, animal politicus*, etc. There is no contradiction among these designations, but only a diachronic and synchronic complementarity. Changeux suggests that everything passes through a "neuronal stage." *Homo neuronalis* does not erase all the others. I believe, therefore, that *Neuronal Man*

60. *Ibid.*, pp. 311, 355, 356.

61. *Ibid.*, pp. 329, 359, 371.

is and will remain a work to be read and referred to often. I also believe that it can help linguists progress in their research into semantics and stylistics. The neurophysiologists can continue the debate. I only wanted to present a reading from the perspective of a linguist.

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