The Sounds of Language

Phonological Form in Relation to Phonic Substance

In some respects, Saussure's phonological theory stands at an important crossroads. Much of latter day phonology and phonetics has focussed on the auditory modality. This has lead to what Repp (1987: 4) has characterized as a preoccupation with psychophysical approaches to the study of speech sounds in relation to auditory perception. The focus on auditory processes in such studies, very often in task-specific experimental settings in the acoustic laboratory, have been shaped by the technology of the spectrographic and formant-based methods of acoustic analysis that were made possible by the technological innovations of xxx and others in the Second World War. Saussurean phonology did not, of course, have the benefit of these developments. Indeed, Saussure points to the impracticability of cinematographic techniques for reproducing Òall the movements of the mouth and the larynx while executing a chain of sounds" (CLG: 64). In doing so, Saussure draws attention to two fundamental aspects of the production of speech sounds: (1) their basis in the articulatory kinematics of the speaker; and (2) the cross-modal basis of both their production and reception. That is, the ways in which both auditory and visual information is integrated in the perception and categorization of speech sounds (Fowler 1986: 8; Repp 1987: 4-5). The articulatory movements of the mouth, lips, and so on are gestures which are, in part, visible to the listener. This concurs with the findings of researchers such as Gibson (1986 [1979]) and Berthoz (1997: 86-92) that there is a high degree of synergistic collaboration between, say, seeing and hearing, which function as part of a more global perceptual system whereby the brain-body complex is cross-coupled to its environment.

Further, this provides the basis for a theory of speech sounds which have their basis in vocal tract gestures rather than in abstract phonological patterns per se. In adopting this view, we may better see that all modalities of linguistic semiosis – speech, sign language, writing, braille – are, or derive from, forms of bodily or gestural activity and their technological transformations whose primary function is to coordinate dialogic interaction between individuals (see also Armstrong et al 1996: 80-82).

Let us consider the following passage in which Saussure reflects on the apparent discrepancy between the production of the coordinated movements of the articulators in the vocal tract and the speaker-listener's perception of these as a sequence of acoustic impressions in "the chain of heard speech"

The acoustic given already exists unconsciously when one approaches phonological units; it is by means of the ear that we know what a b, a t , etc. is. If one could reproduce by cinematographic means all of the movements of the mouth and larynx in the execution of a chain of sounds, it would be impossible to discover any subdivisions in this sequence of articulatory movements; one would not know where one sound starts, or where the other finishes. How can it be affirmed, without the acoustic impression, that in Äãl, for example, there are three units, and not two or four? ***(CLG : 63-4)***

In this passage, Saussure acknowledges the spatio-temporal overlap of articulatory units – "it would be impossible to discover any subdivisions in this sequence of articulatory movements; one would not know where one sound starts, or where the other finishes" – at the same time that he distinguishes this from the way this is heard in "the chain of speech" by the listener. Saussure approaches the problem of the apparent variability of articulation by appealing to the "acoustic impression" that this makes on the ear of the listener. This entails a qualitative judgement on the part of the listener as to the ‘homogeneity’ of the acoustic impression. That is, a given sound may manifest considerable acoustico-articulatory variation depending on the specific context of its articulation. However, two sounds may nevertheless be co-classified as belonging to the same phonological type on the basis of the ‘homogeneity’ of the acoustic impression that the listener perceives. This entails a categorizing judgement by the listener as to the conformity of the two sounds to the more schematic criteria which define the phonological type-category in question. Furthermore, Saussure relates this process to the "chain of heard speech", rather than to individual phonemes considered in isolation. The "chain of heard speech" is of course the stratum of the signifier. The acoustic signifier is defined by Saussure as a chain of elements – phonemes, syllables, and so on – whose distinctive character is "succession in time" (CLG: 103). This is the principle of the linearity of the signifier. In the case of the acoustic signifiers of the spoken language system, this principle is concerned with the way the phonemes of a given language system are combined into groups – syllables, etc. – in language specific ways. Saussure shows in the following passage that it is the syllable, rather than the local differences between isolated phonemes, which is central to this process. Speaking of the way in which "binary groups" of phonemes "implicate a certain number of mechanical and acoustic elements which reciprocally condition each other" (CLG: 79), Saussure observes:

If in the phenomenon of phonation there is something of a universal character which announces itself as superior to all local differences among phonemes, it is without doubt this rule-governed mechanism of which we have just spoken. One sees thereby the importance that the phonology of groups must have for general linguistics. Whereas one is generally satisfied with giving rules for the articulation of all sounds, [which are] variable and accidental elements in all languages, this combinatory phonology circumscribes these possibilities and fixes the constant relations among interdependant phonemes. ***(CLG: 79)***

This principle shows that from the perspective of the spoken chain, the phonological units of a given language are neither context-free nor static. Rather, they are linearly ordered in time and distinguished on the basis of the qualitative impressions they make on the ear of the listener. Phonological units – phonemes, and so on – do not have a direct, empirical correspondence with a given physical sound uttered and heard in a given time and place. Phonemes do not then represent in a univocal way any particular physical manifestion (instantiation) of the phonological categories of the language. Saussure's insistence on the qualitative nature of the impressions received by the ear shows, instead, that the phoneme is a meta-level schema or 'rule' which specifies the possible parameters for the production and perception of a given speech sound.

Saussure also emphasises the role that the syllable plays in the perception and interpretation of the temporal succession of units that occur in the

spoken chain of the acoustic signifier. Phonological types, he points out (CLG: 82), are abstractions which cannot form a moment in time." For this reason, the syllable is the more natural unit on which to base this temporal succession of units. In making this claim, Saussure is very much at one with more recent thinking, according to which the syllable "is the basic unit of speech processing because it is used, both to access the lexicon and to analyse the signal into component segments and features" (Mehler and Segui 1987: 406). Further, as Saussure's analyses of the various combinations of explosion and implosion suggest, there are acoustic correlates to syllabic co-articulation (CLG: 83-6). This highlights the meaning-making potential of the phonic signifier. Rather than being a form which simply carries a meaning which is extrinsic to it, the listener's perception and construal of the temporal succession of units in the spoken chain is not exclusively influenced by top-down lexicogrammatical factors that pertain to the signifier. Rather, there is a constant interaction, to varying degrees, of factors that derive from both strata in the making and interpreting of a given sign. Saussure spells out the role of the acoustic signifier and the importance of studying the phonological principles of its organization as follows:

In the act of phonation that we are about to analyse, we shall only account for differential elements, salient for the ear and capable of serving as a delimitation of acoustic units in the spoken chain. Only these acoustico-motor units must be considered; … ***(CLG: 83)***

Saussure points out here how the ear selectively attends to what is semiotically salient in the concrete succession of units in the spoken chain.

Only those units, dually acoustic and articulatory, that make a meaningful difference need be taken into consideration. This passage is interesting for the emphasis which it places on the reciprocal contextualizing relations between the articulatory activities of the vocal tract and the acoustic chain which is perceived by the listener. This shows that, for Saussure, the acoustic signifier is not simply a form which carries a meaning. Instead, the acoustic signifier construes in semiotically salient ways the speaker's articulatory gestures as a delimination of units in the spoken chain. By the same token, the vocal tract activity of the speaker in the act of phonation is similarly motivated in relation to the semiotically salient differences that are perceived by the ear of the listener in the particular phonological groups, rather than abstract types per se, that constitute the signifiers of the spoken language system. In the above passage, Saussure shows, in other words, that one dimension of the overall meaning-making process, i.e., that which is constituted by the signifier, interfaces with and construes in semiotically salient ways the bodily processes of articulation of the speaker. Importantly, Saussure's emphasis on the dually acoustic and motor aspects of the units so construed shows that, semiotically speaking, the theory of the signifier 'faces two ways', viz. to both the speaker and the listener perspectives on this process.

It is only when phonemes are considered as schematic types that they can be said to be static and context-independent. In this way, the articulatory movements of the speaker and the sounds uttered and heard are functionally correlated with the categorizing judgements – the "acoustic impressions" of the speaker-listener. The latter's perception of acoustic homogeneity is a way of tuning the dynamical behaviour of the articulatory movements and their associated acoustic effects to the requirements of a particular system of phonological categories. Again, this is so from both the

speaker’s and the listener’s perspective. Small changes in the articulatory and acoustic parameters due to coarticulation and other factors typically do not lead to bifurcation, viz. a jump to another, distinct category, but only to small changes in the behaviour of related dynamical systems that are, nevertheless, *intra-,* rather than inter-, categorical (Kauffman 1993: 231). In this way, minor fluctuations in the behaviour of the system do not violate the structural stability of the parameters involved (Thom 1975 [1972]).

It is important to note here the temporal character of the acoustic signifier in relation to the movement of the organs of articulation. These represent two hierarchically distinct scalar levels of organization and behaviour operating at different time scales in the one overall system of relations. Thus, the rapid movement of the organs of articulation is not directly translated into the different time scale which operates on the level of the "chain of heard speech", or the acoustic signifier. System variables due to the spatio-temporal overlap of articulatory gestures change on a comparatively fast time scale which exhibits only its averages to the qualitatively different variables which operate on the slower time scale of the ‘homogeneity’ of the acoustic impressions that are perceived by the ear. Saussure’s criterion of the ‘homogeneity of the acoustic impression’ is a means of tuning the dynamical behaviour of the lower scalar level of articulation to the functional requirements of the particular phonological system that speaker and listener share. In this way, the criterion of the homogeneity of impression decomposes the spatio-temporal complexity of the lower level into functionally related units and structures, or configurations of phonological values, at the same time that phonologically non-salient fluctuations are not necessarily attended to or even noticed by the listener. The system of phonological units and structures is the third level in this

scalar hierarchy. It is the meta-level, or the system's description of its own behavioural possibilities.

The 'homogeneity' of the acoustic impression preserves the separateness and the serial ordering of the percepts in the "chain of heard speech" without, however, suggesting that these are discrete and context-free (Fowler et al 1980: 409-10). The fact that vowels and consonants are different kinds of articulatory and acoustic events serves to maintain the separateness of segments in the chain of speech without, however, implying that their articulatory and acoustic properties are discrete or non-overlapping. Saussure takes the chain of heard speech – the acoustic signifier – to be the focal level in his analysis. Each separate acoustic impression in this chain is a part which is functionally related to the whole to which it belongs. In Saussure's discussion, there is no translation from abstract, context-free phonological units, or pre-motor cognitive plans that serve as "the outputs of perceptual processing and as inputs to the articulatory mechanism" (Fowler et al 1980: 376). That is, he does not postulate an internal and *a priori* cognitive plan or model which controls or governs the translation from the degraded acoustic stimulus to the listener's perception of this as a global percept. Saussure presents an alternative to this cognitivist view. It is one which recognizes that the relationship between the mechanical source – the vocal tract – of the vibratory event whereby sound waves are propagated through the medium of the air and the listener's perception of this requires no translation. Rather, the speech sounds which stimulate the ear of the listener are lawfully structured such that they specify to the listener properties that are specific to the articulatory act which produced them. Here is how Saussure expresses this important point:

The freedom to link the phonological types is limited by the possibility of linking the articulatory movements. To account for that which occurs in groups [of phonemes], a phonology is to be established in which these will be considered as algebraic equations; a binary group implicates a certain number of mechanical and acoustic elements which reciprocally condition one another; when one varies, this variation has a necessary repercussion on the others which can be calculated. ***(CLG: 78-9)***

In this non-translational view of the relationship between environmental source (articulatory act) and the perception of the acoustic elements that provide the listener with information about the former, there is no need to translate the descriptive variables operating at one level into those operating at some other level. Instead, relations at the various levels in the overall hierarchy of relations constitute a single system of mutual constraints. This means that the dynamics of the variables at any given level are specific to that level. For example, the descriptive variables that apply at the level of the vocal tract and those at the level of the chain of heard speech are nontransitive in their relations to each other. Rather than translate from one level to another, the nesting of levels in a scalar hierarchy implies a system of mutual constraints whereby the homogeneity of the acoustic impressions in the former is derived from or emerges from the former. Each level has its ontological specificity in the sense that is has units and relations that are particular to that level. Further, the different time-scales that operate on the different levels means that larger-scale entities have a more macroscopic time-scale. Thus, the cogent moments – the acoustic impressions on the ear – in the chain of heard speech last

longer that the articulatory movements that produce them (Salthe 1993: 46).

Speaker and listener must share the same meta-system of possibilities both in order to interact linguistically with each other as well as to internally represent what the other knows about the language system both share. Rather than a set of static and context-free types, a given phonological system has its own system-internal criteria of the way in whicb its units and structures are linearly combined in time. However, this time is not the same as extrinsic, mechanical, clock time. Rather, it is a system-internal time whereby speakers and listeners can make qualitiative judgements as to the acoustic impressions they perceive in heard speech.That is, speaker and listener have internal systemic models of how sounds are combined and classified and how these models are deployed in actual occasions of speaking and listening. In the passage cited above, Saussure draws attention to the criteria of perceptual invariance or homogeneity whereby speech sounds, in spite of variation in their articulatory and acoustic properties depending on context, may be heard as perceptually the same.

In a number of important respects, Saussure's way of posing the problem foreshadows the latter day debate between speech production and speech perception theorists. According to the former, the production of speech sounds involves the spatio-temporal overlap, or coarticulation, of vocal tract gestures in context-dependent ways. According to the latter perspective of linguistic phonologists, the units of speech are described in terms of a set of context-free, static, discrete (non overlapping) and invariant features such as phonemes, syllables, and so on which are serially ordered as

sequences of segments (see Lindblom 1982 for discussion). Thus, the sequence of phonemes in the sequence /ki :/ – *key* – constitutes a functionally organized relation of parts to whole in the word in question. The functional basis of this relationship is further evidenced by psycholinguistic studies of spoonerisms and other speech errors which show that these functional values have psychological reality for users of the language. The paradox arises in the attempt to reconcile, or to understand the relationship between these two levels of description. In other words, it is the problem as to how the acoustico-articulatory variants of speech sounds as they are produced and heard may be reconciled with the invariant units proposed by phonologists. Lindblom cites experimental evidence using spectographic analysis of the acoustic properties of speech sounds and X-ray tracings of articulatory movements to illustrate the very considerable context-dependent variation and spatio-temporal overlap which may characterize the articulation of the same vowel or consonant in different articulatory environments. With reference to the acoustic properties of the initial phoneme /k/ in the words /ki :/ – *key* – and /ku :/ – *coo* – , Lindblom shows that an acoustic definition of the /k/-phoneme "must depend on context". Spectographically, they have different bursts and different aspirated segments, depending on the vowel with which they co-occur in the two words. Further, there is no discrete segmentation of consonant and vowel. It is not easy to determine where one ends and the other begins. Instead, features of the one merge with those of the other. Thus, the vowel "influences the spectral shape of the burst and the consonant modifies the beginning of the vowels as the presence of the formant frequency variations (transitions) shows" (Lindblom 1982: 5). These observations pertain to the acoustic record or trace of the sound. This is a trace of the motor movements in articulatory space-time that produced the sound. These, too, are not discrete and context-free, but involve considerable spatio-temporal overlap.

Saussure does not have the advantage of spectographic analysis of the acoustic properties of speech sounds or X-ray tracings of articulatory movements. However, this seeming disadvantage is also in my view an important advantage in trying to rethink the relationship between the two seemingly incommensurate levels of analysis – the acoustico-articulatory and the phonological – discussed above. How might we rethink this problem? How can Saussure's apparently outdated phonological theory help us?

The observations made here mean that the sign is the means whereby order, pattern, and meaning are construed in the phenomena that we experience through our sensory systems. This is so along both dimensions of the sign's internal design. In the section that now follows, I shall outline the basic principles of Saussurean structuralism with these questions in mind.

Saussure's Dynamic Structuralism, Contextualizing Relations, and Phonological Form.

In a number of important ways, Saussure's phonological theory is an important precursor of the dynamic structuralism which has developed in the physical, life, and social sciences in the past few decades. It is important to distinguish this dynamic structuralism from the formalistic

tendencies of ‘classical’ structuralism in the mid-twentieth century. In my view, Saussure’s theory, which has generally been regarded as the founder of the latter, is, in fact, much more centrally concerned with the former. Petitot-Cocorda (1990 [1985]: 54) points out that classical structuralism, in its preoccupation with a *"generalized reification* of structures, a reification which allowed them to be algebraized" failed to show how the properties of these structures emerged from their physical-material substrate. In other words, it failed to address the central concern of a truly dynamic structuralism, viz. the cross-coupling of the semiotic and the material-phenomenal in the making of meaning. Saussure’s phonology, which I take to be a species of dynamic structralism, is exemplary in this regard. One of the central questions of this dynamic structuralism is the following: how do we recognize structure in the phenomena of our experience? The structuralist answer to this question can be formulated as follows. In our transactions with our environment(s), we assign representations to some abstracted features of these transactions. We construe these as having some unity or structurally stable "form" (Thom 1975 [1972]).

These material-phenomenal features, which are governed by precise laws, afford their pick up by our sensory and neuroanatomical apparatus and for this reason are potentially meaningful for us. The ability to recognize such a pattern of experience is the first level of conscious meaningfulness. The pattern which is so recognized does not so much have an explanatory function as a constitutive one: it constitutes the basis for our recognition of the phenomena of experience. The resulting pattern constitutes a structure.

Such a structure is connected to still higher levels of contextualizing relations through the social semiotic processes and activities which are enacted in a given culture. The ability to recognize such patterns in experience is the ground of all semiosis. Semiosis (cf. *parole)* is always both a material and a semiotic process, simultaneously. Any given semiotic act is always a cross-coupling of both semiotic-discursive and material-phenomenal relations and processes. It has consequences in both domains in so far as the contextualizing relations which such cross-couplings entail enact and coordinate flows of matter, energy, information and meaning in socially and culturally relevant ways.

The phonological forms of a given language system have no phenomenal existence. They are not immediately given to our senses. The question arises as to how such non-phenomenal forms organize the matter, energy, and information exchanges in and through which we transact with our social and material environments? What is the nature of structure? I shall try to answer this question as follows.

Structuralist analysis is concerned with second- (and higher-) order contextualizing relations. It is interested, above all, in the patterns that are construable among the ‘entities’ in a given phenomenon. It does not, for this reason, consider the physical-material substrate of the interaction to be a ‘truer’ or ‘superior’ reality, i.e., one in which, following positivism, the only significant relations are those between observable entities available to our sense perception. These are what western culture defines as zero-order realities, i.e., the observable ‘things’ of positivism.

Structuralist analysis does not seek to represent structure as such, but the relationships that define what the structure of something is. Relationships between what? Not between ‘things’ or ‘entities’ for, in the final analysis, these are themselves always relationships. The decision to call something an ‘entity’ in a given instance is always a result of the theoretical and practical contingencies of that particular analysis. However, a given structuralist analysis always postulates a level of first focus (Lemke 1984: 35). This is the level of the ‘entities’ which are taken to be the ground for the analysis of a particular pattered relationship. For the above reasons, one of the fundamental *a priori* of structuralism is that structures are relational. In the very earliest stages of infant proto-semiosis, the infant’s vocal tract gestures are restricted to holistic opening and closing gestures of the vocal tract. The vague and very general possibilities of this early stage give way to the increasing determinability of a full-fledged language system. As Fowler (1986: 4) points out: "Were each word to consist of an holistic articulatory gesture rather than a phonotactically organized sequence, our lexicons would be severely limited in size." In Saussure’s analysis of speech sounds, the chain of heard speech is the focal level. This is the level of the qualitiative impressions perceived by the listener. However, these focal level dynamics are made possible by the lower-level dynamics of both the vocal tract gestures of the speaker (efficient cause) and the resulting propagation of sound energy through an information medium such as air (material causes). Further, the focal level dymanics are interpreted and regulated by the higher-level dynamics – the boundary conditions- of a phonological system which constrains and entrains the lower level dynamics in determinate ways. The imposition of boundary conditions means that the microscopic physical-material processes of the lower levels are always interpreted from the macroscopic (cf. morphological) perspective of an observer and his or her system of

interpretance. This follows from the fact that the observer imposes form and structure on the material-phenomenal world by means of the categories provided by some semiotic system. Such form and structure cannot inhere in the source – the neurophysiological processes of articulation – of the microlevel dynamics involved because these microlevel dynamics cannot be said to have a viewpoint which is comparable to the macroscopic scale of the observers's (phonological) categories.

Saussure's phonology demonstrates the centrality of contextualizing relations to Saussure's dynamic structuralism. Neither the lower level phonic terms nor higher level phonemes are substantive 'entities'. Saussure is concerned to analyse the contextualizing relationships that define what a particular phoneme is. The phoneme is always a relationship between some contextually constrained configuration of phonic terms. In Lecture 3, I was concerned to examine how these considerations relate to the phoneme in Saussure's phonology. In the present discussion, I am more interested in establishing the basic principles which are at stake in the way phonological form contextualizes and entrains the acoustico-articulatory domain in determinate ways as a given phonic substance.

Phonic terms such as [+nasality], [-nasality], [+laryngeal vibration], [-laryngeal vibration], and so on refer to an emergent level of phenomenal experience in the acoustico-articulatory flux. They are the level of first focus of Saussure's phonology (see above). Phonic terms are not, however, 'entities' which have some irreducible substantial unity. As the level of first focus in Saussure's phonological theory, they are the perceptible phenomena, or the first level of contextualizing relations, which are

required for the explanation of higher level phonological categories and relations. More precisely, they refer to the informational variants and invariants which our psycho-perceptual apparatus enables us to extract from the acoustico-articulatory flux. The acoustico-articulatory phenomenon to which the linguistic gloss [+nasality], for example, refers does not correspond to any phoneme category in the phonological system of any language. The phonic term, or feature, is a difference that potentially makes a difference to the participants in some ecosocial system.

However, participants do not 'directly' perceive this informational invariant as such. Instead, bundles of phonic terms, rather than individual ones, are selectively contextualized as instances of the phonological categories of a given language system (see Lecture 3). There are not, therefore, two stages in which the perception of acoustic stimuli is primary and social semiosis is simply added on to the original experience. The morphological properties of the phenomenal world do not make a difference in any significant way independently of the higher order processes of social semiosis with which they are cross-coupled.

Saussure's Phonology and the Form-Substance Dialectic.

Saussure's phonological theory represents a major attempt to work through the implications of this point of view for his overall theory of the sign. This means that Saussure's phonological theory constitutes an integral part of his overall theory of the language system in relation to social meaning-

making in *parole.* In particular, his phonological theory shows how the phonic stratum of the sign-relation, or the signifier, parallels the conceptual stratum of the signified in its internal design and functioning. Further, this parallelism of signifier and signified is also reflected in their relations with phonic substance and what I shall henceforth designate as thought-substance, respectively.

Saussure’s discussion of the relationship between "phonic substance" and the signifier illustrates this principle very clearly:

Psychologically, abstracted from its expression in words, our thought is no more than an amorphous and indistinct mass. Philosophers and linguists have always agreed in recognizing that, without the aid of signs, we would be incapable of distinguishing two ideas in a clear and constant fashion. Taken on its own, thought is like a nebula where nothing is necessarily delimited. There are no preestablished ideas, and nothing is distinct before the appearance of the language system.

In the face of this fluctuating realm, do sounds present themselves as entities circumscribed in advance? Not at all. Phonic substance is neither more fixed nor more rigid; it is not a mould to which thought must necessarily fit the forms, but a plastic material which divides in turn into distinct parts in order to provide the signifiers which thought needs. We can therefore represent the overall linguistic fact, that is, the language system, as a series of contiguous subdivisions simultaneously

traced *[dessinées]* on the undefined plane of confused ideas (A) and on the no less indeterminate plane of sounds (B); this may be represented very approximately by the schema:

The characteristic role of the language system vis-a-vis thought is not to create a material phonic means for the expression of ideas, but to serve as intermediary between thought and sound, in such a way that their union necessarily brings about reciprocal delimitations of units. Thought, chaotic by nature, is forced to become precise in being segmented. There is then neither the materialisation of thoughts nor the spiritualisation of sounds, but it is a question of this in some ways mysterious fact that "thought-sound" elaborates its units while constituting itself between two amorphous masses. ***(CLG: 155-6)***

Phonic substance is not simply a material carrier or vehicle of language form. It is not acoustic medium which "embodies" language (c.f. Abercrombie 1967: 1). Rather, it is selectively contextualized by the language system *[langue]* so that some "divisions" rather than others are seen as meaningful in relation to other "divisions", as well as in relation to the overall language system (see Lecture 3, Section 8 for further discussion).

Phonic substance refers to the way in which the analog continuum of the acoustico-articulatory domain is selectively contextualized so that not all possible relations and combinations of sounds are salient or possible in a

given language system. Phonic substance, in other words, refers to the way in which phonologically salient distinctions emerge from the analog continuum of the acoustico-articulatory information produced by the vocal apparatus. Phonological form (the signifier) categorizes this as significant "divisions" in a given language system. In other words, phonological form construes the analog continuum referred to above as a semiotically formed phonic substance, relative to a given language system.

The vocal apparatus is an analog continuum in precisely this sense (see also Lecture 3, Section 2). Saussure describes the vocal apparatus and its functioning as a topological space (CLG: 66-70) which may be subdivided into a number of articulatory parameters. Saussure schematizes these parameters in relation to the diagram which is reproduced in Figure 1, as follows:

INSERT FIGURE 1 HERE

"For the description of the apparatus, we shall confine ourselves to a schematic figure, in which A designates the nasal cavity, B the oral cavity, and C the larynx, containing the glottis between the two vocal cords.

"In the mouth it is essential to distinguish the lips à and a, the tongue á — (á designating the tip and all the rest), the upper teeth d, the palate,

consisting of an anterior part f-h which is bony and inert, and a posterior part i, which is soft and mobile , and finally the uvula ë.

"The Greek letters designate the organs which are active in articulation, the Latin letters the passive parts". ***(CLG: 66-7)***

In effect, the vocal apparatus is an analog continuum of acoustico-articulatory parameters defined by the deformations and movements of the speech organs, respiratory tract rate and volume of inhalation and rate of exhalation, as governed by factors such as speech loudness, phrasing, and articulation, and so on.

Phonic substance, in Saussure's account, is not an objectified and meaningless physical reality in the Newtonian sense. Instead, phonic substance designates the perceptual phenomena – the "object of consciousness", as Merleau-Ponty (1983 [1942]: 145) would call it – that emerge through the application of the phonological categories belonging to phonological form to the analog continuum of the acoustico-articulatory flux. Phonological form only has meaning in so far as it categorizes the emergent phenomena of experience in phonic substance. It does not have an 'autonomous' existence as such.

A precisely parallel situation also exists between the signified and what Saussure calls "thought". "Thought" is the conceptual analogue of phonic substance in Saussure's account. It is for this reason that I have elected to use the term 'thought-substance' in order to suggest this parallelism. The distinction which Hjelmslev (1969 [1943]: 57-60) subsequently made between expression-substance and content-substance made this parallelism clearer.

In Saussure, "thought" refers to the way in which significant conceptual differences emerge from the analog continuum of the things, events, states, and so on that constitute the perceptual phenomena of the world we live in. Thought-form (the signified) categorizes these as significant conceptual "divisions" in a given language system. In other words, the signifier construes the analog continuum of the perceived world as a semiotically formed 'thought-substance' relative to a given language system.

Saussure does not say that the extra-linguistic domain per se is formless, shapeless, or unstructured. There has been a good deal of misunderstanding on this point. Saussure claims that it is "thought" "without the aid of signs" which is "amorphous and indistinct". Saussure's use of the experiential adverbial adjunct "psychologically" [psychologiquement] is most important in this connection. 'Psychological', as distinct from 'psychic', is a subjective and non-semiological principle in Saussure's conception. On the other hand, the sign is a psychic phenomenon which enables speakers and hearers to mutually orient to the meanings and values of events in the speech circuit by virtue of their cross-coupling with the higher-order social-semiological system of *langue* (Thibault 1997: chap. 6). 'Psychological' is,

then, equivalent to ‘pre-semiotic’ in Saussure’s theory. In this paragraph, Saussure makes it clear that extra-linguistic reality is not seen as an unstructured heraclitean flux onto which form is subsequently projected by an intentional consciousness, psychologically defined.

From Saussure’s point of view, ‘thought without the aid of signs’ is the analog continuum of conceptual differences which the signifieds of a given language system reconstrue and categorize as the emergent phenomena of thought-substance. In this way, the emergence of a semiotically formed thought-substance is tantamount to the imposition of informational closure on an analog world (Salthe 1993: 134). There are no digital distinctions in the domain calls ‘thought without the aid of signs’. This explains Saussure’s choice of the epithet ‘amorphous’ to describe it. It is ‘amorphous’ in the sense that it has not been semiotically formed as a thought-substance in relation to the conceptual categories of a given language system. Thought-substance, in other words, may be referred to as ‘thought with the aid of signs’. Thought-substance refers to the cross-coupling of the material-phenomenal domain which we perceive through our various sensory systems with the conceptual categories (the signifieds) of a given language system. The analog continuum of the matter-energy processes of the former is cross-coupled with the digital distinctions of the latter. For this reason, substance is both analog and digital. Hjelmslev’s notion of content-purport suggests this same line of reasoning (1969 [1943]: 50). Thus, Saussure’s ‘thought without the aid of signs’ refers to a phenomenal-material level of reality ‘before’ it has been construed as a specific thought-substance, relative to a given language system. This ‘before’ is a logical, rather than a temporal relation.

Saussure’s point of view resonates very well with Gerald M. Edelman’s argument that the world is an unlabelled placed. A given language system integrates the vaguer possibilities of ‘thought’ and ‘sound’ into a more determinate system of categories. The generalities, the relative disorderliness of ‘thought’ and ‘sound’ become increasingly specified as a more ordered system of conceptual and phonological categories. For example, experimental evidence suggests that the highly specified phonological categories of a given language system derive, in ontogeny, from an initial distinction between a holistic opening and closing gesture of the vocal tract (Fowler 1986: 4). Thus, these rather general initial possibilities of the neonate become integrated, in the course of its further development, into an ever more specified system of categorical possibilities. In this way, the developing individual achieves ever more precise controls over the meaning-making potential of his or her own body. That is, the emergence in the individual of a full-fledged phonological system means that he or she has more stored phonological information as a basis for constructing oneself as a signifying individual.

However, I disagree with Repp and others who argue that it is a question of the relationship "between stimulus properties and precompiled knowledge structures" (Repp 1987: 11). However phonological information might be stored in the brain, it seems necessary in my view to be able to account for statistical fluctuations during development as well as information obtained from accidental or contingent events in the developmental trajectory of the individual (Salthe 1993: 175). In my view, Saussure’s view of memory as associative, rather than hard-wired, is consistent with such a view. Thus, the indeterminate and open ended character of associative relations (CLG: 174) does not rely on all-or-nothing distinctions which are already fixed in memory. When Saussure says of associative relations, "A given term is like

the centre of a constellation, the point at which other coordinated terms converge, the sum of which is indefinite" (CLG: 174), we may see the terms – phonic or conceptual – as attractors in specific networks of relations. These attractors are memories and categories which are held by the neural networks in the brain. An associative network in Saussure's sense is always 'content addressable', irrespective of whether it is concerned with conceptual or phonic 'content'. This means that a given network of associative relations constitutes a 'basin of attraction' (Kauffman 1993: 228) for any specific memory or term, either conceptual or phonic. Therefore, the activation of any term in the given associative series means that the entire system of relations has the potential to flow by virtue of the dynamics of the entire network of associations to the particular term or category which acts as the attractor – the 'centre of the constellation' – for the entire series. The attractor would be the schematic category or categories which constitute the basis of co-classification for all of the terms that belong to a given series. Saussure suggests that the associative series in memory naturally classify and generalize, to paraphrase Kauffman (1993: 228). That is, all of the terms in the same series converge on the same attractor – the same schematic category or term – and in this way are co-classified as having some feature or features in common, or as being instantiations of the same schematic category. Kauffman points out that for this to occur – i.e., for "similar things to be classified as the same", or for neighbouring states to flow to the same attractor – it is necessary that the dynamical behaviour of the associative network as a whole be ordered rather than chaotic (Kauffman 1993: 228). There is nothing natural or inevitable about their flowing to the same attractor.

In Saussurean terms, it is important to point out here that associative relations or solidarities constitute one of the two principles of order –

syntagmatic relations being the other – which constitutes a "partial correction of a naturally chaotic system" (CLG: 182-3), as Saussure, in a remarkable anticipation of the way of thinking under discussion here, puts it. Following the work of Rummelhart and McClelland (1986), Kauffman proposes that learning is the "general mechanism" which "converts chaotic attractors to orderly ones" by affecting the weighted connections among the terms in the network.. However, the parallel processing approach of Rummelhart and McClelland, which is based on the notion of learning as information processing, does not show how observer-dependent criteria of interpretation are responsible for the elaboration of the information in the network as *meaning.* That is, the individual agent-observer, as Edelman (1989: 40) points out, adapts this information so as to selectively re-contextualize an 'unlabelled world' as meaningful. Meaning is not hardwired in neural networks. Rather, the associative networks proposed by Kauffman are coding devices for the specification of the weighted valuesof the variables – cf. terms – in the network.. Saussure's notion of associative relations is, of course, a linguistic, rather than a neural, construct: it posits no biological basis for explaining the neural architecture and mechanisms which underlie these linguistic phenomena, as they are stored and activated in the individual's brain Edelman (1989: 40) points out that no amount of description of these mechanisms can in itself explain meaning. Saussure's associative networks allow for meaning-based criteria of individual variability which are observer-dependent. Further, the associative networks of Saussure derive from the system of *langue,* which is the historically changing product of the collective activities of some socio-cultural group. Meaning is implicit in these activities and in ways which are not reducible to pre-wired neural mechanisms, or to a world which is already arranged into pre-existing categories of objects, events, and so on. The flexible and open ended character of associative relations provides a resource whereby speakers contextualize the analog world of 'thought' and 'sound' as meaningful, and in ways which selectively act on "preexisiting

variation at each level of neural structure" (Edelman 1989: 41) in the individual’s brain.

A Note on Associative Networks and Verbal Paraphrasia.

The arguments presented above in relation to associative networks may also help to shed light on the problem of verbal paraphrasia, or choice of the wrong word, which occupied the thinking of early neurologists such as Lichtheim and Wernicke in the tradition of the localization of brain functions, and Hughlings Jackson, Freud, and Pick in the holistic tradition. Verbal paraphrasia is considered to be a primary symptom of the various types of aphasia that were the focus of the pioneering neurological studies the researchers named above. Here is Pick on the question of verbal paraphrasia :

In verbal paraphrasia [choice of the wrong word], the word determined by thought and by the sentence pattern is inwardly present, or at least there is an intention in this direction, but this normally rigid determination is loosened up. The coherence is not firm enough to maintain the normal suppression of words evoked by association from the sphere of meaning, from parallel lines of thought, or by other sorts of confusion, and thus it leads to the transmission of one of the inapposite words to the speech mechanism … the effect of the intact part of the speech process (especially the sentence pattern) on the wrong word is sometimes evidenced as a

grammatical modification derived from the correct word. ***(Pick 1973 [1931]: 56)***

Paraphasias frequently result in phonemic disortions of the target lexical item. They are caused by a failure to select the correct sound structure, rather than a failure of the motor control apparatus involved in articulation. Saussure emphasised the psychic, or intentional, nature of the speaker-listener's acts of meaning-making in the speech circuit (Thibault 1997: chap. 6). That is, the psychic nature of this process constitues the organizing principle in terms of which 'thought' and 'sound' are selectively re-contextualized in and through the signs of a given language system so as to express an intended meaning. The associative networks in the individual's memory enable him or her to both interpret the world and to interact with it in coherent and organized ways. This depends on the fact that similar contexts are represented or classified as being the same by the networks. This means that the individual has a stable yet flexible and adaptable resource for organizing his or her linguistic responses to the world. A breakdown in the organization of these networks due to damage to the underlying cortical areas in the neural substrate, as in the various types of aphasia, may mean that this stability gives way to a chaotic, rather than an orderly, regime in which "arbitrarily nearby points in state space of the associative networks, PJT] map to arbitrarily different attractors" (Kauffman 1993: 233). In the stable regime, on the other hand, the "normal suppression of words" identified by Pick takes place because the terms in the various associative networks which are involved in the selection of a particular linguistic item flow to the same attractor, thereby allowing the network of choices to converge, for example, on the correct phonemic pattern. In the pathological cases studied by Pick, conceptual terms from, say, the same "sphere of meaning" may arbitrarily flow to the wrong

attractors in the sphere of the phonic terms, thus leading to the articulation of the wrong word. Consider the following example, taken from an aphasic patients recount of the events surrounding his first stroke:

On the day it happened I got on the Friday morning and just collapsed on a belt at the uh hospital. ***(borrowed from Armstrong 1996: 168)***

In this example, the lexical item *belt* is a paraphrasia for what clearly should have been *bed* in the hospital context referred to by the speaker. The phonological similarity of the two items suggests that the conceptual terms which constitute the signified of the word *bed* arbitrarily map onto the phonic sequence which constitutes the signifier of *belt,* or, alternatively, that the "normal suppression" of the conceptual terms associated with the signified of *belt* does not occur, leading to the mapping of two different pathways through the networks of conceptual terms onto the same sound structure. Language in the brain is meaning based (Peng 1997: 32 ; Harré and Gillett 1994: 80-97). As I argued in Lecture 3, Section 2, vocal and other semiotic modalities of gesturing are the means of coordinating the paricipants for the purposes of dialogic interaction. Brain damaged speakers such as the individual featured in the above example may well know what meaning they intend to express. However, their inability to select the correct sequence of phonemes on the basis of which there is a systemic association with a conceptual signified means that the listener's ability to reconstruct in his or her brain the same or approximately the same association of signifier and signified is handicapped. That is, the first-order contextual relations (signifiers) which the speaker provides the listener do not provide an adequate basis for their reconstrual as the contextually

appropriate second-order signifieds which may be assigned to the phonological sequences permitted by a given language system.

The terminological distinctions I have made here are a further refinement of the sometimes latent distinctions in Saussure's own use. Saussure does not actually use the term 'thought with the aid of signs', or its corrollary 'thought-substance'. However, the distinctions I have drawn here follow from the initial qualification that Saussure makes with respect to 'thought without the aid of signs'. It follows, therefore, that there is also 'thought with the aid of signs', which I see as synonymous with thought-substance.

The arguments I have made in the two preceding paragraphs are also pertinent to phonic substance. What is the relation of phonic substance to 'sound with the aid of signs' ? Is this the same as phonic substance ? In Saussure's view, 'sound without the aid of signs' refers to the the analog continuum of phonic differences which the signifiers of a given language system reconstrue as the emergent phenomena of phonic substance. In phonic substance there are both analog differences and digital distinctions. Saussure's term 'amorphous' describes the analog continuum of differences in 'sound without the use of signs'. This is what Hjelmslev referred to as expression-purport:

We can, for example, think of a phonetico-physiological sphere of movement, which can of course be represented as spatialized in several dimensions, and which can be presented as an unanalyzed but analyzable

continuum — for example on the basis of Jespersen's "antalphabetic" formulae. In such an amorphous zone are arbitrarily included in different languages a different number of figurae (phonemes) since the boundaries are laid down in different places within the continuum. An example is the continuum made by the median profile of the roof of the mouth, from the pharynx to the lips. In familiar languages this zone is usually divided into three areas, a back k-area, a middle t-area, and a front p-area. If we consider only the stops, however, Eskimo and Lettish, among others, distinguish two k-areas, whose lines of division do not coincide in the two languages. Eskimo places the boundary between a uvular and a velar area, Lettish between a velar and a velo-palatal area. ***(Hjelmslev 1969 [1943]: 54-5)***

Saussure's 'sound without the aid of signs', on the other hand, is not "amorphous" per se, but in the sense that no specific language system has 'analyzed' it. This acoustico-articulatory space is what Hjelmslev designated as expression-purport. That is, the phenomenal-material level of the acoustico-articulatory domain 'before' it has been construed as a specific phonic substance, relative to a given language system. The topological basis of the phonological categorization of this space is discussed in Lecture 3, Section 6.

The domains Saussure calls "thought" and "sound" suggest, then, that the extra-linguistic world is already qualitatively structured as potential phenomena of experience. These afford their reconstrual as semiotic values relative to a given social-semiological system. That is, both "thought" and "sound" are emergent phenomena of experience. They do

not have form imposed on them by a subjective (psychological) consciousness which remains disjoined from a meaningless and shapeless object world. Instead, forms emerge from the self-organizing character of the matter, energy, and information flows that move through the system and which maintain it.

Both ‘sound without the aid of signs’ and ‘thought without the aid of signs’ refer, then, to this phenomenal-material level of reality, relative to the two strata of the sign-relation. They do not refer to an objectified and meaningless physical reality in the classical sense. Both of these domains are phenomenal-material in character. For example, both the continuous spectrum of qualitative, analog differences "made by the median profile of the mouth" or by the vocalic continuum, as described by Hjelmslev, are analog differences in the "amorphous" domain of ‘sound without the aid of signs’. This domain is in turn digitalized as a specific phonic substance by the phonological distinctions (categories or phonemes) of a given language system.

Analogously, we perceive the material-phenomenal world through our various sensory systems by means of a continuous spectrum of qualitative, analog (morphological and informational) differences in the ambient energy (acoustic, optical, olfactory, haptic, and so on) that surrounds us. Once again, the analog differences in the perceived world may be digitalized as a specific thought-substance, relative to a given language system.

The original distinctions made by Saussure, Hjelmslev's refinements of these, and the more recent insights provided by the morphology of forms may be summarised in Table 1:

Saussure	**Hjelmslev**	**Morphology of Forms**
thought (without the aid of signs);	content-purport	morphological organization and informational differences in material-phenomenal domain of perceived 'inner' and 'outer' experience; analog continuum of precepts
thought-substance	content-substance	semiotically construed phenomena of experience; cross-coupling of semiotic and material domains in *parole ;* analog-digital
signified	content-form	value-producing experiential categories intrinsic to language as pure form; digital distinctions in *langue*
sound (without the aid of signs)	expression-purport	morphological organization and informational differences in acoustico-articulatory flux; analog continuum
phonic substance	expression-substance	semiotically construed speech sounds; cross-coupling of phonological form with acoustico-articulatory flux; analog-digital
signifier	expression-form	value-producing phonological categories intrinsic to languageform; digital distinctions in *langue*

Table 1: Form, substance, and the material-phenomenal; Saussure, Hjelmslev, and modern theories of morphological organization compared.

The terms which belong to the two orders of difference are not, strictly speaking, linguistic to start with. Both phonic and conceptual terms are emergent phenomena of experience. That is, they are phenomenal, rather than linguistic, in character. Phonic and conceptual terms are linguistic glosses on emergent forms of experience in the domains of ‘sound without the aid of signs’ and ‘thought without the aid of signs’, respectively. Saussure’s description of these two domains as "two amorphous masses" does not mean they are formless. Neither of these domains refer to the objectified physical domain which physicists describe in the language of electrons, atoms, and molecules. This is the physical substrate of the two domains under discussion here.

The two domains in question depend on the lower level physical substrate for their existence, but they are not reducible to it. The physical substrate is a lower order of organization in a complex hierarchy of levels. ‘Sound without the aid of signs’ and ‘thought without the aid of signs’ are emergent phenomenal levels of organization: they have all the properties of the lower level substrate, but they also have newly emergent ones that are not reducible to or explainable in terms of the lower level. The emergent properties of this phenomenal level are the basic forms of experience. Rather than the language of electrons, atoms, and molecules, this level is described in the language of morphological organization and informational properties. It is this level with which the psycho-perceptual apparatus of the individual cross-couples.

Petitot-Cocorda borrows the neologism ‘pheno-physics’ from Per Aage Brandt to describe this emergent morphological level of organization. The ‘pheno-physics’, thus, emerges from the fundamental ‘geno-physics’ which is the substrate of the former:

The concept of a qualitative macroscopic physics of forms, of a morphological physics, of a pheno-physics, henceforth belongs, then, to the concept of objective reality. According to us, this fact has indispensable consequences for cognitivism. In effect, the hypothesis can henceforth be made that the morphological constitutes an intermediate term between the physical and the symbolic: it is physical (emergent) in origin but without for all that being material; it is formal but without being for all that symbolic (it is topologically and geometrically formal and not logically formal). This consideration makes the following dual hypothesis legitimate:

(i) there exists morphological and qualitative information which is present in the external world and which, while being entirely physical in origin, is nevertheless phenomenological in nature and, as such, intrinsically meaningful [significative];

(ii) this morphological information is reconstituted after transduction and serves as the basis of properly high-level symbolic, cognitive and semiotic processes.

(Petitot-Cocorda 1994: 23-4; emphasis in original; my translation)

The morphological and informational level of organization referred to by Petitot-Cocorda constitutes the ground of human experience and human social meaning-making. Our sensory systems cannot detect the lower level physical substrate of atoms, molecules, energy waves, and particle transmission. The emergent properties of the morphological and informational level constitute a self-organizing system. They constitute the first-order patterns of difference that make a difference to the human organism in some ecosocial environment.

The emergent phenomena of articulation are not, therefore, the phenomenal appearance of a more ‘real’ physical substrate which is the ’cause’ of these phenomena Petitot-Cocorda, 1985: 102). This material-phenomenal level is not reducible to the lower level physical substrate. Saussure’s phonological theory is, instead, guided by the necessarily complementarity nature of the relations between form and substance (see section 5).

This morphological level of organization, as Petitot-Cocorda (1994: 23) points out, emerges from the physical substrate. It is a macroscopic domain which is phenomenologically dominant with respect to the microscopic physical substrate. The point is that this level of organization specifies

information about the environment to the observer (speaker-hearer). Such information concerns, most centrally, the embodied nature of the meaning-making subject in relation to the material-phenomenal world.

Phonic terms such as those mentioned in section 3 contextually constrain this morphological level of organization by introducing differences into the analog continuum. These are analog differences, rather than digital distinctions. A given phonic term is not a categorial distinction. It does not correspond to a given category of phoneme. Phonic terms provide information relative to the articulatory process. Each term designates a specific parameter of articulation relative to a given acoustic cue. A given configuration of phonic terms functions to control or constrain the global perception of the acoustic impressions – the percept – which the ear receives. The acoustic image regulates the hearer’s perception of the acoustic impressions received by categorizing them as global percepts which correspond to the phonological values which the phonemes in a given language system have.

Jean Petitot-Cocorda (1990 [1985]: 42-3) has discussed this problem in terms of "phonetic perception", which Petitot-Cocorda claims is categorial. Petitot-Cocorda draws on the work of Didier Pisoni (1979; see also Pisoni and Luce 1987). In particular, he uses Pisoni’s notion of "acoustic cue" to explain how phonetic sounds "depend on a small number of parameters, called acoustic cues" (1990 [1985]: 43; my translation). Petitot-Cocorda points out that tests have shown that subjects subordinate the discrimination of phonetic stimuli to their (categorial) identification. This proves, Petitot-Cocorda argues, that it is identification which categorizes

the audio-acoustic continuum as discrete and stable sound percepts in relation to the phonological forms of a given language system. As such, they are categories immediately given to perception and for this reason they possess a psychological reality.

It is worthwhile reflecting on Saussure's choice of the epithet "amorphous" [amorphes] to describe these two domains. The French word *amorphes* has, potentially, the following two meanings: (1) 'passive', 'lifeless', 'spiritless', with reference to persons; and (2) 'amorphous', in the geological sense. The two meanings are highly suggestive in the present context. Human beings do not live in the objectified world of atoms and molecules. This level of physical reality is not self-organizing. Neither atoms nor molecules have individual characteristics, or histories that matter to their behaviour (Lemke In Press [1995]: 9). By definition, this level of reality is "passive", "lifeless", and "spiritless" from the point of view of the ecosocial reality in which humans live. Human perception and activity are oriented or intentional in the sense defined by phenomenologists such as Brentano, Husserl, and Merleau-Ponty. In Saussure's terms, perception and semiosis are psychic acts, as I pointed out above.

The combining of terms from the two orders of difference in the making of a sign is an instance of some social-semiological practice in a given community. The resulting sign, seen as a pure form, is a semiotic type in that community. But in *parole* actual instances of the type are enacted in and through their cross-coupling with physical-material processes. The internally stratified nature of the sign is functional in cross-coupling it with the neurophysiological processes of articulation and with the phenomena of

experience (events, states, objects, and so on) in the material-phenomenal world which are perceived by our sensory systems. This means that every act of parole participates in two systems of relations, simultaneously. As a semiotic act, it enters into meaningful relations with other social-semiological relations and practices in the community. As a material event, it enters into relations of matter, energy, and information exchange with events in the acoustico-articulatory and the material-phenomenal domains that Saussure calls ‘sound without the aid of signs’ and ‘thought without the aid of signs’, respectively.

Saussure’s discussion of the two interfaces that link the sign to these two material-phenomenal domains is an attempt to theorize the unitary nature of the cross-coupling of the social-semiological with the material-phenomenal. This is reflected in Saussure’s terminological choices. Thus, phonic substance and thought(-substance) are not described as if they were entirely separate and independent physical-material domains in the objectified and physicalist sense of Newtonian physics. Rather, the very terms Saussure uses indicate that these are defined in relation to the internally stratified nature of language form. Phonic substance is defined in relation to the phonological categories internal to the signifier; thought-substance in relation to the conceptual categories internal to the signified. Substance and form are, therefore, reciprocally organized in relation to each other.

Substance and form are hierarchically organized levels of organization in a unitary ecosocial system. This unity is a result of the cross-coupling of the two domains in social semiosis. The reciprocal effects of these cross-

couplings produce the emergent phenomena of experience. The two strata of language form each have their internal regularities whereby the material-phenomenal world is reconstrued or interpreted according to the phonological and conceptual categories of a given language system

‘Sound without the aid of signs’ and ‘thought without the aid of signs’ are "amorphous" only in so far as they are not cross-coupled with the meaning-making practices of some community. What really matters, as Saussure shows, is how form and substance are interdependent. It is the interdependency of the two which generates order, pattern, and meaning. Saussure’s term "amorphous" refers to a system whose elements are only weakly coupled. Such a system is low in order, pattern, organization and information. "Amorphous" suggests equilibrium, homogeneity, lack of diversity, and stability.

On the other hand, the semiological cross-coupling of form with both ‘sound without the aid of signs’ and ‘thought without the aid of signs’ produces increased differentiation, complexity and ordered heterogeneity. A social-semiological system such as *langue* is an open, rather than a closed and autonomous, system. The cross-coupling of form with the material-phenomenal in social semiosis means that social-semiological systems exchange matter, energy and information with their ‘external’ environments, i.e., the two interfaces in question.

More precisely, this happens when users of the system deploy its resources in acts of *parole* to construe informational and morphological variants and invariants in the phenomenal-material world of experience. At the same time, the system generates cultural meanings and values whereby material-perceptual phenomena are entrained, organized and made meaningful in a given community. The self-organizing character of a social-semiological system is a result of the system's transactions with its environments by virtue of the cross-coupling mechanisms that interface the two strata of language form with the material-phenomenal world. In relation to the kinetic-bodily interface of articulation, phonological form (cf. the signifier) entrains and coordinates these bodily processes according to the structuring requirements of a given phonological system. In this way, the individual's vocal tract gestures are motivated in relation to the symbolic requirements of a shared system of social meaning-making.

Phonic substance and thought-substance are the two interfaces that cross-couple the individual to his or her immediate ecosocial environment. They have no subjective psychological or mentalistic status in Saussure's theory. Instead, they refer to principles of order, information, and pattern which are generated by the cross-coupling of the individual to the environment. That is, they are generated by the dynamics of the system as a whole. From the point of view of the individual, he or she is endowed with specific neuroanatomical capabilities which allow vocal tract activity to take place (cf. firstness). However, the individual's cross-coupling to the ecosocial environment generates semiotic and material 'friction' as the self comes up against and interacts with the non-self (cf. secondness). In turn, the possibilities for such interaction to take place are mediated by a higher-order social semiotic system of possibilies and constraints such as *langue* (cf. thirdess). Thus, the indexical necessities of secondness –

the interaction of self and non-self – are expanded by the symbolic possibilities afforded by thirdness (see section 6 below).

The immediate environment in which this occurs is the speech circuit. The speech circuit is a microlevel ecosocial environment comprised of the two individuals in Saussure's diagram. It is, by definition, concerned with *parole*, rather than langue. The microlevel environment of the speech circuit is cross-coupled to a higher order social-semiological system which is implicit in the many different acts of *parole*that are enacted over time in a given community (Thibault 1997: chap. 6).*langue* is a higher-order environment which regulates the transactions in the immediate ecosocial environment of the speech circuit.

Phonic substance and thought-substance are the two boundaries or interfaces that cross-couple the individual to the environment. They are the boundaries across which the individual exchanges energy and information with the environment. Along the acoustic-articulatory interface, the individual speaker projects acoustic-articulatory patterns into the contexts in which one interacts with one's fellows. Along the phenomenal-perceptual interface, the individual picks up information about the environment through his or her sensory systems.

However, the cross-linking of individual to environment is not an individual activity. There is also the social-semiological dimension. The cross-coupling of the two strata of language form (the sign) with phonic substance and

thought-substance means that phenomenal-material patterns are, in turn, linked to the higher-order social and cultural practices of the community in and through the social meanings that are assigned to them. It is not the case that language form imposes order on an otherwise shapeless reality. Saussure does not say that language imposes order in a univocal way.

Rather, the system of pure values is a system of contextualizing relations. It is not a purely formal calculus which is based on logico-combinatorial principles. The language system provides criteria of preferential salience (c.f. values) for construing and contextualizing the phenomenal-material patterns of experience in ways that are relevant to the cultural practices of the community. In this way, morphological and informational differences in the phenomena of experience are linked to and shaped and entrained by the system of social-semiological relations and practices in some community.

We see how along both dimensions of the sign's internal design a psychic principle of form works to operationalize 'sound without the aid of signs' and 'thought without the aid of signs', respectively. These are emergent phenomena of experience rather than raw physical stimuli. The language system, as pure form, is the principle whereby the emergent phenomena of our experience are defined and categorized relative to an intentional consciousness. It is in this sense that the phenomena of our experience are dually reconstituted as "thought-sound" [pensâe-son]. That is, as language form. Merleau-Ponty has pointed out, that form, so defined, exists both "in" the physical world, and "in" the living body" (1983 [1942]: 137). In

synthesizing "thought" and "sound" in this way Saussure's notion of language form overcomes the antinomy of form and substance.

Substance has no causal role in Saussure's phonological theory. Instead, there is a single "universe of form", as Merleau-Ponty (1983 [1942]: 133) has put it. The emergent properties of the articulatory act, in relation to the acoustic impression, is a question of material-phenomenal form. Form, in Saussure's account, is the means of synthesizing 'matter' and 'idea' in a new higher-order unity (Merleau-Ponty, 1983 [1942]: 137; 143-4). Speech sounds are not, we have seen, reducible to the world of particles with absolute properties which is described by Newtonian physics. Speech sounds have a structure and a meaning within the ecosocial environment inhabited by speakers and hearers.

Saussure's conception of the relationship between phonic substance and phonological form does not accept the premises of either an objectified physical world onto which meaning is projected by an individual consciousness. Saussure's conception is much closer to recent developments in both the ecological theory of perception propounded by Gibson (1986 [1979]) and the macroscopic physics of forms developed by Petitot-Cocorda (1990) on the basis of the catastrophe theory of René Thom (1975 [1972]). Nor does Saussure say that the mind produces a representation of a given articulatory act and that this representation, in turn, commands the muscles to carry out the required muscular movements. Saussure does not posit the 'middle-man' of representation which mediates between the mind and the external environment of the

speaker-hearer. The complementarity of oral articulation and acoustic impression entails quite a different set of principles.

These may be outlined as follows. First, in arguing against the reduction of speech sounds to either oral articulation or acoustic impression per se, Saussure shows that what modern psychologists call action and perception are inseparable. Secondly, the central role which Saussure assigns to the language system means that instead of fixed mental representations or programs which control articulation the language system provides procedural models which specify the functional value that a given sound has in the spoken chain. Thirdly, the relationship between oral articulation and acoustic impression is neither a linear nor a causal one. Saussure's discussion of the speech circuit shows that speech sounds can only be adequately understood if one focusses on the whole system of relations which is involved. Articulation emerges as a result of the system's capacity for self-organizing behaviour. The relevant criterion is that of the complementarity between the two levels of oral articulation and acoustic impression. It is to this issue that I shall now turn.

The Complementarity of Oral Articulation and Auditory Impression.

In chapter III of CLG, 'The Object of Study', Saussure refers to a number of complementarities which he proposes as the basis of linguistic science. The first of these will be the focus of attention in this lecture. The complementarity in question is that between the "acoustic impressions

perceived by the ear" and "oral articulation" (CLG: 23-4). The relationship between these "two faces" of a particular articulatory event such as the syllable (CLG: 23) is, Saussure argues, a two-way and reciprocal one: the one does not exist without the other:

The syllables which one articulates are acoustic impressions [impressions acoustiques] perceived by the ear, but the sounds would not exist without the organs of speech; thus, an n only exists through the correspondence of these two aspects. The language system [lalangue] cannot be reduced to the sound, nor can the sound be detached from oral articulation; reciprocally the movements of the organs of speech cannot be defined if one abstracts from the acoustic impression. ***(CLG: 23-4)***

The acoustic impression is not a physical reality per se. That is, it does not refer to the sound waves which are propagated through the air. Rather, it refers to the psychic representation of a specific category of speech sound in a given language system. For this reason, it has no direct reference to any particular acoustic event, in the physical sense. The phonological category referred to here belongs to phonological form. This is what it means to say that it is a particular phoneme category in some language system. Phonological form, as I pointed out above, is the stratum of organization which Saussure calls the signifier in the sign-relation. How does a given phonological form relate to concrete speech events?

I shall answer this question as follows. A given phonological form (e.g., syllable, phoneme) "faces two ways": it is the interface between a given oral articulation in the act of phonation and the acoustic impression which the hearer perceives in the act of audition. Phonological form is the means whereby particular speech events are construed as patterned differences that are significant in that language system. The fact that phonological form interfaces both oral articulation and acoustic impression means that one continous circuit of differences links speaker to hearer. Thus, the speaker's bodily processes of oral articulation produce patterned differences in sound that flow through the ecosocial environment of the circuit. These act on the receptive faculties of the hearer and are changed into acoustic impressions which in turn tell the hearer something about the bodily activities of the speaker. It is not the case, then, that phonological form simply imposes an interpretative grid on the sound waves that are propagated from speaker to hearer. Sound waves as such have no meaning for us. They are the matter-energy substrate that carries the emergent acoustico-articulatory phenomena that I discussed in section 2.

Nor is it the case that the hearer simply imposes a subjective act of perception on a neutral and objective physical reality. Acoustic impressions are not subjective experiences of the hearer. Rather, Saussure's complementarity means that oral articulation has properties with reference to the hearer (Gibson 1986 [1979]: 137). The patterned differences which the speaker produces in oral articulation are there to be perceived whether a given hearer attends to them or not. Oral articulation affords possibilities of interaction in the ecosocial environment because of what it is. That is, it is a pattern of differences that potentially makes a significant difference in that environment.

The physical world per se, as Gibson (1986 [1979]: 33) has shown, is not meaningful to us. We do not live in the domain described by acoustic physics. Further, meanings are not imposed by us on an inert physical world. Likewise, we do not impose meanings on an inert and objectified physical world. Instead, we live in an ecosocial environment in which patterns of differences are there to be discovered and interpreted. This brings me back to the complementarity which Saussure proposes between oral articulation and acoustic impression.

Speech sounds belong to the ecosocial level of reality. They are an example of what Gibson (1986 [1979]: 127) calls an affordance. In Gibson's terms, speech sounds are an affordance because of what they afford or offer to the members of some speech community. In particular, they afford possibilities of meaning and interaction.

Saussure's notion of complementarity anticipates one of the central premises of the new science of self-organizing systems. Complementarity, as Saussure defines it, means that a material change in the speaker (oral articulation) corresponds to a related change in the hearer (acoustic impression). Both speaker and hearer are in some way changed by this process. The process is, by definition, ecosocial, not individual.

The reciprocal contact between speaker and hearer which this complementarity entails is not contingent. Rather, it takes place in a precise ecosocial context of material change and energy exchange. The complementarity of oral articulation and acoustic impression refers, then, to the reciprocal adaptation of, or orientation to each other, of these two poles of attention and awareness. The relationship between oral articulation and acoustic impression is not a fact of the objectified physical world described in the mathematical abstractions of the physicist. Gibson (1986 [1979]: 8) has talked about the "mutuality" of animal and environment in this connection.

The two poles of awareness are subordinated to a higher-order principle of complementarity which regulates the relationship between them. In other words, oral articulation and acoustic impression form a metastable complex in which neither of the two terms is privileged. One does not ’cause’ or ‘command’ the other. Rather, the complementarity of oral articulation and acoustic impression is contextual. It is a result of the selective and adaptive orienting to and modification of the one in relation to the other. The phoneme is the higher-order contextual principle which is the basis of this complementarity.

A given acoustic impression A selectively contextualizes corresponding features B in articulation. The result is a metastable complex which emerges from the interaction of A and B. Saussure refers to this as "the acoustic given" *[la donné acoustique].* Speech sounds, Saussure says just a few pages later, are complex units which result from the combined effects of both "acoustic impressions" and "articulatory movements" (CLG: 65).

However, the complementarity between oral articulation and acoustic impression means more than that the two are mutually defining. Speech sounds are neither objective physical properties nor subjective mental ones (Gibson 1986 [1979]: 129). Saussure's complementarity provides, therefore, an alternative to psychophysical dualism. That is, speech sounds cannot be reduced to external physical stimuli and their corresponding mental sensations. Saussure manages to avoid the Cartesian psychophysical dualism.

According to this doctrine, consciousness stands in a relation of correspondence – cf. indexical necessity – with the outside physical world and the correspondence between the two is expressible as psychophysical dualism.

Symbolic Possibility, Indexical Necessity, La*langue* Interieure, and the Internal Modelling of the Ecosocial Environment.

The notion of the sign per se simply makes no sense: the internal design of the sign is functional in symbolically cross-coupling it with physical-material processes in the 'outside' world. However, Saussure's conception of the sign is neither a representational nor a 'standing for' one. Further, Saussure's discussion of the signifier focusses on the specifically phonological (categorical) dimension. He does not consider other facets of

the phonic signifier which index the speaker's emotional and bodily states, and so on. In other words, Saussure's interest in the phonological dimension of the signifier rather than in indexes of the speaker's affective and bodily states highlights his symbolic conception of the sign as a whole. Phonic indexes such as voice quality *necessarily* correspond to specific aspects of the speaker's affective and other bodily states. The phonological categories that Saussure is most interested in do not. Instead, phonological types and their patterns of combination in a given language system stand in no such relationship of necessity to the bodily and affective states of a given speaker. We have already seen that there is no direct translation from the physical activities of the vocal tract and the acoustic impressions received the the listener. Rather, both vocal tract gestures and the acoustic impressions perceived by the listener are symbolically transduced as phonological categories and their combinations. This is so both from the production and perception points of view. Phonological categories are stored in the individual's brain as acoustic images. Acoustic images are neural impulses which are in turn 'linearized' as acoustic ouput in the process of sending these impulses to the organs which produce the actual sounds (Peng 1997: 42). This means that the individual who has such an internal model does not simply produce sounds which index individual affective and other states. Rather, he or she is in possession of a phonological system whose symbolic properties enable the individual speaker bodily to project by means of an appropriate energy medium such as air information into the environment such that its potential for symbolic reconstrual as the conceptual categories of the signified may occur. This is made possible by the fact that both speaker and listener are in possession of an internal model –*langue interieure* – whose symbolic possibilities raise it above the workings of indexical necessity. This is a consequence of the systemic constraints – cf. arbitrariness – whereby only some phonological categories and their combinatons cross-couple with only some of the conceptual signifieds in a given language system.

This does not mean that factors such as voice quality, prosody, rhythm, tempo, and so on, are any less important to the overall meaning and organization of the spoken signifier in the chain of heard speech. Saussure's concentration on the categorical nature of abstract phonemic type-categories is offset by his discussion of what he calls a 'combinatory phonology' of the functional values that phonemes have in the spoken chain (Lecture 3, Section 9). A given phonemic type-category, as we have seen, constitute a set of context-free organizational parameters for the articulation and perception of speech sounds. In Saussure's account, these are based on abstract principles concerning the "position of the organs" (CLG: 78). In other words, there is a context-free equivalence relation between a given phoneme-type and a given extra-phonological (i.e. articulatory) 'state of affairs' in the abstract topological space which Saussure postulated as the best basis on which to describe speech sounds. In this perspective, abstract phoneme classes correspond to such articulatory parameters independently of the constraints imposed on them by the "possibility of linking the movements of articulation" (CLG: 79). Phonological categories so defined are explicitly meaningful for the users of a given language, as shown, for example, by the way in which these may transcribed according to the conventions of the phonetic alphabet indepednetly of any specific context. Phonemes, so defined, are segmented into discrete particles and are seen as predominantly typological-categorical in character. However, in the speech chain, phonemes are always grounded by their relations to other phonemes and their possibilities of co-articulation. Further, they are also grounded in and through their relations with a range of other indexical (rather than symbolic) aspects of speech sounds – prosodies, voice quality, volume, tempo, and so on – that are necessarily tied to the bodily, affective, and other states of the speaker on the particular occasion of speaking. Such factors tend to be

topological and continuous, rather than discrete and digital, in character. They cannot be so readily segmented into discrete chunks of phonological categories. Saussure's discussion of his 'combinatory phonology' suggests that phonemes, too, when instantiated in the spoken chain have *both* symbolic and indexical properties. If the former set the nonsubstantive parameters for the articulation of a given sound-type, the latter indexically substantively ground the phoneme-type in question by indexing the specific co-articulation of articulatory movements which takes place on that speaking occasion as an instantiation of the type category at the same time that the phonic significance of this particular instantiation of the symbolic character is contextualized in relation to the indexical necessities of intonational, prosodic, rhythmic and other phenomena which are not strictly phonological – i-e. in the narrow, segmental sense – in character.

The construing of phonological values in the acoustico-articulatory flux enables a language specific phonic substance to emerge from the analog continuum of possibilities in the vocal tract (cf. Hjelmslev's expression-purport). This results from the categorization of the articulatory processes through the progressive convergence of the forms of the articulatory process and those which are internal to the phonological system of the language. Articulatory acts are construed as instances of phonological categories, rather than as specific physical acts per se. Categories are created by the contextualizing of diverse sets of articulatory parameters. That is, the articulatory act is not comprised of fixed physical properties which predefine it. Rather, a given set of articulatory parameters constitutes information which must be interpreted in relation to the requirements of the individuals in the speech circuit.

In this way, morphological structures or forms emerge from a lower level physical substrate. As Merleau-Ponty (1983: 143) points out, form is not a physical reality, but a perception; form is a phenomenon of human experience. Phonological categories provide procedural models for selectively attending to and acting on the acoustico-articulatory information according to specific contextual demands. In this way, the process of categorization reveals only those properties of the physical-material event which are salient or relevant in a given context.

One of the few linguists who has understood the real import of Saussure's conception of the sign and its relation to what lies 'outside' along both of the 'interfaces' – viz. the kinetic-bodily and the perceptual-phenomenal – is Hjelmslev :

That a sign is a sign for something means that the content-form of a sign can subsume that something as a content-substance. Just as we felt before a need to use the word purport, not simply of the content, but also of the expression, so here again, in the interest of clarity, despite the time-honored concepts whose shortcomings now become increasingly evident, we feel a desire to invert the sign-orientation: actually we should be able to say with precisely the same right that a sign is a sign for an expression-substance. The sound sequence [ri(ng)] itself, as a unique phenomenon, pronounced hic et nunc, is an entity of expression-substance which, by virtue of the sign and only by virtue thereof, is ordered to an expression-form and classified under it together with various other entities of

expression-substance (other possible pronunciations, by other persons or on other occasions, of the same sign).

The sign is, then – paradoxical as it may seem – a sign for a content-substance and a sign for an expression-substance. It is in this sense that the sign can be said to be a sign for something. On the other hand, we see no justification for calling the sign a sign merely for the content-substance, or (what nobody has thought, to be sure) merely for the expression-substance. The sign is a two-sided entity, with a Janus-like perspective in two directions, and with effect in two respects: "outwards" toward the expression-substance and "inwards" toward the content-substance. ***(Hjelmslev 1969 [1943]: 57-8)***

The sign is dually implicated in the physical-material processes with which it cross-couples. The sign is a 'putting into form' of this relationship with the phenomena of experience. This occurs along the following two dimensions:

1. the individuation of the speaker-hearer as an embodied participant in semiosis;

2. the exploration and construal of the phenomenal world which the subject perceives and acts on.

The first dimension corresponds to the phonological pole of the signifier; the second to the conceptual stratum of the signified. Neither sound-substance nor thought-substance are objectified physical realities in the Newtonian sense. They are phenomena of experience which emerge from their respective physical-material substrates. This means that the sign categorizes and construes the phenomena of our experience along the two interfaces of (1) the bodily processes of articulation and (2) our perceptions of things, states, events, and so on in the phenomenal world – both the 'outer' world of observed events, etc. and the 'inner' world of consciousness, bodily states, and so on. It does so along the two dimensions simultaneously. In such a view, the sign functions as the interface which mediates between the self and its ecosocial environment. 'Sound' and 'thought' are transduced into the symbolic categories – phonological and conceptual – of some language system which the self has internalized as a semiotic resource for modelling and predicting both its internal and external environments Saussure's*langue interieure* constitutes an internal model of the environment whereby the self semiotically interprets the analog domains of sound and thought by means of symbolic signs. The symbolic character of the sign means that there is no necessary connection between the internal model of the self and external events. Sound and thought, on the other hand, are indexical necessities (Salthe 1993: 180-1). There is a necessary fit between incoming stimuli and sensory receptors as well as between, say, modulated vocal tract activity and the acoustic percepts that go out into the environment. On the other hand, the transduction of indexical necessities into symbolic possibilities means that the self is creatively freed from the immediate here-&-now, and in ways that enable the self to adaptively modify its relations to the environment as well as to psychically orient to it by way of the sign-making activities which it returns to the environment.

In both cases, an *a priori* system of phonic and conceptual categories which are defined by the language system are deployed in order to categorize and construe the phenomena of experience along these two dimensions of semiosis. The language system provides the phonic and conceptual categories which enable the language user to explore and interpret the ecosocial environment. The process of categorization is not a simple naming of external phenomena. Rather, the categories of the language system are 'filled' with the phenomena of experience at the same time that the variables and contingencies of experience are 'standardized' by the categories of the language system. In this way, the phenomena of experience are inserted into and manipulated by the structuring potential of language form.

References.

Abercrombie, David. 1967. *Elements of General Phonetics.* Edinburgh: Edinburgh University Press.

Armstrong, David F., Stokoe, William C., and Wilcox, Sherman E. 1995. *Gesture and the Nature of Language.* Cambridge and Melbourne: Cambridge University Press.

Armstrong, Elizabeth. 1996. ‘A grammatical analysis of aphasic discourse: changes in meaning-making over time.’ Unpublished Ph.D. thesis. Macquarie University (Sydney): School of English, Linguistics and Media.

Berthoz, Alain. 1997. *Le Sens du Mouvement.* Paris: Editions Odile Jacob.

Edelman, Gerald M. 1989. *The Remembered Present. A biological theory of consciousness.* New York : Basic Books.

Fowler, C. A., P. Rubin, R. E. Remez, and M. T. Turvey. 1980. ‘Implications for speech production of a general theory of action.’ In *Language Production. Vol. 1: Speech and talk,* B. Butterworth (ed.), 373-420. London and New York: Academic Press.

Fowler, Carol A. 1986. ‘An event approach to the study of speech perception from a direct-realist perspective.’ *Journal of Phonetics* 14, 3-28.

Gibson, James J. 1986 [1979]. *The Ecological Approach to Visual Perception.* Hillsdale, NJ : Lawrence Erlbaum.

Harré, Rom and Gillett, Grant 1994. *The Discursive Mind.* London and New Delhi: Sage.

Hjelmslev, Louis. 1969 [1943]. *Prolegomena to a Theory of Language.* Trans. Francis J. Whitfield. Revised English edition. Madison, Milwaukee, and London: The University of Wisconsin Press.

Kauffman, Stuart A. 1993. *The Origin of Order. Self-organization and selection in evolution.* London and New York: Oxford University Press.

Lemke, Jay L. 1984. 'The formal analysis of instruction.' In *Semiotics and Education,* 23-58. Victoria University, Toronto: Toronto Semiotic Circle Monographs, Working Papers and Prepublications, No. 2.

Lemke, Jay L. In Press [1995]. 'Cognition, context, and learning : a social semiotic perspective.' In *Situated Cognition Theory: Social, neurological, and semiotic perspectives.* D. Kirshner (ed.).

Lindblom, B. 1982. 'The interdisciplinary challenge of speech motor control.' In *Speech Motor Control,* S. Grillner, B. Lindblom, J. Lubker, and A. Persson (eds.), 3-18. Oxford and New York: Pergamon Press.

Mehler, Jacques and Segui, Juan 1987 ‘English and French speech processing: some psycholinguistic investigations.’ In In *The Psychophysics of Speech Perception,* M.E.H. Schouten (ed.), pp. 405-18. Dordecht and Boston: Martinus Nijhoff.

Merleau-Ponty, Maurice 1983 [1942]. *The Structure of Behavior.* Trans. Alden L. Fisher. Pittsburgh: Duquesne University Press.

Peng, Fred C. C. In press. ‘From meaning to wording: a neurolinguistic approach.’ *Acta Linguistica Taiwanica.*

Petitot-Cocorda, Jean 1990 [1985]. *Morfogenesi del Senso. Per uno schematismo della struttura.* It. Trans. Marcello Castellana, Mario Jacquemet and Francesco Marciani. Milan: Bompiani.

Pick, Arnold 1973 [1931]. *Aphasia.* Trans. J. W. Brown. Springfield, Ill.: Thomas.

Pisoni, D.B. 1979. ‘On the perception of speech sounds as biologically significant signals.’ *Brain, Behavior, and Evolution* 16, 330-50.

Pisoni, D.B. and P.A. Luce 1987. ‘Trading relations, acoustic cue integration, and context effects in speech perception.’ In In *The Psychophysics of Speech Perception,* M.E.H. Schouten (ed.), pp. 155-72. Dordecht and Boston: Martinus Nijhoff.

Repp, Bruno H. 1987. ‘The role of psychophysics in understanding speech perception. ‘In *The Psychophysics of Speech Perception,* M.E.H. Schouten (ed.), pp. 3-27. Dordecht and Boston: Martinus Nijhoff.

Rummelhart, David D. and McClelland, James L. 1986. *Parallel Distributed Processing. Explorations in the microstructure of cognition. Vol. 1 : Foundations.* Cambridge, Mass.: and London: The MIT Press.

Salthe, Stanley N. 1993. *Development and Evolution. Complexity and change in biology.* Cambridge, Mass. And London: The MIT Press.

Saussure, Ferdinand de. 1971 [1915]. *Cours de Linguistique Générale.* Paris: Payot.

Thibault, Paul J. 1997. *Re-reading Saussure. The dynamics of signs in social life.* London and New York: Routledge.

Thom, René 1975 [1972]. *Structural Stability and Morphogenesis.* Reading, M.A.: W.A. Benjamin.