On how to Define Anticipation in the Verbal Flow

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Abstract

Few studies in French concern *anticipation* in language, and much of this research draws on computing and its algorithms which are based on the vocabulary of linguistics, using terms such as semantics and grammar. This raises a major problem, however, which is bound to the notion of *anticipation*, namely that of *recursion* (the role of the subject's linguistic competence and memory). These two interrelated functions of *anticipation* and *recursion* contribute to constructing sequences. However, while we can legitimately speak about sequences and concatenation in computing, this is not possible with respect to language, because language is based on a *continuum*, a combinatorial structure that is constantly evolving. *De facto*, language and its production rely on a dynamic and complex cognitive operation, anchored in space, time and the subject's knowledge: the speaking subject has to constantly adapt to this ever-changing space, time and knowledge in the continuous information flow.

Keywords: Language, Cognition, Anticipation & Recursion, Verbal flow, Memory

1. Introduction

Few studies in French concern anticipation in language, and much of this research draws on computer algorithms which are based on the terminology of linguistics, using terms such as semantics and grammar. In other words, computer specialists use the metaphor of language. This fact is generally neglected, whereas the opposite – explaining language and cognition by using the metaphor of computing – is commonplace. This raises a major problem, related to the notion of *anticipation*: namely that of *recursion* which, together with *anticipation*, constructs a sequence. However, while we can legitimately speak about sequences and concatenation in computing, this is not possible with respect to language, because language is based on a *continuum*, a combinatorial structure that is constantly evolving.

From the moment that it is conceived, and before it is even produced, a linguistic unit is "hooked up" to other units, hooked up to "other things" than itself, and it is variable. Put differently, language and linguistic production is a dynamic and complex cognitive operation, anchored in space, time and the subject's knowledge, which are themselves

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in a constant state of flux. The speaking subject has therefore to constantly adapt to this ever-changing state of affairs, in a continuous flow of information. *De facto*, at each time *t*, the subject sees the space s/he occupies changing before his/her very eyes, in both a recursive and forward-looking operation, in a relationship with the past and with *his/her* past (memory plays a major role here) and, at the same time, in a relationship with the future, *his/her* future and the new information to be acquired/learnt.

Current theories of action (Berthoz, 2006) and language both stress that when faced with an incoming percept – which provides clues to its meaning – the subject anticipates and, simultaneously, backtracks on what he already knows / recognizes which may or may not provide immediate responses, and which also contain loops (for example the audio-articulo-phonatory loop of the utterance). The whole is thus linked to the need for anticipation, in order to create overall semantic coherence and maintain what, as a first approximation, we will call rhythm.

At an underlying level, these data are related to the theory of *self-awareness* and consciousness (Damasio, 2010), which is bound up with emotions and the subject's degrees of consciousness; they are also based on the theory of mirror neurons (Rizzolatti & Sinigaglia, 2008). At the highest levels of consciousness, i.e. language in the present case, the same data are linked to a set of rules that are automatically applied (semantico-syntactic rules) but also to other unusual possibilities, more specifically subjected to the intuition and/or to the will of the speaking subject, and to his/her creativity (Coseriu, 1952/1973).

To illustrate this problem, we put forward here a novel conception of language which takes the neurophysiology and neuropsychology of the subject into account. Our aim is to explore what might be involved in *anticipation* and *recursion* in the verbal flow, in this *continuum* which, as we claimed above, cannot be reduced to a sequence of discrete units. We define three levels, each with their control and regulation systems. We will first present certain aspects of the neurobiology of language that are related to the notion of *anticipation* (an anchor point to the future) and to the inseparable notion of *recursion* (an anchor point to the past); we then address the neuropsychological aspects of communication and lastly, more strictly linguistic aspects.

2. Human Communication and Neurobiological Control

The human being learns to understand and to adapt to the large amount of information that s/he receives from the outside world; s/he also learns to use this information. For that purpose, human beings possess a biological instrument, called nervous tissue, which processes perceptions in order to understand them, and processes reactions and actions (Gazzaniga et al, 2001). Any contact between neurons is an *innervation*, the site of which is the *synapse*.

2.1. Neurons, Synapses and Neurotransmission

Neurons possess two specific characteristics compared to other cells: Firstly, for the most part, they live and die without reproducing themselves (there is no cellular division). However, several studies have observed the multiplication of cells in certain families of neurons, mainly in the *hippocampus*, one of the neuronal structures of memory (Dunan, 2004). Secondly, with regard to other cells, neurons contain an additional organ: the axon, which is highly specialized in the transmission of information. Linguistic information is initially sensory (auditory and visual especially), motor and emotional, and related to affectivity. These particular cells constantly receive numerous excitatory or inhibitory signals; at each time *t*, the balance between excitation and inhibition determines whether or not an action potential (AP) will be triggered. Certain neurons and chemical transmitters are specialized in the transmission of excitatory messages, and others in the transmission of inhibitory messages.

This fact agrees well with classical psycholinguistic data: any message is the result of strict selection, involving elimination of a set of less suitable possibilities (Jakobson, 1963). In particular, at a time *t*, certain neurons can both inhibit certain synapses and activate others: from a neurolinguistic point of view, excitation and inhibition are inseparable from selection and are based on *anticipation*, which is connected to backtracking that acts to spot the known elements with respect to a new percept.

The cortical and sub-cortical control of cognition is thus related to neurotransmission. In most synapses – the sites where nerve messages are transmitted from one neuron to another – the information propagated along an axon is an electrical impulse, which is then transformed into a chemical message, and reaches the postsynaptic membrane where the chemical signal is transformed back into an electrical message. The complex mechanisms of synaptic transmission require neurotransmitters.

2.2. Neurotransmitters

Among the best known neurotransmitters, there is *glutamate* (GLU), considered as the most important one for the normal functioning of the brain, *acetylcholine* (ACh) and *γ-aminobutyric acid* (GABA), which are detailed below. In the central and peripheral nervous system, three categories of transmitters are distinguished, which can be either fast or slow: *amino acids* and *amines* (fast synaptic transmission), and *peptides* (slow transmission).

Briefly, neurotransmission comprises two essential phases: *presynaptic* and *postsynaptic*, followed by a return to the initial state (*anticipation* or *recursion*), then rest. These phases correspond to the transmission of information from one cell to another *via* a *synapse*, the place where neurotransmission takes place. In the presynaptic phase, a neurotransmitter is released. It carries an excitatory message (entry of positively charged [Ca^{2+}] or sodium [Na^{+}] ions, for example) or an inhibitory message (negatively charged [Cl^{-}] ions). This process is called *exocytosis*. This phase of neurotransmitter release corresponds to the result of *anticipation*, otherwise, there would be gap between the time *t* of the expected response and the effective response. The postsynaptic phase is receptive, and gives birth to excitatory or inhibitory potentials[1]. These processes are called *post synaptic excitatory potential* (PSEP) or *post synaptic inhibitory potential* (PSIP).

The similarity to language seems clear, with the differentiation between automatic answers (fast) and the construction of predicates and clauses (slow); the respective proportions of each (cognition and metacognition) can vary depending on the level of language and the context.

2.3. Neurotransmission and Language: Some Examples

2.3.1. Acetylcholine (ACh)

ACh is the neurotransmitter of the *cholinergic motor neurons* and *tyrosine* is an *amino acid* precursor of three neurotransmitters: *dopamine* (DA), *noradrenaline* (NA) and *adrenaline* (A)[2]. They are called *aminergic* and are located in the neuronal structures that regulate motion, which are in turn linked to other functions. Concerning language, the relevant functions are: a) motility, verbal articulation, eye movement in reading, co-verbal gestural mimicry, and writing; b) attention, which ensures that dialogue or other kinds of linguistic enunciation are maintained and followed. Attention is an important precursor of memory, and is underpinned by vigilance (wakefulness). Attention is based on constant *anticipation*, either understanding and projection towards expression (the *phatic* or *appellative function*, the *injunctive function*), or the mood experienced (emotional aspects of the exchange: the *expressive* or *emotive function*); c) the preservation of vegetative functions (automated and unconscious processes such as breathing, cardiac rhythm, etc.) is essential for life and is a synchronous repetitive process, in a constant link between before and after.

The aminergic functions, which are fast, contain both excitatory and inhibitory processes, in an economy based on selection: location, choice / elimination, and organized action.

2.3.2. γ-aminobutyric Acid (GABA)

The ionic channels opened by neurotransmitters that are permeable to [Cl^-] ions cause complex chemical reactions with an inhibitory effect (PPSI). This important process exists in 40% of synapses. *γ-aminobutyric acid* (GABA) is a specific inhibitory transmitter. It is found in all the highly selective sensory and motor functions such as visual, auditory and articulatory functions, which are fundamental for language.

2.3.3. Receptors Associated with G Proteins

The receptors associated with *effector G proteins* can cause slower transmission. At a very local level, GABA receptors (inhibitors), associated with *G proteins*, which can act on certain *enzymes*, activate a complex series of biochemical reactions on other enzymes and act on neuronal functions: they are called *second messengers*. This multi-

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[1] The return to the initial state by endocytosis remains a poorly understood process.

[2] These three neurotransmitters have a common structural core (catechol core) and are called *catecholamines*.

staged process which associates the neurotransmitter with activation of an enzyme situated downstream is called a "*second messenger cascade*". The slow transmission signal cascades amplify the signal and can induce activation of a large number of ionic channels at the same time: they are capable of both processing and distributing a coherent data set.

Thanks to this complex process, the cellular metabolism can be long-lastingly modified. Indeed, these properties turn out to be necessary for understanding the complex stimuli of language and for producing appropriate responses: recognition, learning, memorization, etc. The most elaborate language processing responses are distributed over several sensory (vision and hearing, in particular) and/or motor modes, which requires a powerful system of *anticipation*. Attention plays a significant role in the preservation of useful information at each time *t* of the process (slow neurotransmission), and memory is the place where the selected information is extracted (slow and/or fast neurotransmission, depending on the moment), but also registered and memorized.

After this brief incursion into the neurobiology of language and its control, we move on to the functioning of the cellular structure on which it rests from very early on in life (before birth), though in no way negating the importance of the speaking subject's capacity for thought, which is always present in the background, nor his volition which underlies all his actions, including that of communicating. This cellular structure is the brain, where the higher cognitive functions and emotional and affective behavior take place. It is the place where all the messages received and their responses are processed, regardless of the sensory channel. Let us now see how the speaking subject takes advantage of it, either consciously or unconsciously.

3. Human Communication and Neuropsychological Control

Originally neuropsychology, a new science situated on the border between neurology and psychology, was a science of observation, based on differential diagnosis. The most frequently mentioned precursors of the discipline are Gall & Spurzheim (1809) and Broca (1861). Among the various approaches, the most stable scientific orientation remains the anatomo-functional perspective, accompanied by the clinical observation of specific disorders due to congenital or accidental deterioration of the nervous structures. The current boom in this discipline is mainly due to the explosion of neurosciences thanks to the tremendous technological advances in brain imaging during the past twenty years (Bortfeld et al, 2007). The next section briefly specifies the functional anatomy of language.

3.1. Language: a Controlled Functional Anatomy

On receiving a linguistic signal, the sensory functions – hearing and vision, mainly – are the entry points for understanding. Language production is accomplished by the motor structures: controlled articulation, reading and writing. In the background, mnesic structures register and store information of all kinds (feelings, affects, knowledge and experience): memory is a sensori-motor process which registers, organizes, stores, and makes information available to the subject who uses it. It is an instrument to search for established knowledge, one which the subject masters more or less and, when the conditions are right, it "obeys his orders"; to a certain extent, it takes its orders from the subject's intelligence.

The areas of the brain (the content of the skull) that are directly or indirectly involved in language and communication are extensive areas of the cerebral cortex and the *basal ganglia*[3], located beneath the cerebral cortex; these regions are strongly interconnected. The regions concerned are mainly located in the left cerebral hemisphere (LH), which is usually the dominant one, but also in the right hemisphere (RH). Underlying inter-hemispherical and complex structures are connected to both frontal lobes (FL), for planning (pragmatics), taking into account emotions (affects) that are present in all human behavior. These operations and actions at the highest cognitive level are grouped under the term of "executive functions".

The cortical mantle (some $2m^2$ when unfolded) consists of six layers of body neurons (gray matter) connected to other areas through their myelinated[4] axons that form the *cortical white matter* (CWM), which principally comprises the *Corona radiata* (CR), a crown-shaped bundle of fibers that ensure intra-hemispherical connections, and the *corpus callosum* (CC), a bundle of fibers that ensure inter-hemispherical connections.

Human communication involves both conscious and unconscious cognitive processes, with two essential levels of control: (1) automated control (AC): biological *excitation/ inhibition*; (2) voluntary control (VC), or volition: *slow excitation/ inhibition*. As a result, in normal conditions, the speaking subject says the right word in the right place and at the right moment in the speech flow, a flow that is ceaselessly subjected to backtracking (*recursion*) and *anticipation*, in order to maintain the rhythm of flow.

3.1.1. Wernicke's Area and Broca's Area and the Arcuate Fasciculus

The reader will find the main cortical zones of the linguistic function in the Figure 1 (*infra*). In broad outline, Wernicke's area (BA 22) is the functional neuronal substratum of the *semantic skill*; it comprises the posterior zone of the temporal lobe in the left hemisphere (LH), which is generally the dominant but not the exclusive hemisphere for language. Broca's area (BA 44 & 45), which governs the *grammatical skill* and verbal expression (motor articulation), is situated at the base of the third frontal convolution (F3) of the LH, preferentially. The nerve fibers of the *arcuate fasciculus* (AF) (curved bundle) connect the Wernicke and Broca areas, establishing a junction between the lexicon and semantico-grammatical skills. These brain structures contribute to verbal communication, control its meaning, grammaticality and rhythm, in connection with

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[3] *Basal ganglia*: *thalamus*, *caudate nucleus*, *putamen*, *globus pallidus*; the *sub-thalamic nucleus* and the *black substance* are often included there. The thalamus, the largest of the *basal ganglia* (midbrain) is closely connected to the cortical mantle (*neocortex*) and its functions: hearing and visual relay, in particular.

[4] *Myelin*: a kind of membrane which sheathes and protects the axons of neurons; its structure has an influence, which is still poorly understood, on the speed of transmission of the nerve impulse.

others which control adaptation of the language to the spatiotemporal circumstances and to the interlocutor: the choice of a suitable level of language, etc.

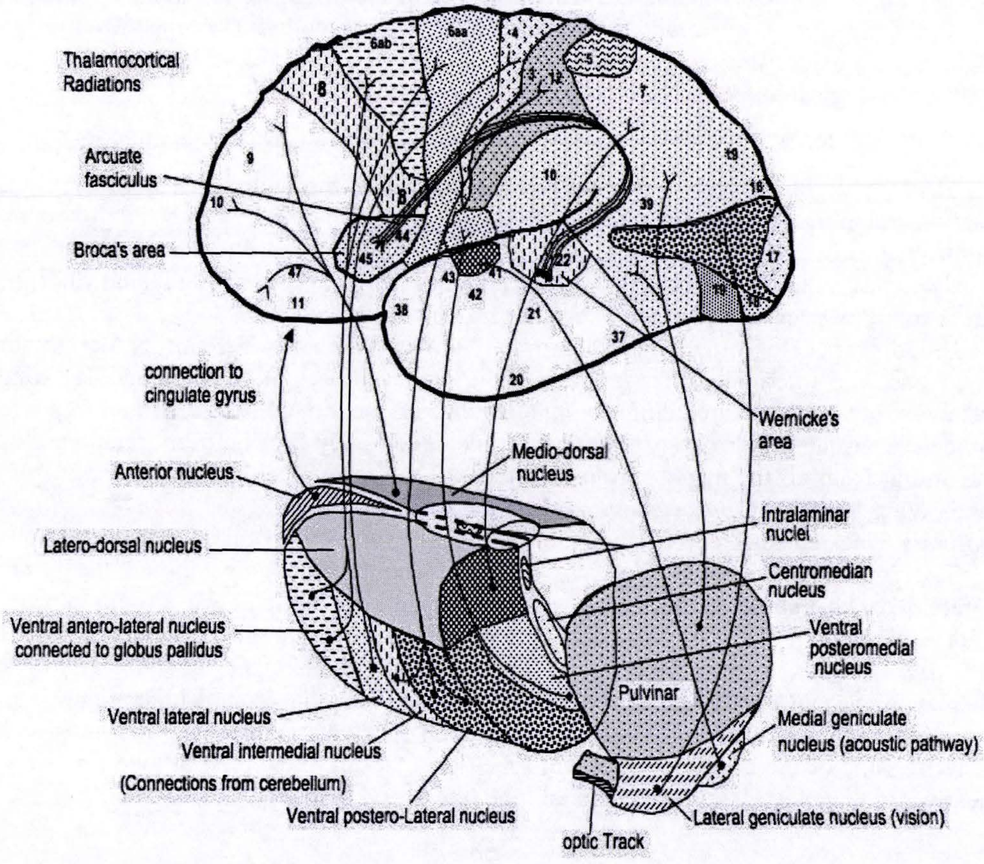

FIGURE 1: Anatomy of cerebral Cortex, Thalamus & interconnexions (J. Colloc)

3.1.2. Sensory Areas: Auditory / Visual

In both hemispheres, specific areas of the temporal and occipital cortex contribute to registering the heard and/or seen message, namely: a) the two occipital lobes process visual information: spatial recognition, understanding gestural mimicry, lip-reading, the acts of reading and writing; b) these four visual aspects of language also require the processing of three-dimensional space: the vestibular functions of the internal ear (R & L) and the right temporal cortex; c) the areas for the auditory processing of received *stimuli* (pitch, intensity, rhythm of speech sounds) are located in the bilateral temporal cortex.

In order to be registered, understood and interpreted, the *verbal stimuli* or speech sounds, which are organized in utterances and linguistically structured in phonemes, syllables, words and sentences of Language (*langue* in its linguistic meaning) combine with the visual aspects of oral communication (spatiotemporal circumstances); they engage all the cortical and sub-cortical structures of the linguistic function. In reading, the oral competence of the language underlies the visual recognition of the message and its comprehension: this involves the discrimination and function of letters, associated with phonological and/or semantico-syntactic processing.

3.1.3. Frontal lobes: Motor Functions, Cognitive Planning and Executive Functions

The large frontal lobes (≅1/3 of the cortex) contain the motor and executive functions (action planning, attention, linked to consciousness) which are organized in highly controlled processes (*cf. supra*). Burdach (1919) considered them as "the special workshop of thought processes"[5]. The frontal lobes support the behavioral control of the most complex cognitive processes such as abstraction.

Broadly speaking, the posterior frontal cortex handles and controls the motor function[6]. The anterior prefrontal cortex is the site implicated in planning and adjusting behavior (pragmatic), including communication, as mentioned above. It receives and processes visual, auditory, spatiotemporal, and specifically linguistic information, etc., stemming from all the major regions of the cortex[7]. It also receives indirect input from underlying levels: the *Basal ganglia* (*thalamus*, *caudate nucleus*[8] and *putamen*[9], *globus pallidus*, black substance, etc.) and from the *cerebellum* and the brainstem.

The prefrontal cortex is therefore informed about what happening in the brain: internal data (organic) and external data (receiving, registering, and storing sensory data). Its relations with the structures underlying the forebrain are important. Figure 1 (*cf. supra*) illustrates this complexity with respect to the linguistic function. The code displays neuronal connections between the thalamus and the frontal lobes (emotions, attention, memory, planning, motor function, etc.). They also indicate connections with other regions of the cortex: the parietal lobe (kinesthesia), the temporal lobe (memory, hearing and language), and the occipital lobe (the visual function).

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[5] Burdach, quoted by Sieroff (2004): "*l'atelier spécial de la pensée*", p. 140.

[6] The areas of the motor functions and its control are: primary motor areas (ascending frontal convolution, AFC), the secondary motor areas side premotor cortex (SPM), the supplementary motor area (SMA) in the superior side, the oculo-motricity area and Broca's area (base of F3). We also include the front part of the *cingulate gyrus* (CG), one of the areas of the limbic system, which has the following important functions: consciousness, emotion, memory, motivation/intention (*cf. infra*, data concerning memory).

[7] *Planning areas*: visual information (occipital lobe, OL), linguistic information (part of the left temporal lobe, LTL, Wernicke's area) and spatiotemporal information which is processed in the right temporal lobe (RTL) and the two parietal lobes (PL: Somatosensory system).

[8] *Caudate nucleus* and *putamen* are often mentioned as being implicated in complex cognitive functions (memory, language); they form a very ramified and streaky structure, hence the term: *striatum* or *neostriatum*.

[9] *Limbic System*: It includes a set of cortical and sub-cortical structures: the limbic lobe (cingulate gyrus and parahippocampal gyrus), *hippocampus*, *amygdala*, hypothalamus (mamillary body) and the thalamus (the anterior of its dorsal part), interconnected regions.

3.1.4. Memory and Feelings: the Limbic System

The complex and intricately connected cortical and sub-cortical structures of the limbic system and associated structures support the functions of memory and feelings. Roughly speaking, it includes the part of the temporal lobes located on the inner side of the two brain hemispheres. Nowadays, the role of the brainstem is better understood and it is considered as essential in understanding the brain structures of emotion (Damasio, 2010). The control of emotions is highly variable as it rests on internal reactions and body reflexes. The emotional state of the moment influences verbal production; this influence is more controlled during writing. Control varies from one subject to another and with the human circumstances of the interlocution. Memory is more strongly controlled and is highly involved in acquiring knowledge and skills (speaking skills, reading, writing, calculation); it is strongly influenced by emotional and social behavior, as well as the subject's motivation.

On the anatomo-functional plane, there are two essential components: *short-term Memory* (STM), more often called *working memory* (WM, or active memory, is the most important component of STM)[10] and long-term Memory (LTM). Information processing is supported by the WM, and knowledge that has been "registered", processed and organized is then stored in the LTM. This knowledge can be split into two classes: a) Encyclopaedic knowledge (of the real and/or virtual world), which is part of semantic memory; the retrieval of encyclopaedic knowledge is controlled by the subject's will; b) Experience (events in real life) is stored and ordered in the episodic memory, which is less tightly controlled than the semantic memory due to the emotional impact of its contents.

While it may seem paradoxical to split memory into two structured lexicons, the study of memory pathologies has in fact revealed that there is sometimes a clear dissociation between experienced events and acquired and/or learnt knowledge. In normal conditions, the synchronous operation of these two components results from a complex specific control, with diverse degrees of consciousness and contextualization. From a cognitive point of view, an external stimulus is processed differently depending on its nature (cognitive control) and its importance for the subject (emotional control). The model of the cognitive functioning of memory proposed by Laurent (1998) satisfactorily accounts for our current understanding of its neuropsychology (*cf.* Figure 2, *infra*).

After having first considered the neurobiology of communication and second, its neuropsychology, we will now see how these functional systems that underpin language influence its general coherence and its control.

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[10] Short-term memory (STM) contains two components: passive (PSTM) and active (ASTM). The latter is called working memory (WM = ASTM). See Figure 2, *infra*.

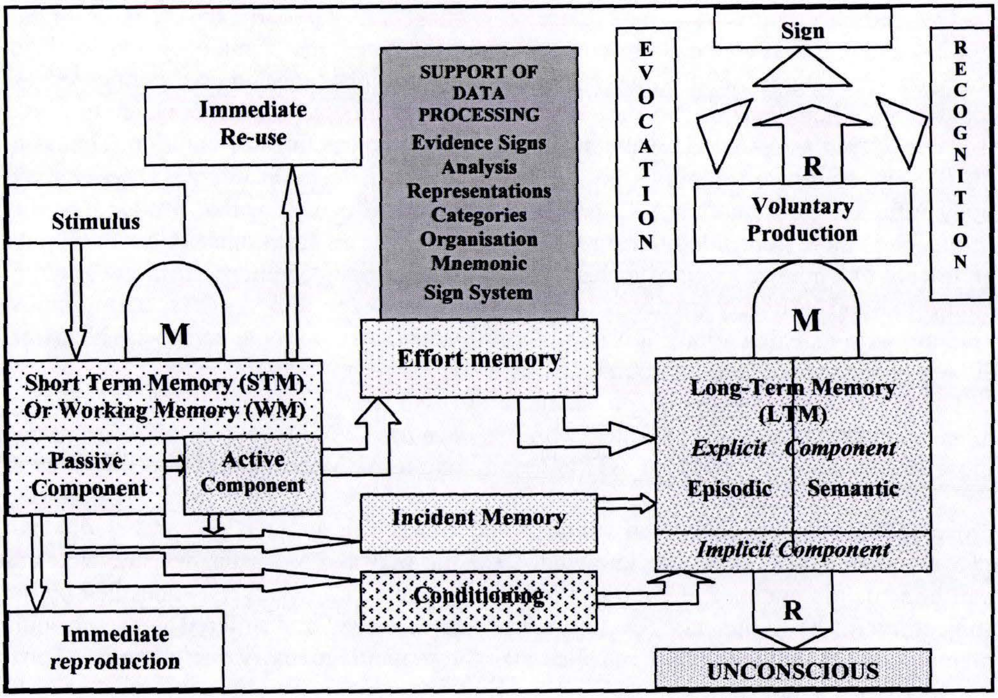

FIGURE 2: Cognitive aspects of the operation of memory[11]

4. Language, a Highly Controlled Cognitive Function

The control features of human communication are rarely mentioned in linguistics, neuropsychology or neurobiology, and much less correlated. Yet, any human behavior (including speaking or writing) undergoes a large number of limitations and inhibitory processes. During verbal exchanges, the most obvious controls are of three kinds: 1- the speaking subject's will to speak or to remain silent (volition[12] and the transmitted meaning); 2- the contextual constraints of the exchange; 3- linguistic conventions and the level of language.

On the neuropsychological and neurobiological plane, neurons (brain cells) capture many excitatory and inhibitory signals coming from the outside world. At each time *t*, the cellular excitation/ inhibition ratio calls on the acquired knowledge and the past of the subject, who recognizes or not (recursion) and anticipates what the subsequent response will be; this *excitation/ inhibition* ratio determines whether a neuro-

[11] Reproduction of an image by B. Laurent, Professor of neurology, with his kind consent.

[12] Volition: "act of will"; "willpower" is the "faculty of wanting" (Littré, *Dict. de la langue française*, t. 7, p. 1868, our translation).

psychological action potential (NAP) will be triggered or not: the action of speaking or remaining silent, of expressing one particular feeling rather than another one, of transmitting information orally or in writing, etc. We will focus on oral expression here. (Note that we are no longer in the field of emotions, strictly speaking.)

From an argumentative point of view, this entails the following two hypotheses: a) Underlying neurobiological responses (activations) such as cellular excitation and/or inhibition correspond to the controlled and automated aspects, which are closely involved in verbal communication; b) Neuropsychology and neurobiology may offer a new perspective on certain universal aspects of language and make it possible to specify the notion of cognition in linguistics through the operations of *anticipation* and of *recursion* which respectively project the subject into the future and take his past into account, in a specific rhythm.

When a subject speaks, he shapes his utterances to suit a real-life situation. This conformity of the message to a communicative situation, defined by the circumstances and the language used, presupposes adaptation to the place and time (in order to ensure the spatio-temporal legibility of the message), to the interlocutor (his/her personality and social practices), and to the language (Custom, according to Hjelmslev, 1966, or Norm, according to Coseriu, 1952). This adaptation corresponds to a strict selection resulting from the elimination of a set of less suitable possibilities: inhibition, which may or may not be conscious depending on the level of consciousness, is inseparable from any selection.

The spatiotemporal dimension, the social conventions observed by the interlocutors and the language used correspond to three closely correlated norms. For methodological and didactic reasons, they will be dealt with successively below.

4.1. Spatio-Temporal Circumstances

The first norm governs the conventional way in which the particular space and time of the exchange is expressed, given the general spatio-temporal organization of the society in question, its collective representations (for mutual comprehension) and private representations (specific to the speaking subject). For interlocutor Y to understand the circumstances related to speaker X's words, X must respect at least some of these spatio-temporal conventions, so that they evoke (memory) plausible and acceptable circumstances for Y in his own system of representations. X's utterances call on Y's thoughts (mental representations) and memory (the real-life memory *substratum*)[13], mainly *via* the visual and auditory sensory functions, and the related sensory representations. In summary, thought, real-life experience, and visual and auditory sensory representations facilitate and control understanding of the

[13] *Real-life memory substratum*: a set of acquired / learnt skills and organized knowledge, in a specific psychoaffective climate. It is built through the human being's connection with the outside world (family, society, etc.) and undergoes various influences, either consciously or not. We coined this expression to meet a didactic need in the multidisciplinary field of normal and pathological linguistic communication (Jacquet-Andrieu, 2008, vol. 2, p. 88).

spatiotemporal aspects of the enunciation: in order to construct a coherent representation of what is said / heard, both *anticipation* and *recursion* come into play.

4.2. Social Conventions

The second norm is related to the first one, and governs the social conventions of communication, taking into account their psychological effects on the interlocutors X and Y. X complies, at least partially, with the locutionary[14], illocutionary[15] and perlocutionary[16] conventions (Searle, 1972) which control any speech act and ensure its success. Conventional social patterns, adapted to X's particular message, are influenced in a more or less controlled way by his emotions (Damasio, 1999, 2010) and provide incidence to those of Y. As for the spatiotemporal circumstances, the social representations of the two speaking subjects serve as a *mnesic reference for control*. Their social representations are cue points for X and Y, whose thinking affects the flow of the interlocution, in which their behavior is modified.

4.3. Linguistic Norms

The third norm governs the general coherence of the exchange and the utterances produced: it covers propositional meaning and grammaticality, adapted to the spatiotemporal circumstances and to sociocultural conventions. The coherence of the dialogue is related to the linguistic competence of the subjects X and Y (Chomsky, 1969), and results from a constant control of what has been said (*recursion*) and *anticipation* of what remains be said, subjected to a linguistic and sociocultural norm. Thought and mnesic functions intervene and control every level. Nevertheless, accidents occur, and "the machine jams" sometimes: the initial cause is a loss of voluntary control of the verbal act at a time *t*. It induces involuntary, unconscious utterances (*lapsus linguae*, paraphasia), sorts of "hitches" in the biological responses, which are attributed to diverse neuropsychological, or even psychoanalytical causes (Freud, 1923; Lacan, 1966). In other cases, it's as if the cabling of the automated answers was defective, producing stereotypical or fossilized utterances (*cf.* Table 1).

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[14] *Locutionary act*: a speech act on the level of the utterance production: the actual utterance (denotation, propositional meaning), and the sequence of sounds, words or concepts it comprises, combined in a specific syntax.

[15] *Illocutionary act*: this refers to a deliberate aspect of the speech act (request, promise, order), which is directly detectable in the locutionary act (message) and the situation in which it is used. It can modify circumstances in a specific context that the social conventions of the community dictate (performatives).

[16] *Perlocutionary act*: a *speech act* viewed at the level of its pragmatic consequences; it is indirectly included in the speech act (message) and the enunciative situation, it broadens these circumstances, and can project the consequences into a more or less distant future (esteem, respect, contempt).

TABLE 1	*LAPSUS LINGUAE* – PARAPHASIA – MISINTERPRETATION,etc. PROCESSES CONTROLLED OR NOT BY THE WILL		
SUBSTITUTION TYPE	PROCESS (+) Controlled (–) Uncontrolled	KIND OF IMAGE	PRODUCTION TYPE
WITTICISM – TROPES	+	Subtle	Creative
LAPSUS LINGUAE SLIPS OF THE TONGUE	–	"Nomadic" or "floating" (Freud)	Revealing
PARAPHASIA 1	–	Parasitic	Accidental
PARAPHASIA 2	+	Approximate	Analog
STEREOTYPE 1	+	Duplicated	Reuse
STEREOTYPE 2	–	Duplicated	Fossilization
NEOLOGISM 1	+	Created	New word
NEOLOGISM 2	–	Parasitic	Barbarism

In fact, any anomaly in production, whether accidental or fixed, is an error of selection which reveals an error in biological activation: principles of *excitation/ inhibition*. There is thus a link between the consciousness / unconsciousness of saying and the neuropsychological and biological control of our utterances (Jacquet-Andrieu, 2003).

We can say first that, in any interlocution, thought and memory are called upon, mainly *via* the visual and auditory functions of language. The interlocutors' experience and sensory representations pervade their understanding of the enunciative situation and the constantly updated verbal exchange, in a flow of recognition and discovery, and therefore of understanding and interpretation. From the point of view of linguistic competence and of its pragmatics, verbal production corresponds to more or less strict choices and to a large number of automatisms which are immediately available in memory, associated with other elements that are more consciously sought after in the specific circumstances, such as a play on words or an additional detail, for example.

In terms of cognitive neuropsychology, in normal conditions, the sensory *stimuli* stemming from the environment of the speaker or listener (captation) are registered and processed thanks to unconscious but biologically controlled processes, in the sensory structures of the central nervous system (CNS) : (1) The received stimuli are new and/or recognized (calling on memory) recursively. (2) The automatic recognition processing is biologically adapted and controlled, hence the speed of responses (thanks to the effect of *anticipation*) but not voluntarily (no volition)[17]. (3) Consciousness is complete when there is reasoned processing of complex *stimuli*, with specific involvement of the will (intention, focused attention, reasoning, argumentation), the whole remaining under strong neurobiological control. In fact, the two states of control and/or automatism

[17] We have explained the most common case, without considering the notions of the subconscious and the unconscious.

coexist and are intertwined in the course of the interlocution or during reading and writing, for example.

5. Conclusion

Our purpose in this study was to consider language from an interdisciplinary perspective and to review some current data of its neurobiology and neuropsychology, in connection with more structural and universal features of communication, based on two inseparable dimensions: 1- *anticipation*, which is forward-looking and concerns the response to come; 2- *recursion*, the necessary feedback on what is already known. These two dimensions lead to a specific congruence and this approach has been developed on three levels, biological, neuropsychological and linguistic.

When in contact with other speaking subjects and the external world, a human being, who is imbued with his inner world and his home and sociocultural environment, receives and experiences sensory and emotional impressions that he recognizes or discovers, understands and/or interprets, then he evokes or not, as a feeling or an emotion. Language, which is but one means of expression among others, allows the "speaking subject", or the "*parlêtre*" (speaking-being) as psychoanalysts say, to evoke his feelings, engage in dialogue or share a memorable moment… while his body already expresses another message that is sometimes at odds with the conscious communication (Turchet, 2009, 2013).

We first very briefly discussed the underlying neurobiological functions and the principle of *excitation/ inhibition*, along with the dimensions of *anticipation* and *recursion*. We then considered the foundations of human neuropsychology (the anatomo-functional aspect), a field that is currently evolving very rapidly (Jacquet-Andrieu, 2008), and is largely based on *anticipation* and *recursion*, which are part of executive functions at this level. Lastly, we considered the speaking subject in her/his linguistic community, her/his spatiotemporal, sociocultural and intercultural space, in the world of communication, simply, where s/he is subjected to the conventions of language use (*langue,* in the Saussurien meaning). These conventions form the foundations of the subject's linguistic competence, even though, unknowingly, his reaction to the impact of a sensory percept, whether complex or not, is emotional, *stricto sensu*, and physiological, at various levels of consciousness.

On this *substratum*, the production of language thus presupposes the operation of a complex network of associated neurobiological, neuropsychological and cognitive functions: the three levels which we have addressed. Dubois (1990) evokes memory, and upstream of memory we have also specified the impact of vigilance (wakefulness) and of attention (listening or looking at the sensory percept) "*for the acquisition and reconstruction of information*", which downstream enables the memorization and processing of at least part of the information received. We are dealing here with the percept as it passes through the filter of the subject's emotional world – and its flow –, and the subject's reponse which is largely based on *anticipation* and *recursion*. Both these processes are required to situate oneself in space and time, whether experienced, known, or unknown.

The synergy between language, emotions and consciousness is first materialised in the body (Varela, 1979): this is the notion of embodiment (Varela et al., 1991). The body is a sensory and emotional receiver, as we have stressed elsewhere (Jacquet-Andrieu, 2012), and the locus of perceptions and the concept of self-awareness. This anchor point and the initial emergence of language depend on the presence or absence of (varying degrees of) consciousness and on intentionality and decision-making (Dubois, 2010; Cadet, 2009; Cadet and Jacquet, 2012), i.e. the decision to express something in diverse semiologic systems, not only in words.

In summary, our intention here was to explore the multidisciplinary field of language and idioms which concern the mind, consciousness, the body and discourse in context; they are inseparable from neurophysiology and neuropsychology upstream, and from the perceptible and analyzable result in its various forms (gestures and words, ranging from the most literal meaning to the most sophisticated metaphors, for example). A powerful and complex control system on the three levels we have briefly described (physiological, neuropsychological, and linguistic) regulates the operations of *anticipation* and *recursion*, in the space and time of the speaking subject's life. Finally, these data also echo some fundamental concepts of the fractal theory of intelligence put forward by Dubois (1990) and its evolution towards the field of emotional intelligence (Dubois, 2010).

References

Berthoz, A. (2006). Physiologie de l'action et phénoménologie. Paris: O. Jacob.

Bortfeld, H. & al. (2007). "Assessing infants' cortical response to speech using near-infrared spectroscopy". Neuroimage, vol. 34-1: 407-415.

Broca, P. (1861). Sur le siège de la faculté du langage articulé avec deux observations d'aphémie (perte de parole). Paris: Masson.

Cadet, B. (2009). « Le jugement et la décision, repères historiques et notionnels ». In B. Cadet & G. Chasseigne, Psychologie du jugement et de la décision. Des modèles aux applications (pp. 25-53).

Cadet, B. & Jacquet-Andrieu, A. (2012). « Émotions, langage et prises de décision: un réseau cognitif », in Холизм и Здоровье/Holism and Health, 6(1): 26-32. http://journal.celenie.ru/index.php/cadet-jacquet-andrieu-emotions.

Chomsky, N. (1969). Le langage et la pensée. Paris: Payot.

Coseriu, E. (1973). "Sistema, Norma y Habla". In E. Coseriu. Teoría de lenguaje y Lingüística general. Madrid : Gredos (1e éd. du texte seul, Montevideo, 1952).

Coseriu, E. (1978). Système, Norme, Parole/trad. annotée de: Sistema, Norma y Habla, par A. Jacquet-Andrieu, éd. de 1973, Mémoire de Recherche. Lyon: U. Lyon 2.

Damasio, A.R. (1999). Le sentiment même de soi. Paris: O. Jacob.

Damasio, A. (2010). L'Autre moi-même. Les nouvelles cartes du cerveau, de la conscience et des émotions. Traduit par J.-L. Fidel. Paris: O. Jacob.

Damasio, A.R. (2010). Self Comes to Mind. Constructing the conscious brain. London: W. Heinemann.

Dubois, D. (1990). Le labyrinthe de l'intelligence. Paris: InterÉditions/ louvain-La-

Neuve: Academia.
Dubois, D.M. (2010). Natural and artificial intelligence, language, consciousness, emotion, and anticipation. Computing Anticipatory Systems: CASYS'09, Ninth International Conference. AIP Conference Proceedings, 1303: 236-245.
Dubois, D.M. (2010). Breakthrough in the human decision making based on an unconscious origin of free will. Acta Systemica, X: 13-18.
Dunan, R.S. (2004). "Role of neurotrophic factors in the etiology and treatment of mood disorders". In Neuromolecular med, 2004-5(1): 11-25.
Duus, P. (1998). Diagnostic neurologique: les bases anatomiques/Trad. 6[e] éd., par J.P. Brown, revis. scient. par G. Rodesch et P. Lasjaunias. Bruxelles: De Boeck.
Freud, S. (1967). Psychopathologie de la vie quotidienne. Paris: Payot (1[e] éd. 1923).
Gall, F.J., Spurzheim, J.G. (1809). Recherches sur le système nerveux en général, et sur celui du cerveau en particulier. Mémoire, Institut de France, 14 mars 1808, Paris.
Gazzaniga, M.S., Ivry, R.B., Mangun, G.R. (2001). Neurosciences cognitives: la biologie de l'esprit/Trad. de J.-M. Coquery. Bruxelles: De Boeck.
Hjelmslev, L. (1966). Le langage. Paris: É. de Minuit.
Jacquet-Andrieu, A. (2003). « Du concept au mot dit ou traduit ». In Bulag, 28, 11-2003: 97-114.
Jacquet-Andrieu, A. (2008). Langage de l'homme. De l'étude pluridisciplinaire à l'action transdisciplinaire. Thèse d'HDR. Paris: U. Paris Ouest.
Jacquet-Andrieu, A. (2012). Langage de l'homme. De l'étude pluridisciplinaire à l'action transdisciplinaire. Saarbrücken: Presses académiques francophones.
Jakobson, R. (1963). Essais de linguistique générale. Paris: É. de Minuit.
Lacan, J. (1966). Écrits. Paris: Seuil.
Laurent, B. (1998). Les grands profils sémiologiques de l'aphasie [Images animées]. Merdrignac, Service audiovisuel du CHU: Hôpitaux de Saint-Etienne [1 cass. vidéo (VHS) (1h17 min) : n.et b. (PAL), sonore].
Morel, M.-A. (1995). « Valence et structure hiérarchique de l'énoncé oral ». In F. Madray-Lesigne, J. Richard-Zappella, J. (Ed). Lucien Tesnière aujourd'hui. Paris: Peeters.
Purves, D., Augustin, G.J., Fitzpatrick, D. Ed. (1999). Neurosciences/Trad. de J.M. Coquery. Bruxelles: De Boeck Université.
Rizzolatti, G. & Sinigaglia, C. (2008). Les neurones miroirs. Trad. de l'italien par Marilène Raiola. Paris: O. Jacob.
Searle, J.R. (1972). Les actes de langage: essai de philosophie du langage. Paris: Hermann.
Sieroff, E. (2004). La neuropsychologie: approche cognitive des syndromes cliniques. Paris: A. Colin.
Schristol, A. (1995). « Stemma, actants et typologie linguistique ». In F. Madray-Lesigne, J. Richard-Zapella (Ed). Lucien Tesnière aujourd'hui. Paris: Peeters, 277-282.
Tesnière, L. (1959). Éléments de syntaxe structurale. Paris: Klincksieck.
Turchet, Ph. (2009). Le langage universel du corps. Comprendre l'être humain à travers la gestuelle. Québec (Canada): Les éditions de l'homme.