THESIS

ACTIVATION AND INHIBITION. CONTROL MECHANISMS IN A BILINGUAL BRAIN. AN OPTIMALITY THEORY MODELLING.

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Author	**María Angélica González Díaz** **0534897** **06-44335972** **demiandorian@hotmail.com** **Passeerdersgracht 24L** **1016 XH Amsterdam**
1st reader	**Prof. Dr. Paul Boersma**
2nd reader	**Prof. Dr. J.H. Hulstijn**

Master in General Linguistics
Faculty of Humanities
UNIVERSITEIT VAN AMSTERDAM

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1. Introduction

Bilinguals are individuals who master —comprehend and produce— two languages. They are able to appropriately speak in either language without mixing them erratically, making a straightforward distinction between the two linguistic systems, in the same way as they are capable of actually mixing them accurately, efficiently borrowing and code switching, combining both systems successfully. In addition, most of them are able to translate and some to interpret (e.g., simultaneously) one language into the other, building a parallel of equivalences between both languages. These abilities suggest the existence of mental control mechanisms that effectively manage and regulate both linguistic systems.

A number of researchers have investigated the nature of these control mechanisms, and there is an ongoing debate about the locus or loci of control, the means of regulation, and the way it is exerted. There are some bilingual language models that offer consistent proposals, and there is agreement on specific issues, although the other issues remain open to discussion.

In this document, I aim to provide a plausible description of bilingual phenomena sensitive to regulation, such as language mixing, within the Optimality Theory (OT) framework, and to explore the dynamics involved in them. There seem to be specific factors that play a decisive role in these phenomena that are to be taken into account, such as the language dominance of the speaker and the addressee, and the initial task demands. Considering that bilinguals have two languages with their corresponding rankings co-existing in one single brain, I am inclined to think that there is an interaction, not only between the languages, but also between their different linguistic levels that is efficiently regulated in order to enable successful speech perception and production.

OT tableaux are able to express the contest between candidates generated by both languages that compete in order to provide the optimal output in a given task, which supplies initial demands that are processed in bilingual linguistic events. The computations engaged in these processes can be modeled in constraints hierarchies. The control mechanisms engaged in them seem to operate by means of activation and inhibition, which reflect the conflicting nature of the constraints. The selection of the best possible contestant reflects the solution of such conflicts.

2. Outline

In the first part of this document, I will briefly review four bilingual language models, namely, François Grosjean's (1998) language modes model, the neurofunctional approach from Michel Paradis (2004), David Green's Inhibitory Control Model (1998), and Ton Dijkstra and Walter Van Heuven's (2002) BIA+ model. Although every model views regulation from a different perspective, there seems to be an agreement on control being exerted by means of activation and inhibition.

In the second part, I will offer a short presentation of physiological and functional neuroanatomical data that seems to be relevant for a better understanding of how the brain works, that is, the locus of language. I will focus on the neuronal structure and synapses, and their regulation by means of excitation (that is, activation) and inhibition. I believe that the linguistic representations are related to the functional representations in the brain, to the extent that both exert control in similar ways.

In the third part, I will present Optimality Theory (OT) in brief. This introductory presentation is based on information gathered from the works of Paul Boersma (1998), René Kager (1999), and Alan Prince and Paul Smolensky (1997, 2004), and will be followed by my view on OT in bilinguals.

In the fourth part, I will present some language mixing and language switching phenomena. Next, I will model some cases of lexical borrowing and code switching by means of OT tableaux. I will focus on the role of language dominance of both the speaker and the addressee, and task demands in the computations engaged in the constraints rankings that express bilingual events. I think that OT provides proper tools for an adequate description of these phenomena. Furthermore, it seems to be compatible with a view of regulation via activation and inhibition.

Subsequently, in the fifth part, the discussion will be centered around the dynamics involved in the processes of bilingual speech comprehension and production, and simultaneous interpreting events. I am inclined to think that there is an interaction between the different linguistic levels of representation that is triggered by task demands. In order for this interaction to be successful, efficient regulation mechanisms are required.

Cerebral and linguistic representations may share a common ground in the way they regulate these competitive selection processes.

In the sixth part, two conclusions will be drawn. The first one regards the plausible role of activation and inhibition as regulation forces within a bilingual linguistic system. The second one regards the interactivity of different linguistic levels of representation.

Finally, three issues for further research are proposed. One relates to the role of the typology of the pairs of languages in bilingual brains, and their effect in the interaction of their rankings. A second one relates to the locus of the storage of the information about the addressee. The third one looks into the way how two language-specific rankings interact in a bilingual brain.

3. Control mechanisms

A main issue regarding bilingual phenomena is the issue of having two languages in a single brain. “Bilingual speakers need to control their production in such a way that the two languages do not end up mixed in an inappropriate manner during the discourse” (Costa and Santisteban, 2006, p.115). Speakers rely on control mechanisms that enable them to speak in either one of the languages, or mixing both of them successfully, to the same extent as they are able to comprehend mixed utterances.

Kroll, Bobb and Wodniecka (2006) note that “language selection depends on a set of factors that will vary according to the proficiency, dominance, and language experience of the bilingual speakers, the demands of the production task, particularly with respect to the degree to which concepts uniquely specify words in one language alone, and the degree of activity of the nontarget language […]” (p.120). David Green (1998a) proposes in his Inhibitory Control Model, that “competition between alternative responses should increase with fluency in contexts where both languages are active. Increased competition should induce grater inhibition of unwanted competitors. […] In situations where both languages are active, translation equivalents compete to control output. […] In code-switching the relationship between the production schemas must therefore be cooperative rather than mutually inhibitory” (p.103).

Thus, activation and inhibition appear to play an important role in regulation in bilingual phenomena. According to Green (and other scholars, like Franco Fabbro, 1999), normal language use not only requires intact language (sub)systems and intact connections between them, but also the means to activate and inhibit them, as well as to inhibit improper outputs of the system. He argues that both activation and inhibition require resources that need to be replenished constantly. (De Groot and Christoffels, 2006, p.190) This also happens on a smaller scale in the neurons, which recover by remaining inactive during the refractory period, which is the amount of time it takes for their excitable membrane to be stimulated and then be ready for stimulus again. Thus, any re-excitation of the axon does not occur immediately. Moreover, most action potentials travel unidirectionally because the node behind the propagating action potential is refractory.

In the next pages, I will succinctly review four bilingual language models that propose activation (or excitation) and inhibition (or deactivation) as regulation mechanisms.

2.1 Language modes model (Grosjean)

According to Grosjean (2003), bilingualism is defined within the regular use of two languages, a fact that does not necessarily imply that the individual is equally proficient in both languages. Bilinguals are an heterogeneous group and there are several factors that define their diversity, such as language proficiency, "language history, language stability, the functions of each language, and language mixing habits" (p.163).

The language mode concept is the basis of a dynamic view of bilingual language processing. Grosjean argues that "in some situations the bilingual must indeed only process one language (the mode is close to being monolingual) but in others, several languages are processed on-line with one taking the lead role (as in the case of mixed language where the base language is more active than the guest language" (p.160).

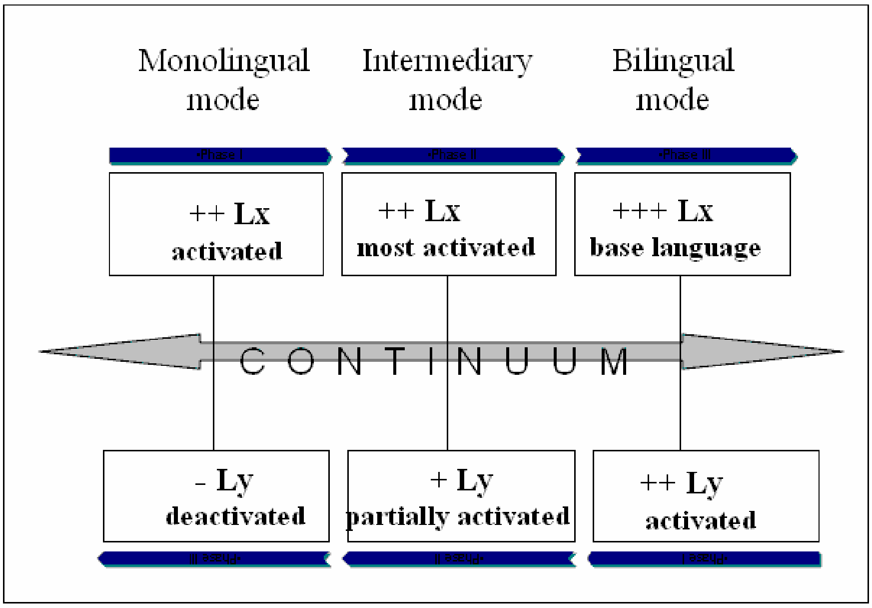

Figure 1 : Explanatory sketch of Grosjean's language modes (Based on Grosjean, 1998, p. 136)

Grosjean (1998) asserts that "a mode is a state of activation of the bilingual's languages and language processing mechanisms. This state is controlled by such variables as who the bilingual is speaking or listening to, the situation, the topic, the purpose of interaction, and so on” (p.136). At one end of the continuum, bilinguals are in a totally monolingual language mode, in which one language is active and the other deactivated (Figure 1). At the other end, bilinguals are in a bilingual language mode, in which both languages are active, but one is more active than the other. The more activated language is used as the main language of processing, that is, the base or matrix language.

2.2 Neurofunctional model (Paradis)

Paradis (2004) integrates a neurofunctional model and a set of hypotheses about language processing in his theoretical approach of bilingualism. The neurofunctional model contains the components of verbal communication and their relationships, such as implicit linguistic competence, metalinguistic knowledge, pragmatics, and motivation. In addition, language processing is accounted by neurofunctional modularity, the activation threshold, the language vs. cognition distinction, and the Direct Access Hypothesis.

“According to Paradis (1994), when a bilingual intends to speak in one language only, the activation threshold of the non-selected language is raised sufficiently (inhibited) to prevent interference from that language during production” (De Groot and Christoffels, 2006, p.195).

Paradis supports the logical assumption that each language is represented in different networks within the bilingual brain. These networks are neurofunctionally different and subserved by different neural circuits, though they are represented in the same cortical areas.

On the basis of evidence gathered in his aphasia investigations, Paradis presumes that “when a language is not available, it is not because its neural substrates have been physically destroyed, but because its system has been weakened […] This weakening can be explained in terms of increased inhibition, raised activation threshold, or unbalanced distribution of resources among the various languages” (Fabbro, 2001, p. 212).

2.3 *The Inhibitory Control Model (Green)*

Green (1998) proposes the Inhibitory Control Model (ICM) with three separable aspects: First, a level of control that involves language task schemas that regulate the outputs from the lexico-semantic system by altering the activation levels of representation and by inhibiting other schemas. Secondly, a stage that involves word selection at the lemma level (the level between the conceptual and the phonological levels) and the use of language tags, and third, the inhibitory and reactive nature of the control at the lemma level.

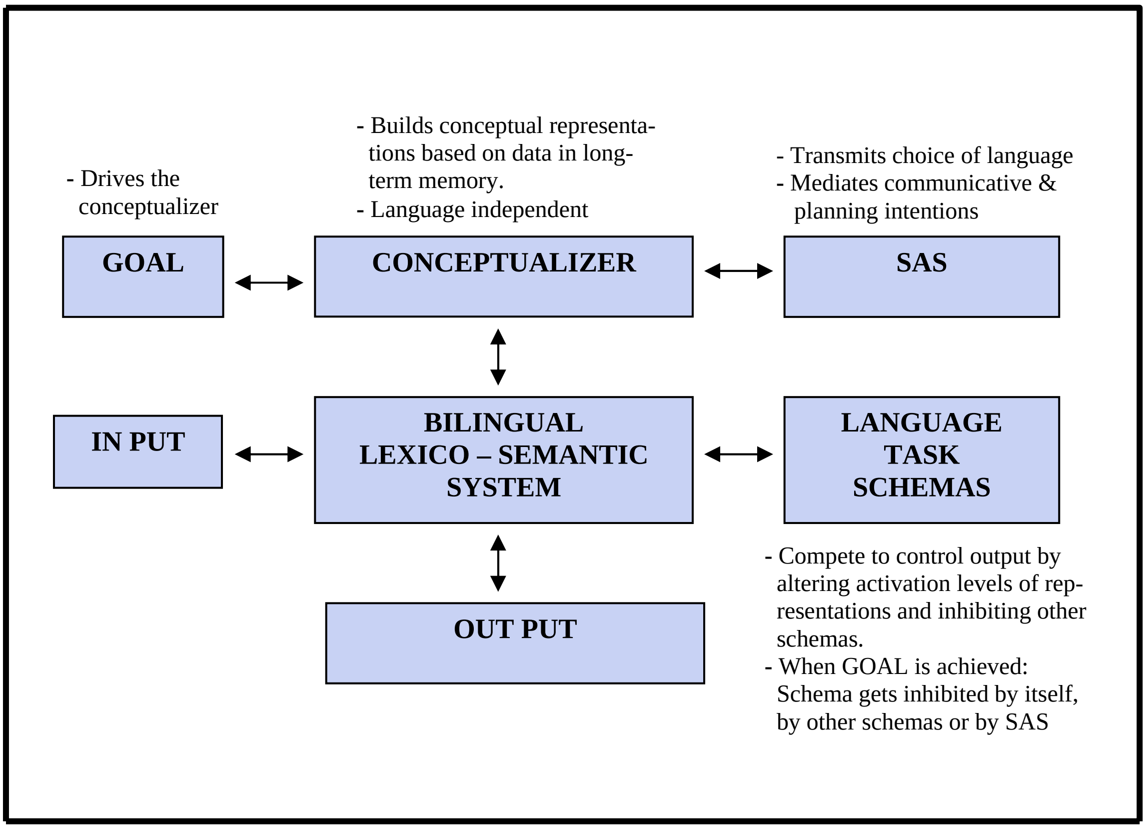

Figure 2 : Explanatory sketch of Green's IC model (Based on Green, 1998a, p.69)

The Language Task Schemas (LTS) control module allows existing routine schemas (i.e. networks detailing action sequences) that underlie automatic performance of certain skills stored in long-term memory, to compete to control behaviour by altering their activation levels. These schemas are triggered by perceptual or cognitive cues and concern language actions, and are arranged in a specific hierarchy. The lowest level corresponds to linguistic events, such as the articulation of a word. The intermediate one includes lexical decision and word translation, and the highest level relates to events, such as letter writing and entertaining a conversation. Schemas function as control circuits that undergo a process of active suppression over competition. In addition, the SAS (Supervisory Attentional System) controls novel tasks, monitors performance and builds or modifies existing schemas. It also modulates activity tasks. (Figure 2)

A selection process at the lemma level is engaged in order to win and control the lexicon. Each lexical concept is associated with a lemma that specifies its vital syntactic properties and a language tag. The binding-by-checking procedure ensures that the right lemma is associated to the right token. On top of this, there is also an inhibitory control that suppresses the lemmas with incorrect tags as a second checking procedure in order to guarantee that the correct response becomes a speech output form. In the meantime, all pairs remain active until the task or the checking procedure is completed.

Regulation is achieved by means of the modification of levels of activation of language networks, which requires sensitivity to external input and the capacity of internal direction. A simulation of the IC model "would involve both continuous variables (degree of activation) and discrete variables (the binding by checking mechanism) and would be an instance of a hybrid model" (Green, 1998b, p.100).

Inhibition is reactive and it takes time to recover from prior inhibition This is why the activation of specific lemmas requires input from external source or from the conceptual system. According to Green, it takes a longer reaction time to switch (back) into a dominant –and therefore more suppressed– language, because of the switching costs in perception and production. This asymmetry in translation is explained by the fact that the more active the lemmas, the more they will have to be inhibited.

Green considers that inhibition can be selective, as well as global. "Selectivity may be achieved either directly via attentional control, or indirectly via lateral inhibitory links between competing responses" (1998a, p.102).

2.4 The BIA+ Model (Dijkstra and Van Heuven)

Ton Dijkstra and Walter Van Heuven (2002) present an updated version of the bilingual interactive activation model (BIA, 1998), which is now more explicit than its predecessor with respect to the timing of the bilingual identification word process, the interactions between representations (orthographic, phonological, semantic) and the language tags. The BIA+ rejects the asymmetric top-down inhibition mechanism from language to word nodes and proposes the task/decision component as its functional alternative.

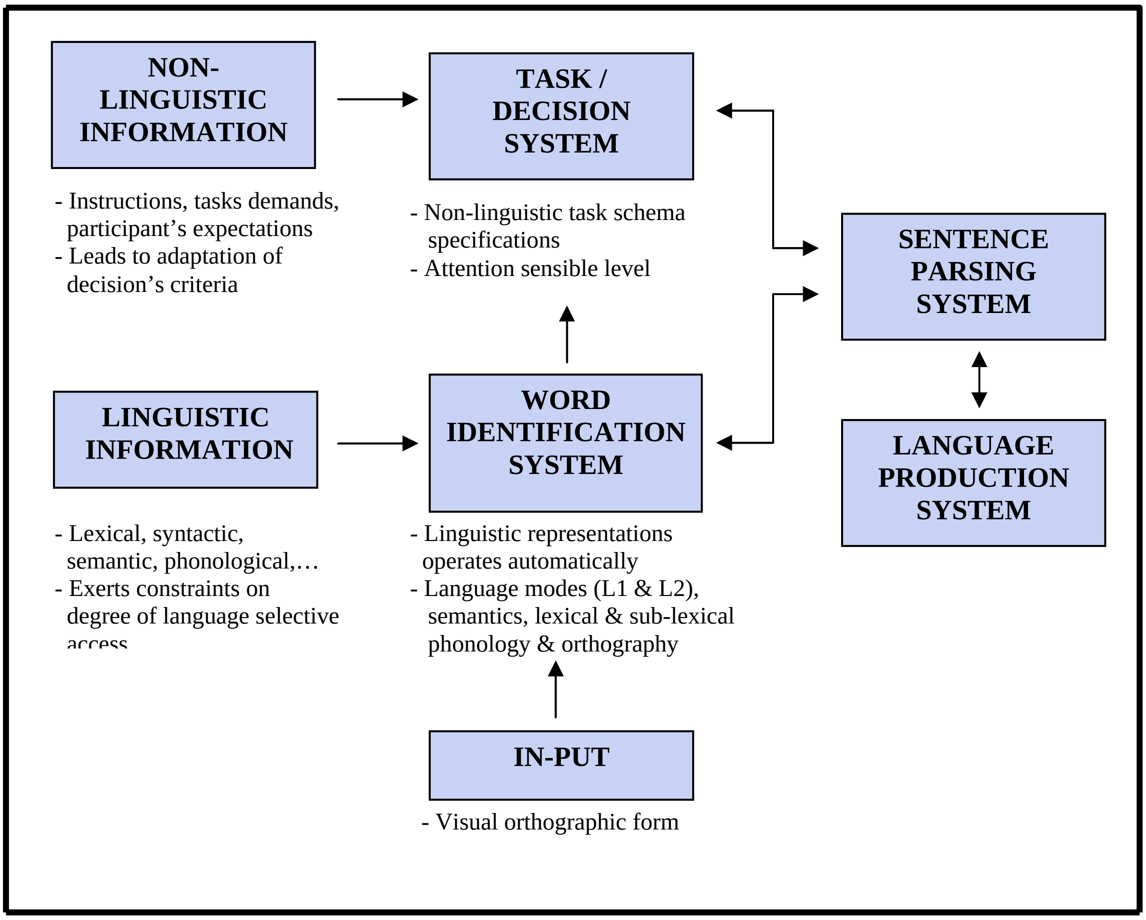

Figure 3 : Explanatory sketch of the BIA+ model (Based on Dijkstra and Van Heuven, 2002)

The WIS, the SPS & LP belong to the Language User System.

The Word Identification System (WIS) takes into account sentence context. Its activation levels are not affected by other systems. The Task/Decision System (TDS) is shaped by non-linguistic information, and is the locus of the specifications of mental processing operations required to perform a determined task. The task schema can be set up during practice or retrieved from memory, and contains a decision mechanism. The

TDS interacts with the WIS and with the Parser, which is a higher-order system. (Figure 3)

Visual input (a string of letters) excites lexical orthographic candidates containing these features and inhibits those lacking of them. These activated items excite words in both languages where they occur at the given position and inhibit all others. In the same way, activated orthographic word candidates transmit activation to their corresponding (e.g., phonological, semantic) representations. Due to language-specific features, the initial set of activated lexical candidates may become restricted to one language.

At the word level, all words inhibit each other: Activated word nodes from L1 send activation on the L1 node, and L2 activated words do the same with the corresponding L2 node. Both activated language nodes (L1 & L2) send inhibitory feedback to all word nodes from the opposite language. The language nodes fulfill two representational functions in the WIS: They serve as language tags and are fed with activation from the lexical representations within a language (global lexical activation).

The presentation of the previous four bilingual language models aims to highlight the role of activation and inhibition in control mechanisms in bilingual brains. Even though these models offer four different views on bilingual phenomena, they seem to agree on regulation by means of activation and inhibition. The following chapter intends to describe the neuroanatomical aspect of such regulation in brief.

4. Activation and Inhibition

According to Fabbro (1999), a fundamental issue of the neurolinguistics of bilingualism is whether the cerebral representations of language in bilinguals differ from those of monolinguals, and if they do so, in what way. To a certain extent, this implies that there *is* a correspondence between cerebral and linguistic representations. Taking into account that the linguistic system's anatomical and physiological base is located in the brain, it appears to be relevant to know about its structural organization, in order to be able to relate it to the linguistic phenomena.

According to Frank Netter (2000), "the complexity of the central nervous system is such that one must be guided by the fundamental requirements of simplicity if effectiveness in presentation is to be achieved" (Part I, p. ix). The same goes for proper linguistic models of representation, with the aim of accounting for extensive complex linguistic phenomena. Here I will present some physiological and functional neuroanatomical data that seems to be relevant for a better understanding of the neurolinguistics of bilingualism, specifically, the regulation mechanisms in the brain.

The human brain contains billions of neural cells, i.e., neurons. A typical neuron consists of three parts, the dentritic tree, the cell body (soma), and the axon (Figure 4). The dentritic tree has many branches and a much greater surface than the rest of the neuron. Incoming synaptic terminals make direct contact with it or its spines (called gemmules). The soma contains the organelles (discrete cell structures that have a specialized function) that control and maintain the neuronal structure. The soma membrane is also covered with synaptic endings that, due to their closeness to the origin of the axon, have a particularly potent effect on the rate of discharge of the neuron.

"One neuron can influence 1000-10,000 other neurons and, in turn, can be influenced by other neural cells, irrespective of their distance" (Fabbro, 1999, p.21). Neurons continuously exchange information through their axons, which are the cell-body extensions that can be longer than one meter. The axon membrane is specialized for the transmission of the action potential, which is the basic mechanism that allows the axons of neurons to send information over long distances.

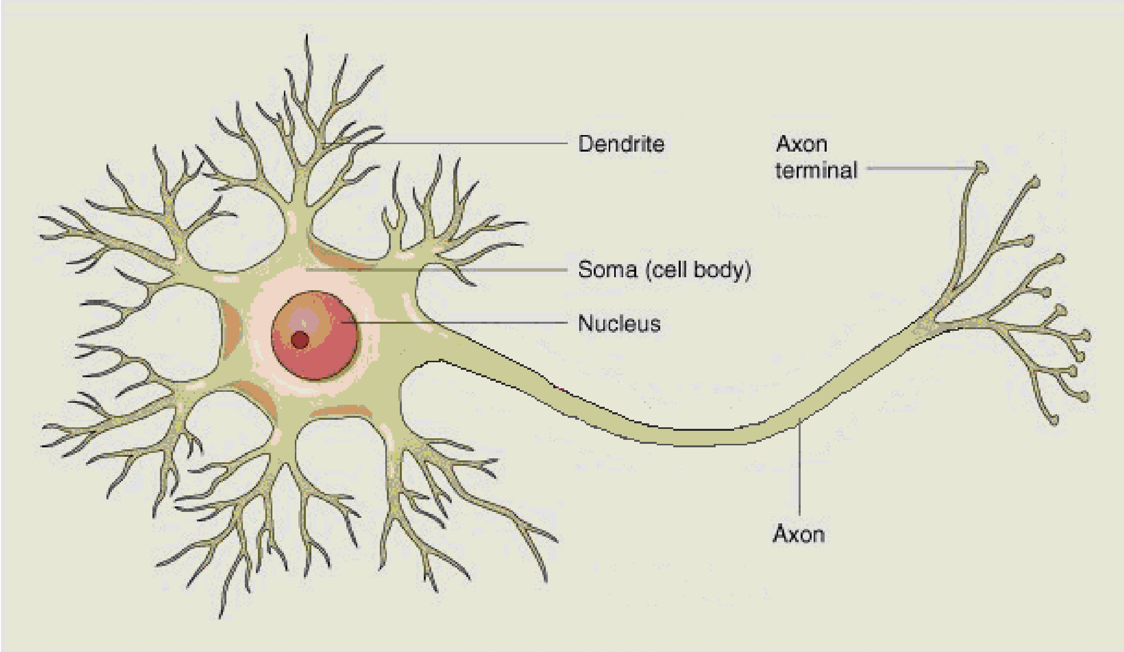

Figure 4 : A neuron. (Adapted from © 2000 John Wiley & Sons, Inc.)

The initial segment of the axon is usually the site of the generation of the action potential due to its shape and high excitability. The action potential then spreads down the axon and back to the soma and nearest dendrites, whose low excitability prevent the impulse to spread very far into the dendrite tree. At its distal end, the axon divides into numerous branches (i.e. axon terminals), which end up in synapses, which are the contact points between the neurons. In their vicinity, electrical signals release chemical substances that modify the electrical activity of the post-synaptic neuron (the receiving neuron of a synapse).

The most common synapses are the axodentric (between axon terminals and dendrites) and the axosomatic (between the axon terminal and the soma), which occur within complex structures. There are also axoaxonic (between axon terminals) synapses responsible for presynaptic inhibition, a mechanism that acts on the terminals of incoming excitatory fibers to reduce their power to excite the target neuron. The other mechanism is postsynaptic inhibition, which acts directly on the target neuron to reduce its excitability. Both forms of inhibition prevent or reduce the discharge of neuronal action potentials in response to an excitatory synaptic input.

Thus, “neurons are the basic elements of the brain. One of their essential features is that they are organized in circuits, within which information (of both excitatory and inhibitory type) is continuously changed.” (Fabbro, 1999, p.69)

The electrical potential of the protoplasm (the living substance inside the cell) of a neuron at the resting state is more negative than the electrical potential of extracellular fluid (outside the cell) by approximately 70mV (milivolts). This difference across the neuronal membrane is called resting membrane potential (RMP).

If the membrane of a neuron is depolarized (i.e. positive current flows into the membrane capacitor) from -70mV to approximately -40mV, the neuron responds with a brief impulsive flow of ionic current that shifts the membrane potential to +20mV, and then back to -75mV, that is, 5mV below resting level. This response is the action potential. If the initial depolarization does not reach the threshold level of -40mV, the membrane potential goes back to its resting level, and no action potential occurs.

The summation of excitation and inhibition is the fundamental principle on which the functioning central nervous system is based. Temporal summation takes place when a burst of action potentials reaches a nerve fiber terminal. If the latter is an excitatory fiber, then it is able to evoke the firing of a target neuron, even though the individual excitatory postsynaptic potentials (EPSP) evoked by single action potentials are too small to produce a suprathreshold depolarization. If the fiber is an inhibitory one, the inhibitory postsynaptic potentials (IPSP) can summate to produce a large hyperpolarizing potential. Spatial summation involves the activation of two or more terminals at about the same time, and it plays an essential role in the interaction of patterns of activity originating in various neuronal pathways.

Optimality Theory takes into account the summation of excitation (activation) and inhibition in the neural network. Boersma (1998) notes that constraint rankings could be seen as neural-nets, in which “the loudness of the protest of a constraint is the value of an inhibitory postsynaptic potential: it depends on the synaptic strength (the ranking as specified in the grammar) as well as on some things like the incidental amount of locally available neurotransmitter” (p. 283). Prince and Smolensky (1997) add that “[…] an inhibitory connection between two model "neurons" or "units," modelled as a negative weight, embodies a constraint that when one of the units is active, the other should be inactive; this is the activation configuration that maximizes harmony at that connection” (p.1607).

Furthermore, according to Prince and Smolensky (1997), “in the particular class of model neural networks admitting a harmony function, the input to a network computation consists of an activation pattern held fixed over part of the network. Activation then flows through the net to construct a pattern of activity that maximizes –optimizes– harmony, among all those patterns of activity that include the fixed input pattern. The harmony of a pattern of activation is a measure of its degree of conformity to the constraints implicit in the network's "synapses" or connections” (p.1607).

In the next chapter, I will offer an introductory presentation of Optimality Theory.

5. Optimality Theory

“The central idea of Optimality Theory (OT) is that surface forms of language reflect resolutions of conflicts between competing demands or *constraints*. A surface form is ‘optimal’ in the sense that it incurs the least serious violations of a set of violable constraints, ranked in a language-specific hierarchy. […] Languages differ in the ranking of constraints, giving priorities to some constraints over others. Such rankings are based on ‘strict’ domination: if one constraint outranks another, the higher-ranked constraint has priority, regardless of violations of the lower-ranked one. However such violations must be minimal, which predicts the *economy* property of grammatical processes” (Kager, 1999, p.xi).

5.1. Optimality Theory

According to Prince and Smolensky (2004), Optimality Theory “[…] is a strengthened theory of Universal Grammar, conceived as a set of violable constraints the interactions among which are determined on a language-particular basis” (p.257).
Kager (1999) adds that “[…] OT assumes that UG defines a set of universal and violable constraints, as well as principles by which constraints interact. Individual languages differ along the dimension of constraint ranking (as well as in their lexicons). If grammars are essentially rankings of universal constraints, then acquiring a language must involve the acquisition of a language-specific hierarchy of universal constraints. The language learner has exclusive access to the output forms of the target language, and is faced with the task of extracting the information from the outputs that is necessary to rank all constraints in a way predicting the outputs” (p.297). Boersma (1998) notes that these constraints, that is, these specifications, are universal because languages tend to share common linguistic phenomena, due to similar functions of communication in all languages, and due to our homogeneously built human speech production and perception organs.

Prince and Smolensky (1997) emphasize that “strict domination hierarchies composed of very simple well-formedness constraints can lead to surprisingly complex grammatical consequences. Furthermore, different rankings of the same set of constraints can give rise to strikingly different linguistic patterns. These properties show that strict domination, though a narrow mechanism, answers to the basic requirements on the theory of human language, which must allow grammars to be built from simple parts whose combination leads to specific kinds of complexity and diversity" (p.1604). OT proposes that the interaction between the constraints is based on strict ranking, in which a high-ranked constraint will always prevail over any number of lower-ranked constraints. "Any degree of failure on the weaker constraint is tolerated, so long as it contributes to success on the stronger constraint." (Prince and Smolensky, 1997, p. 1604) Besides, "a constraint does not have to leave the grammar if it becomes weaker. It may even still be active, but less visibly so" (Boersma, 1998, p. 265).

Prince and Smolensky (1997) state that "grammaticality is optimality; competition for optimality is restricted to representations containing the input; complexity arises through the interaction of simple constraints, rather than within the constraints themselves; constraints are violable and gradiently satisfiable; constraints are highly conflicting; conflict is adjudicated via a notion of relative strength; a grammar is a set of relative strengths; learning a grammar is adjusting these strengths" (p.1608). They add that "[…] the ranking of constraints of an optimality theoretic grammar orders linguistic structures from most to least harmonic: from those that best to those that least satisfy the constraint hierarchy. It is the constraint ranking and the ordering of structures it provides that is OT's characterization of knowledge of grammar" (p. 1608).

Thus, an OT grammar consists of violable conflicting constraints arranged in a language-specific ranking based on strict domination (i.e. firm dominance of higher-ranked constraints over lower-ranked), minimal violation, and maximal harmony. The generated candidates will compete to win, and will be evaluated considering their violation degree (marking the violation of every constraint), and their harmony degree (assessing the satisfaction of the constraints). Ultimately, the most harmonic candidate will be selected as the winner, that is, as the optimal outcome. Of course, violated constraints in the winning candidate must always be dominated by other higher-ranked constraints.

Hence, an OT grammar operates as an evaluation device that selects the most harmonic output form from an infinite candidate set, according to a language-specific ranking of universal constraints. The grammar defines pairs of underlying and surface forms (input- output), and "each input is associated with a candidate set of possible analyses by the function Gen (short for 'generator') […]" (Prince and Smolensky, 2004, p.5).

In order to acquire an OT grammar, "learners start with empty grammars, and have to learn both the constraints and their rankings. A convergent and robust gradual learning algorithm exists" (Boersma, 1998, p.269). The gradual learning algorithm (GLA) solves the problems by re-ranking the constraints by means of loosening them via promotion and demotion within the ranking under construction. The GLA starts with a ranking in which all constraints are equally ranked –or unranked, and compares the given output to various other suboptimal candidates and identifies the relevant dominating constraints. This way, the learner is able to deduce the constraints' hierarchy.

Output forms are the only source of positive information, which is maximally used by the learner, because "no underlying forms are innate, and hence the learner has to infer them solely on the basis of surface forms" (Kager, 1999, p.329). "[…] the substantial content of these constraints does not have to be innate for the learners to be able to acquire an adequate grammar from a realistic amount of overt data" (Boersma, 1998, p.269).

An OT grammar could be learnt from scratch. A language–specific ranking could be learnt from the given input through a constant and consistent re-ranking process by means of the GLA. The given linguistic input, which seems to perceptually maximize recognition and minimize confusion (e.g., motherese) would enable the GLA to succeed.

5.2. OT in bilinguals

In the case of bilingual individuals, there are two languages in one brain. Each language has a corresponding language-specific ranking of the universal constraints. This implies that both rankings consist of the same constraints, though arranged in different ways. The commonalities of these rankings (i.e. the universal constraints) suggest that they could be compatible or comparable to each other, and, consequently, it could be plausible for both rankings to interact. In addition, they also share the common ground of the linguistic levels (conceptual and semantic, syntactic and morphological, phonological and phonetic), in which they operate. Here, I am not implying that they share exactly the same areas in those levels, but that both languages function in and throughout them, like all languages do.

Furthermore, it could be possible that both languages, that is, Lx and Ly, generate candidates that compete all together in the same contest in order to become the optimal outcome of a given task. Therefore, in order to avoid mayhem, a {Lx ∪ Ly} linguistic universe would have to regulate the candidates' competition, evaluation, and selection. Successful bilingual phenomena like language mixing and language switching imply the existence of control mechanisms effectively exerted over those competing candidates. As other organic functions, it could be the case that regulation in a bilingual linguistic system may be accounted for by means of activation and inhibition.

6. OT modeling

In this chapter I will present some cases of language change during lexical borrowing and language switching, in an attempt to describe the processes involved in the selection of a specific linguistic token in a situation that involves bilingual individuals. I aim to illustrate the interaction of semantic information, structural demands, the role of the speaker and addressee's language dominance, and the context language in these phenomena. By means of rankings in OT tableaux, I will show a plausible view of the computations engaged in a bilingual brain in a given task. I intend to relate this to the principles of activation and inhibition.

6.1. Language mixing and language switching

Ansaldo and Joanette (2002) consider language mixing (LM) and language switching (LS) as two different phenomena common to bilinguals. During LM, the bilingual individual introduces linguistic items, such as morphemes, words, modifiers, and clauses from one language (Lx) into a sentence, utterance or discourse produced in the other language (Ly). Thus, LM could be seen as an intra-sentential phenomenon, in which a sentence may contain different elements from different languages. E.g. an utterance in Spanish that contains English items:

El sábado hice bungee jumping.

'On Saturday I did bungee jumping.'

They note that, alternatively, LS implicates an alternation between Lx and Ly across sentence boundaries, which is restricted by discourse principles. E.g. discourse initiated in English alternating with Spanish:

I spoke to my mother on the phone. Hace mucho tiempo que no la veo y …

'I spoke to my mother on the phone. It has been a long time since I saw her and …'

Therefore, LS could be regarded as an inter-sentential phenomenon. Fabbro (1999) adds that "the habits of bilingual individuals to alternate two languages within one coherent discourse may determine, at the psychological level, a low threshold of activation of switching phenomena and a reduction in the mutual inhibition of the languages" (p.150). He also observes that “this switching mechanism is peculiar not only to polyglot subjects, but also to monolinguals who use it in the selection of the different linguistic registers according to the communicative context” (p.151). Furthermore, he points out that “bilinguals switch and mix languages, while monolinguals switch and mix registers; bilinguals translate from one language into another, while monolinguals may paraphrase from one register to another […]” (Fabbro, 2001, p.213).

According to Fabbro (1999), bilingual and multilingual individuals follow certain patterns in their normal (as opposed to pathological) mixing of languages, such as, producing the pronoun in subject position and the verb in the predicate in the same language, and avoiding to express the preposition alone in a different language than the one used in the whole utterance. I am inclined to think that these patterns ascribed to ‘normal’ mixing could be seen as a hint of regulation via inhibition, in which the context language (Lx) may inhibit the other language (Ly), being able to keep its status as matrix language, that is, the language that provides the utterance with specific structural properties, accepted by the embedded language that supplies the imported items. Thus, the selected language (Lx) inhibits the non-selected language to a certain degree: If the bilingual subject (Lx $\cup$ Ly) is speaking to a monolingual subject (Lx), the non-selected language (Ly) will probably be a lot more inhibited than when speaking to another bilingual (Lx $\cup$ Ly), due to the shared linguistic knowledge.

However, the fact that bilingual individuals produce and comprehend mixed utterances suggests that both languages are activated to the extent that they are able to succeed in mixed production and comprehension. This suggestion seems to be backed up by the information gathered from bilingual and polyglot aphasic patients by a considerable number of neurologists and scholars that propose that when a language is not available, it is due to but to the weakening of its system, caused by temporal or permanent inhibition. “[…] various forms of language pathology can be accounted for in terms of failures in setting, sustaining, or undoing the activation levels of the two language systems appropriately” (De Groot and Christoffels, 2006, p.195).

Hence, the degree of inhibition of the language not being used in a bilingual brain during language mixing or switching is very mild in comparison to the extreme inhibition exerted over a language in the brain of e.g., an aphasic patient, and therefore, language change may be engaged.

6.2. Language mixing: Borrowing

Ansaldo and Joanette (2002) consider lexical borrowing as a particular kind of LM phenomenon. They suggest that it consists of the incorporation of lexical items from one language (Ly) into the regular processing and production of another language's (Lx) utterance. For them, there seems to be a hierarchy of material to be borrowed, in which nouns are the most easily borrowed followed by verbs, derivational morphology, inflectional items, and syntactic structures, which are the least likely to be borrowed. (p. 262).

Pavlenko (2002) considers that languages are acquired by engaging in natural meaningful interactions that, if successful, allow learners to acquire conceptual knowledge, which they store and are later able to retrieve. These concepts are mental representations that enable speakers of a specific language and cultural group to perceive, comprehend, categorize and produce along similar lines. That is, that regardless of the aspects in which mental representations may differ from individual to individual, or within individuals, there is a common conceptual core that allows sustained communication between these particular speakers.

She adds that in the case of second language acquisition, the encounter with a new language and culture implies contact with new objects, events, abstract concepts (e.g., emotions), and else. These new concepts are to be incorporated along the lines of the new language, in order to achieve full understanding and avoid misinterpretation.

According to Pavlenko's view of conceptual change in bilingual memory, these individuals undergo a transition that require adjustments, such as "[…] developing an additional set of conceptual representations, which may co-exist, compete with, and at times even replace the ones already stored in an individual bilingual's memory" (p. 78-79). Thus, we could imagine that some of these new conceptualizations in L2 may or may not have a corresponding token in L1. This phenomenon of language contact may manifest itself in lexical borrowing, which is one way to combine two languages in a brain, in which L2 lexical items can be borrowed by L1, and vice versa.

Lexical borrowing could be expressed in the interaction of both the constraints rankings present in a bilingual brain. Given a task in Lx and therefore being Lx the most activated language and Ly the most inhibited one, candidates from both rankings will be –inevitably– generated and will compete in order to fulfill the task requirements. These candidates will have different degrees of activation and inhibition according to their degrees of harmony and violation (of constraints), respectively. In addition, the most activated language, that is, the context language (Lx, in this case), will generally provide the most activated candidates; unless the competing language (Ly) is able to generate a better candidate, that due to its very high activation (harmony) degree is able to overcome the inhibition exerted over itself (due to being an Ly member), and even win the competition leaving less activated (harmonic) Lx (and Ly) candidates behind. The success of this Ly token in an Lx context task does not need to precipitate the total change of the language choice, as the election of one token alone may not be enough to activate the language (Ly) as a whole.

6.2.1 Fietstas vs. bolsa

The following example presents a case of lexical borrowing in a conversation between two bilingual individuals, Laura, who has Spanish as L1 and Dutch as L2, and Ellen, who has Dutch as L1 and Spanish as L2. Both reside in a Dutch speaking community. The conversation is being held in Spanish, thus, the context language is Spanish. Laura is addressing Ellen and producing the following utterance:

¿Tú sabes dónde me puedo comprar una fietstas ?

Do you know where I can buy a bicycle bag?'

Fietstas is a Dutch lexical item. Why does Laura use it in her predominantly Spanish utterance when addressing Ellen? Why does she not use a Spanish token instead?

I aim to explore the processes involved in the selection of *fietstas*, as Laura speaks. She starts producing a question in Spanish directed to her interlocutor, who is a native speaker of Dutch with advanced knowledge of Spanish, which is the reason why she does not hesitate in using Spanish as the context language. But instead of retrieving a Spanish token that can precisely tell what she means, that is, 'a luggage compartment attached to the back of a bike for carrying purposes', she chooses a Dutch item in its place. This suggests that *fietstas* is better than any other candidate that might have been competing in this task, and even though the context language (Lx) may have anticipated the arrival of an Lx token, a Ly item turned up instead.

Laura's bilingual brain is equipped with two languages, with corresponding rankings of constraints. Both generate candidates that compete to win. These candidates are activated or inhibited accordingly to their harmony or violation degree, added to the degree of activation of the language being used as context language and the degree of inhibition of the other one. Candidates may either satisfy or violate specific requirements evaluated by the constraints. The constraints are fundamentally in conflict, and the ranking of these constraints operates as a conflict-regulating mechanism.

The hierarchical constraint ranking is the selection device that manages the interactions between a set of universal constraints and the linguistic representational categories, in which higher-ranked constraints have precedence over lower-ranked ones. Thus, taking into account that absolutely no degree of satisfaction of lower-ranked constraints ever compensates for the violation of a higher-ranked constraint we understand that the higher the degree of satisfaction, i.e., the more harmonic the candidate is, the more activated it will get. Or, looking at it from a different angle, the higher the degree of violation of constraints, the more inhibited it will get. The conflicting nature of the constraints can be observed in the contest between activation and inhibition.

"The view of constraint ranking as exemplified in tableaux is a hybrid representation of grammar: it is meant to represent both the behaviour of the speaker and the properties of the language" (Boersma, 1998, p.272). In Tableau 1, there are only twelve of the many candidates generated by the two languages that Laura has in her brain. They are located in the left vertical column. Some of them belong to Spanish (Span), the context language (Context L), e.g., Span |bolsa| 'bag'; and some belong to Dutch, e.g., Dutch |hɑndtɑs| 'handbag'. In addition, some constraints are positioned in the top row, organized from highest-ranked to lowest-ranked from left to right.

In the big square at the top left of the tableau, in the intersection of the candidates column and the constraints row, there is an image that corresponds to the concept (that is, 'a luggage compartment attached to the back of a bike for carrying purposes' or –

PRODUCTION TABLEAU 1

¿Tú sabes dónde me puedo comprar una _______ ?

'Do you know where I can buy a ________ ?'

SEM: 

Context L: Span Speaker: Laura Addressee: Ellen	Addressee: María Comprehension L: Dutch	* SEM INS 'trade'	*SEM DEL 'inanimate object used as a container'	* SEM INS 'used to carry money or personal items'	* SEM INS 'carried by straps on back'	STRUC INS SYN CAT: noun	*SEM DEL 'attached to bike'	*SEM DEL 'placed in the back of the bike'	Context L: Span /SF/ in Context L	*Addressee: Ellen ComprehensionL: Span	*Addressee: Ellen ComprehensionL: Dutch	*Addressee: María ComprehensionL: Span
Span |bolsa| 'bag'							*!	*		*		
Span |bolso| 'handbag'				* !			*	*		*		
Span |kartera| 'purse'				* !			*	*		*		
Span |bolsatraseraparabisikleta| 'bag for rear of bicycle'						* !				*		
Span |bolsadebalores| 'stock exchange'		* !	*			*	*	*		*		
Span |kosa| 'thing'			*!				*	*		*		
Span |motʃila| 'backpack'					* !		*	*		*		
Dutch |tɑs| 'bag'							* !	*	*		*	
Dutch |hɑndtɑs| 'handbag'				* !			*	*	*		*	
☞ Dutch |fitstɑs| 'bicycle bag'									*		*	
Dutch |rʏχzɑk| 'backpack'					* !		*	*	*		*	
Dutch |fitsmɑnd| 'byclicle basket'								* !	*		*	

Figure 5 : Production Tableau 1 - Fietstas vs. bolsa

shortened- ‘a cycling bag attached to the rear of a bicycle’) of what Laura (the speaker) intends to transmit to Ellen (the addressee) in order to finish her utterance. Thus, this image is next to the abbreviation SEM, short for ‘intended semantics’. Laura intends to make the meant content available to Ellen in order to facilitate comprehension (interaction). To achieve the realization of the intended semantics, actual semantic features captured in relevant specifications will be computed. The computation of the ‘realized semantics’ expresses approximations of the intended semantics to meet sufficient requirements in order to attain semantic concretization.

Tableau 1 is a production tableau that expresses the search of a specific linguistic item that bests fills in the gap in this sentence. The initial task demands apparently have a great influence in the result and will probably shape the search for the winning candidate. These initial requirements provide diverse and complementary data. Specific information regarding the context language (Spanish, in this case), the language comprehension level of the addressee (for Spanish, as well as for Dutch, in this case), as well as, information that belongs to different linguistic levels, such as the semantic level (e.g., ‘inanimate object used as a container’) and the syntactic level (e.g., noun), will be supplied. All these requirements, among other specifications, will be taken into account in accordance to their place in the ranking. Thus, some will be high-ranked, medium-ranked or low-ranked.

In this tableau, we can see that some of the candidates violate certain constraints, and therefore they are marked with a “*” sign. When a high-ranked constraint is violated, and this violation leaves the candidate out of the competition, the violation is marked with a “*!” sign. Thus, this candidate will be inhibited from then on, a fact shown by the grey area on its row. Further violations will be marked as well.

Please note that there are two constraint columns (the first and the last) that are unmarked. This occurs because they specify data about María, who is not a participant in this conversation. Thus, as she does not play an active role in this event, these constraints should be ignored. The relevance of their presence in the tableau will be further explained (See Tableau 2).

The highest-ranked constraints are the semantic constraints in Tableau 1. Some of them insert semantic information (SEM INS), and others delete it (SEM DEL). These specifications relate to ‘intended semantics’, as they indicate which semantic features should be present –or not– in the winning candidate. The highest-ranked semantic constraints embody the most vital semantic requirements. A “*” sign in front of a constraint, could be read as “it should not be the case of”. E.g., the highest-ranked constraint * SEM INS ‘trade’ indicates that ‘trade’ should not be considered as a semantic attribute of the optimal candidate. Thus, it is not the case that ‘trade’ should be inserted in the semantics of the optimal candidate. The fact that the fifth candidate, which is Span |bolsadebalores| ‘stock exchange’, contains ‘trade’ in its semantics, makes it violate the constraint that disallows this feature to be present in a winning output, if it is not in the input. The violation of this high-ranked constraint puts this candidate out of the competition.

There is also a medium-ranked structural constraint STRUC INS SYN CAT: noun, which indicates that the searched candidate should belong to a specific syntactic category, i.e., it should be a noun. Thus, all candidates that do not fit this profile (e.g., noun phrases, verbs, prepositions) will violate this requirement and will be inhibited.

This constraint seems to be decisive in this competition, because it is violated by the fourth candidate Span |bolsatraseɾapaɾabisikleta| ‘bag for rear of bicycle’, which fulfils all given semantic specifications, but nevertheless, fails to satisfy the structural ones, due to being a noun phrase. This violation causes its elimination from the contest.

There is an ongoing inhibition and elimination of other candidates until one of them if left over as the winner. Some minor violations are marked on the winning candidate’s record, but these violated constraints are ranked so low, that Dutch |fitstɑs| ‘bicycle bag’ remains being the optimal output.

As Laura, the speaker, perceives Ellen, the addressee, as a very proficient bilingual (both in Dutch and in Spanish), those constraints regarding her ability to comprehend either language are very low-ranked in her ranking. This means that the violation of these will not jeopardize the selection of the candidate that violates them, because the speaker can rely on her interlocutor’s languages comprehension levels, which are accordingly represented in her ranking.

In addition, the constraint that indicates that the surface form (/SF/) of the candidate should belong to the context language (fourth from the left) is also low-ranked here. Its position in the ranking indicates that its violation may be considered minor or maybe even futile. The lack of priority of this constraint may suggest that it is not relevant for any candidate whatsoever to belong to the context language that is to the language being used. This could be seen as freedom to use either Lx /SF/ or Ly /SF/, regardless of the context language, namely, that language change is not restricted, nor forbidden. Thus, language change can therefore be tolerated, as both participants are able to handle /SF/s from either Lx or Ly.

The position of this constraint in a speaker's ranking may also be related to the frequency of use of language change. The more frequent borrowing is in the speaker's speech, the lower this constraint will be ranked. The less frequent it is, the higher it will be ranked.

In Tableau 2, the ranking of constraints remains the same as in Tableau 1, because both express the speech production of the same speaker, namely, Laura. This time, though, she is addressing María, who is a monolingual native in Spanish with no knowledge of Dutch. Laura is producing the following utterance:

¿Tú sabes dónde me puedo comprar una <u>bolsa</u> ?

'Do you know where I can buy a bag?'

As we can see, this question looks exactly the same as the one examined in Tableau 1, except for having the Spanish token *bolsa* instead of the Dutch lexical item *fietstas* as a winner. It seems to be the case that a very important variable has changed. This change has caused the selection of a different candidate as the winner of this competition.

Tableau 2 expresses the new search for a linguistic token, given the same constraints in the same ranking of the same speaker, with the same competing candidates, but accordingly to a changed factor: The new addressee is not bilingual in Spanish and Dutch anymore. She is a monolingual Spanish listener.

First of all, those two very low-ranked constraints that describe how Laura (the speaker) perceives Ellen's comprehension levels of Spanish and Dutch are not going to

PRODUCTION TABLEAU 2

¿Tú sabes dónde me puedo comprar una _______ ?

'Do you know where I can buy a ________ ?'

SEM: 

	Context L: Span Speaker: Laura Addressee: María	Addressee: María Comprehension L: Dutch	* SEM INS 'trade'	*SEM DEL 'inanimate object used as a container'	* SEM INS 'used to carry money or personal items'	* SEM INS 'carried by straps on back'	STRUC INS SYN CAT: noun	*SEM DEL 'attached to bike'	*SEM DEL 'placed in the back of the bike'	Context L: Span /SF/ in Context L	*Addressee: Ellen ComprehensionL: Span	*Addressee: Ellen ComprehensionL: Dutch	*Addressee: María ComprehensionL: Span
☞	Span |bolsa| 'bag'							*	*				*
	Span |bolso| 'handbag'				* !			*	*				*
	Span |kartera| 'purse'				* !			*	*				*
	Span |bolsatraseraparabisikleta| 'bag for rear of bicycle'						* !						*
	Span |bolsadebalores| 'stock exchange'		* !	*			*	*	*				*
	Span |kosa| 'thing'			*!				*	*				*
	Span |motʃila| 'backpack'					* !		*	*				*
	Dutch |tɑs| 'bag'	* !						*	*	*			
	Dutch |hɑndtɑs| 'handbag'	* !			*			*	*	*			
	Dutch |fitstɑs| 'bicycle bag'	* !								*			
	Dutch |rʏχzɑk| 'backpack'	* !				*		*	*	*			
	Dutch |fitsmɑnd| 'byclicle basket'	* !							*	*			

Figure 6 : Production Tableau 2 - Fietstas vs. bolsa

actively participate here, to the same extent as Ellen, the previous bilingual addressee, is not either taking part in this event. Therefore, they will not be marked.

Secondly, the first and the last constraint in the tableau, which did not play a part in the previous exercise, are vital in this contest. They specify María's Dutch and Spanish comprehension level, according to Laura's knowledge. On one hand, the highest-ranked constraint of Tableau 2 indicates that María's Dutch comprehension level is extremely poor. All Dutch candidates violate this specification, and get highly inhibited due to this major violation. For that reason, they are left out of further competition. The rank of this constraint is too high for its violation to go unnoticed or ignored. Otherwise, María's comprehension of Laura's utterance would be compromised, as well as the communicative goal of this task. The straightforward elimination of these candidates is decisive, and changes the face of this competition.

On the other hand, the lowest-ranked constraint indicates the very high comprehension level of Spanish of María, and ensures that she will be able to understand linguistic data encoded in this specific language.

Still, semantic and structural constraints keep on working on the candidates, and more of them get inhibited and eliminated due for not being able to fulfil the given requirements. Finally, an optimal candidate is found, namely, *bolsa*. This candidate does not contain some relevant semantic features, which indicate that it is not only a 'bag', but one attached to the rear of a bicycle in order to facilitate carrying goods while driving it, yet, it is better than the other candidates due to the given circumstances. The information that is not included in this lexical item will have to be added and explained to the interlocutor to familiarize her with the concept.

Tableau 1 and 2 provide a proper description of the fact that the comprehension level of the addressee plays a decisive role in the selection of a linguistic token in a given task. Furthermore, these tableaux show explicitly how the linguistic production of a bilingual speaker –e.g., regarding her language choice, may be altered accordingly to her perception of the interlocutor's comprehension levels of the languages she speaks, enabling or disabling language mixing phenomena, such as lexical borrowing.

In addition, it is important to realize that speaker and listener share common knowledge, which does not have to be language-specific. Concepts that comprise very particular cultural data in detail, like *stampot* (mashed potatoes mixed with certain mashed cooked vegetable, a Dutch dish) or *cebiche* (fish marinated in a spicy lemon-based sauce, a Peruvian dish), as well as worldwide used English tokens, such as, *USB* and *memory stick*, may be saved in the lexicon in their original form, in order to preserve their semantic faithfulness. Some of them, may even start as borrowed items and then become included in the host formal lexicon, depending on specific factors, e.g., frequency of use, lack of practical alternative. We all know that language change is inevitably related to language contact, and vice versa.

6.2.2 Wohnung vs. residencia

A second case of lexical borrowing is expressed in Tableau 3. Here, a conversation between Cristina, a bilingual speaker native in Spanish and very proficient in German, and Sylke, her bilingual interlocutor, a native in German and highly proficient in Spanish, both residents of a German speaking community. Cristina intends to address Sylke about a place she saw, where she would like to live. Thus, she utters:

Vi un <u>Wohnung</u> donde me gustaría vivir.

'I saw a dwelling where I would like to live.'

Cristina's brain is furnished with both Spanish and German rankings that supply candidates to compete in the given task, which is to look for the optimal output that best verbalizes what she has in mind. Tableau 3 expresses this competition while she speaks to Sylke. The constraints that refer to Sylke's comprehension level of both languages are very low-ranked because she is proficient enough to understand speech in both languages –according to Cristina.

Constraints about María's comprehension levels of these languages are also included in this tableau. We remember that María is a monolingual native speaker of Spanish. The fact that her comprehension level of Spanish is expressed as the lowest-ranked constraint in the tableau may suggest that her monolingual brain will have less load of work while understanding Spanish than Sylke. This may be due to Sylke having Spanish as L2, or maybe because there will be candidates that are generated by one ranking alone, during any linguistic event, in which she participates. Having two languages in the brain may imply that there is a collaboration –facilitating the solution of a

PRODUCTION TABLEAU 3

Vi un _____donde me gustaría vivir.

'I saw a ________ where I would like to live'

SEM: 

Context L: Span Speaker: Cristina Addressee: Sylke	Addressee: María Comprehension L: Ger	* SEM INS 'working place'	* SEM INS 'for temporary stay only'	*SEM INS 'a whole building'	* SEM INS 'emotionall family feeling'	* SEM DEL 'selfcontained'	* SEM DEL 'one floor in a building'	Context L: Span /SF/ in Context L	*Addressee: Sylke ComprehensionL: Span	*Addressee: Sylke ComprehensionL: Ger	*Addressee: María ComprehensionL: Span
Spa |ogar| 'home'					* !	*	*		*		
Spa |kasa| 'house'				* !			*		*		
Spa |residensia| 'place where one resides'							* !		*		
Spa |ofisina| 'office'		* !				*	*				
Spa |otel| 'hotel'			* !				*		*		
Ger |pɛnzjoːn| 'boarding house'			* !				*	*		*	
Ger |tsimɐ| 'room'						* !	*	*		*	
Ger |hauz| 'house'				* !			*	*		*	
☞ Ger |vonuŋ| 'dwelling'								*		*	
Ger |haim| 'home'					* !	*	*	*		*	

Figure 7 : Production Tableau 3 - Wohnung vs. residencia

task due to having more assets in all linguistic levels, between languages, in which both help each other in finding the best solution. On the other hand, it may signify that there is a mutual interference between them during a bilingual conversation, as both rankings provide candidates that require more processing work in order to find the best output. Thus, there may be advantages or disadvantages in having two rankings providing candidates to solve one task, or maybe both. Whatever the case is, it suggests an interaction between these rankings. OT tableaux seem to describe adequately this competition process.

Tableau 3 shows semantic constraints that indicate which semantic features shall be included (* SEM DEL) or avoided (* SEM INS) by the candidates that attempt to win the competition. All semantic constraints try to specify what kind of contender the linguistic system is looking for. In this case, Cristina saw a place, e.g., where she would like to reside, not work. She is thinking about a self-contained (complete in itself) space that does not occupy a whole building, and she wants to transmit this information to Sylke. The different candidates fail to satisfy certain constraints and fulfil others, in an ongoing computation that leaves one of them as the winner. The latter is a German token that fulfils all semantic requirements in full. And this is probably the reason why this contest selects this over the others. Thankfully, Sylke is also proficient in German, and even though this item does not belong to the context language, which is Spanish, it is still able to win. Its violation of the low-ranked context language constraint may cause a slight inhibition on a candidate, but all the others were out of the competition already, and therefore this failure is not enough to eliminate Ger |vonʊŋ| ‘dwelling’. The outcome is the optimal form, not necessarily a perfect form. It is the form that better resolves the constraints’ conflict, the most harmonic item.

In this tableau we do not find structural constraints that indicate the syntactical features that the candidates are required to have. But we understand that there are indeed structural specifications involved in this computation. E.g., Spa |bibiɾ| ‘to live’ would have to be eliminated from the competition due to not being a noun, but a verb. The structural constraint that specifies this requirement is higher-ranked that the context language constraint, and therefore its violation would be worse than the winner's minor violation.

The presence of high-ranked semantic constraints may be related to the fact that production processes normally start at the highest level. Concepts and their semantic features strongly shape the expected output form. Violations of this kind of constraints are decisive, and cause a great amount of inhibition of the activated candidates. Thus, regulation by means of inhibition appears to take place at the semantic level in a linguistic production event. This does not mean that it does not happen at any other levels as well.

We can see that violations of constraints with complementary information from different linguistic levels (such as, the syntactic level) also do play a role in the final decision, and that they may determine the inhibition and resulting elimination of some candidates. Thus, there seems to be an interaction between linguistic levels that enables the selection of the optimal candidate.

In tableau 4, Cristina is speaking to María, the Spanish monolingual subject. The constraints in Cristina's ranking remain the same, but the result turns out to be different. The level of comprehension of German of María is extremely low, and therefore, the constraint that specifies this is very high-ranked. All five German candidates violate this constraint and get highly inhibited, and eliminated from the competition. It seems that their participation in the contest depends on the fulfilment of this constraint. It appears to be that the nature of this constraint (that specifies the comprehension level of the addressee in German), its rank (very high), and its violation, restrain all German tokens from competing in this task. Thus, control may be exerted over the German candidates, restricting their further participation in this contest, according to the violation of this very high constraint, by means of inhibition.

Here, the candidate that does fulfil all the given semantic constraints, i.e., Ger |vonʊŋ| 'dwelling', has been eliminated due to a major violation and it is out of the contest. The best remaining candidate, i.e., Spa |residensia| 'place where one resides', wins.

PRODUCTION TABLEAU 4

Vi un _____donde me gustaría vivir.

'I saw a ________ where I would like to live'

SEM: 

Context L: Span Speaker: Cristina Addressee: María	Addressee: María Comprehension L: Ger	* SEM INS 'working place'	* SEM INS 'for temporary stay only'	*SEM INS 'a whole building'	* SEM INS 'emotionall family feeling'	* SEM DEL 'selfcontained'	* SEM DEL 'one floor in a building'	Context L: Span /SF/ in Context L	*Addressee: Sylke ComprehensionL: Span	*Addressee: Sylke ComprehensionL: Ger	*Addressee: María ComprehensionL: Span
Spa |ogar| 'home'					* !	*	*				*
Spa |kasa| 'house'				* !			*				*
☞ Spa |residensia| 'place where one resides'							*				*
Spa |ofisina| 'office'		* !				*	*				*
Spa |otel| 'hotel'			* !				*				*
Ger |pɛnzjoːn| 'boarding house'	* !		*				*	*			
Ger |tsimɐ| 'room'	* !					*	*	*			
Ger |hauz| 'house'	* !			*			*	*			
Ger |vonuŋ| 'dwelling'	* !							*			
Ger |haim| 'home'	* !				*	*	*	*			

Figure 8 : Production Tableau 4 - Wohnung vs. residencia

Those very low-ranked constraints that refer to Sylke's comprehension level of Spanish and German are not marked because she is not participating in this linguistic event. They are still present in Tableau 4, not only to provide the reader with a proper and consistent description, making it clear that we are talking about the same bilingual speaker's brain, but also to visualize that this information is saved in it. The data about Sylke may not be relevant here, and it may not be present in the working or short-term memory, but it is certainly stored in the long-term one. Otherwise, Cristina would not have the means to know that she can only address María in Spanish, and Sylke both in Spanish and German.

6.3. *Language switching: Jugada vs. move*

According to Ansaldo and Joanette (2002), language switching involves the alternation between two languages across sentence boundaries. However, it may be the case that the language change happens within the bilingual discourse, causing minimal syntactic disruption, without necessarily coinciding with inter-sentential boundaries. Here I will give an example, in which Lx is the initial context language, and Ly the language that alternates and follows production in Lx. This could be seen as a case of borrowing that precipitates language switching. We could visualize it as if we were pulling a piece of yarn out of its skein with such an effect, that instead of just getting a piece of yarn out of it, we would pull a much longer piece, that does not break from the rest of the yarn, but instead makes the skein start to roll away from our feet. Thus, linguistically, we would start speaking in Lx, then borrow an element from Ly, and inevitably go on speaking in Ly.

"[…] language switching may be used to specify the addressee of a message, to relate to a particular topic, to convey a meaning above and beyond the explicit message, or to express a social role."(Ansaldo and Joanette, 2002, p. 264) In the example showed in tableau 5, we have two bilingual subjects watching a game of soccer. Andrés, the speaker is a Spanish native with high proficiency in English, and his interlocutor is Mark, an English native, who is highly proficient in Spanish. They have been talking about the game in English, when Andrés utters:

PRODUCTION TABLEAU 5

Look at that! He is always in la jugada,hace unos pases excelentes.Desde que jugaba en Boca …

'Look at that! He is always in the outstanding move, he makes excellent passes. Since the time he played for Boca…'

SEM: 

Initial L: Engl Speaker: Andrés Addressee: Mark	*Addressee: Simon Language Level: Span	* SEM INS 'reference to a person'	* SEM INS 'thing to play with'	* SEM INS 'risk of money'	* SEM INS 'contest restricted by rules'	STRUC INS SYN CAT: noun	* SEM INS 'turn to play'	* SEM DEL 'out of the ordinary'	*SEM DEL 'specific action during an event'	Initial L: Engl /SF/s in Initial L	*Addressee: Mark Language Level: Span	*Speaker: Andrés Language level: Engl	*Speaker: Andrés Language level: Span	*Addressee: Mark Language level: Engl	*Addressee: Simon Language level: Engl
Engl |geim| 'game'					* !			*	*			*		*	
Engl |plei| 'to play'						* !		*	*			*		*	
Engl |tɔi| 'toy'			* !					*	*			*		*	
Engl |gæmbl| 'gamble'				* !				*	*			*		*	
Engl |muv| 'move'							* !	*				*		*	
Span |χugador| 'player'		* !						*	*	*	*		*		
☞ Span |χugada| 'outstanding move'										*	*		*		
Span |χuego| 'game'					* !			*	*	*	*		*		
Span |χugete| 'toy'			* !					*	*	*	*		*		

Figure 9 : Production Tableau 5 - Jugada vs. move

Look at that! He is always in la jugada. Hace unos pases excelentes.
Desde que jugaba en Boca …

‘Look at that! He is always in the outstanding move. He makes excellent passes.
Since the time he played for Boca…'

Tableau 5 expresses the selection of Span |χugada| ‘outstanding move’, the item that initiates and facilitates the language switch. This Spanish lexical form has very specific semantic features, and designates an outstanding action that is produced during a sports match (or a cards game). It is therefore hard to find an equivalent item in English without needing to use an adjective to be more precise. In addition, we have to take into account the non-linguistic context of soccer that may explain Andrés need to express himself in Spanish. It could be that he is emphasizing the striking move of certain player, in order to get Mark’s attention, or just using the language that could demand less effort in his brain, as his attention is already captured by the game he is watching.

The lowest-ranked constraints in this tableau describe not only the languages levels of the addressee, but those of the speaker as well, as he perceives both his interlocutor and himself. The position of these constraints relate to the proficiency of the subjects, e.g., Mark’s language level in English is better than Andrés’, and therefore, the constraint that specifies this is lower-ranked than the constraint that informs about the English level of Andrés. Conversely, the constraint that specifies Andrés’ level of Spanish is then lower-ranked than the constraint that specifies Mark’s level of Spanish. It is important to take into account that the speaker is aware of his interlocutor’s languages levels, but also, of his own. This may be decisive for language switch. If the interlocutor is very proficient in both languages, but the speaker is not, then the speaker’s language level would not allow him to continue in the initial context language, and he would be forced to switch. In this case, the constraint that specifies the speaker’s own language level would be medium- (or high-) ranked, and thus, it would play a vital role in the selection of the language to be used, as it would restrain the use of that specific language.

Please note that there are two constraints that refer to the language levels of Simon, a third subject, who is not a participant of this linguistic event. Therefore, the corresponding columns are unmarked in this tableau, and will be explained in Tableau 6.

PRODUCTION TABLEAU 6

Look at that! He is always in the move, he makes excellent passes. Since the time he played for Boca…

SEM: 

	Initial L: Engl Speaker: Andrés Addressee: Mark	*Addressee: Simon Language Level: Span	* SEM INS 'reference to a person'	* SEM INS 'thing to play with'	* SEM INS 'risk of money'	* SEM INS 'contest restricted by rules'	STRUC INS SYN CAT: noun	* SEM INS 'turn to play'	* SEM DEL 'out of the ordinary'	*SEM DEL 'specific action during an event'	Initial L: Engl /SF/s in Initial L	*Addressee: Mark Language Level: Span	*Speaker: Andrés Language level: Engl	*Speaker: Andrés Language level: Span	*Addressee: Mark Language level: Engl	*Addressee: Simon Language level: Engl
	Engl |geim| 'game'					* !			*	*			*			*
	Engl |plei| 'to play'						* !		*	*			*			*
	Engl |tɔi| 'toy'			* !					*	*			*			*
	Engl |gæmbl| 'gamble'				* !				*	*			*			*
☞	Engl |muv| 'move'							*	*				*			*
	Span |χugador| 'player'	* !	*						*	*	*			*		
	Span |χugada| 'outstanding move'	* !									*			*		
	Span |χuego| 'game'	* !				*			*	*	*			*		
	Span |χugete| 'toy'	* !		*					*	*	*			*		

Figure 10 : Production Tableau 6 - Jugada vs. move

In Tableau 5, the language level constraint refers to proficiency both in comprehension and in production. In order to make the tableaux as economic (regarding space) as possible, I have merged both in one. Both abilities may differ within one speaker, e.g., a subject's comprehension level in Lx may be much better than his level in production, and therefore his Lx comprehension level constraint would be lower-ranked than his production level constraint.

Tableau 5 expresses a competition of tokens generated by both English and Spanish. Semantic and structural constraints that specify the requirements of the desired output form, and specific given factors, such as the topic of the conversation (soccer), the diverted attention of the speaker (who is watching a sports match while speaking), the language levels of both the participants, and the lack of lexical availability (of a token that belongs to the initial context language (English) that precisely communicates the conceptual information that the speaker has in mind), contribute in the selection of the winning item.

Tableau 6 expresses a similar competition that differs in the addressee, Simon, who is a monolingual speaker of English. Here, a different winner is selected due to the interaction of all of the above described factors. The Spanish tokens get inhibited and eliminated in consideration of this change of interlocutor, as they all violate the highest-ranked constraint of the tableu. Thus, Eng |mu:v| 'move' is selected. In any case, there is always the possibility of filling in the semantic gaps with other lexical items that may accompany the selected item. That will be up to the speaker's creativity, will and ability.

6.4. Comprehension vs. production: Humo

So far, we have only seen production tableaux. Tableau 7 expresses the competition of Spanish and Dutch candidates in a real comprehension process of an utterance in Spanish. The speaker, Marcel, is a Dutch native speaker with some knowledge of Spanish, and the addressee is Alejandra, a Spanish native bilingual individual with high proficiency in Dutch. She was walking into a room filled with smoke when Marcel says:

COMPREHENSION TABLEAU 7

¡Hay mucho fumo !

'There is a lot of ____!'

/fu.mo./SF Context L: Span Speaker: Marcel Addressee: Alejandra	* 'Ø'	MAX (rhotic)	IDENT ONSET (voice)	IDENT (back)	* AdjVerb	IDENT ONSET (labial)	IDENT (nasal)	DEP (segment)	DEP (σ)	*Speaker: Marcel Language Level: Span	Context L: Span /SF/ in Context L	*Addressee: Alejandra Own Language Level: Dutch	*Addressee: Alejandra Own Language Level: Span	*Speaker: Marcel Language Level: Dutch
/fu.mo./SF Span |fuma| 'He/she smokes'				* !	*					*			*	
/fu.mo./SF Span |fumo| 'I smoke'					* !					*			*	
☞ /fu.mo./SF Span |umo| 'smoke'								*		*			*	
/fu.mo./SF Span |vumo| 'ø'	* !		*							*			*	
/fu.mo./SF Span |θumo| 'juice'						*!				*			*	
/fu.mo./SF Span |fumaɾ| 'to smoke'		*!		*	*					*			*	
/fu.mo./SF Dutch |rok| 'smoke'		*!	*			*	*	*	*		*	*		*
/fu.mo./SF Dutch |rokə| 'to smoke'		*!	*	*	*	*	*				*	*		*
/fu.mo./SF Dutch |fut| 'foot'							*!	*	*		*	*		*

Figure 11 : Perception Tableau 7 - Humo

¡Hay mucho *<u>fumo</u>!*

'There is a lot of __*___ !'

Fumo looks like a Spanish lexical item, but it is a non-word in this language. When Alejandra's bilingual brain has to process this information and make sense out of it, candidates from both languages are generated to compete in order to come up with a form that will allow her to comprehend what Marcel is saying. Thus, her ranking of constraints will evaluate all forms activated as candidates to compete to resolve this comprehension task, by finding the optimal underlying form (UF) for the given surface form (SF) */fu.mo./*.

The given auditory data is complemented by visual information. It is known that visual aid is used within individual processing strategies, as they tend to assist in linguistic comprehension, though sometimes they may interfere. Thus, Alejandra could suspect that the smoke in the room is supplying some semantic hint. Semantic constraints need to be taken into account in this tableau. Thus, the highest-ranked constraint is a semantic constraint that specifies that the optimal UF should relate to meaning. As the fourth candidate does not meet this requirement, it is eliminated from the competition.

The context language suggests that the optimal token is a Spanish token (as the rest of the utterance). Though, Marcel's Spanish is not that good, a fact that is expressed by a medium-ranked constraint that specifies the speaker's level of Spanish. Thus, Alejandra's constraint ranking has to select a winner, out of a very broad selection of candidates. Maybe those candidates are not just generated as Lx and Ly tokens, but as (Lx)Ly and (Ly)Lx tokens as well. That is, Lx forms that may have passed by the Ly ranking, and vice versa: Bilingual speakers are known for using both their languages in a very creative way. Sometimes, they create forms that may not be available for monolingual speakers of Lx or Ly, because they are the result of their languages contact. E.g., they may take a string of Lx phonemes with their corresponding SF and UF in Lx and add a suffix according to Ly structural specifications, adding a string of Ly phonemes.

In addition, there are phonological constraints that participate in the evaluation of the given SF, which provide articulatory and auditory specifications. These constraints are high-ranked. They seem to interact with semantic constraints in pursuing the optimal underlying form. The second high-ranked constraint is MAX (rhotic) specifies that if a rhotic segment (trill or tap) were present in the optimal UF, then it should have a corresponding segment in its SF. The fact that three candidates have a rhotic segment in their UFs and no rothic segment is found in */fu.mo./*, leaves them out of the competition. The MAX constraint identifies the elements of two representations (UF and SF) that stand in the relation of correspondence, suggesting that the underlying segment should surface.

The third high-ranked constraint requires a correspondence in voicing in onset position between SF and UF. This faithfulness constraint is violated by the fourth candidate because its UF has the voiced version of the voiceless labiodental fricative present in the given SF. This IDENT constraint is also violated by those candidates that have a trill in the onset position of their UFs. Thus, the IDENT ONSET (voice) constraint is violated by those candidates that have a +voice segment instead of a -voice one, due to violating the requirement of a precise featural match between correspondent segments.

The fourth constraint is IDENT (back) which compares the location of the vowels of both representations. The given SF has two back vowels. All candidates have at least one back vowel (as their first vowel). But three of them violate this constraint due to having a front (first and sixth candidates) or a central vowel (eighth candidate) in their UFs (as their second vowel).

The fifth constraint *AdjVerb is a structural constraint that specifies that in the given Spanish context no verb should follow the adjective *mucho* (‘a lot of’) after the impersonal verbal form *hay* (‘there is/are’). Thus, it is violated by all the verb-forms.

The next IDENT constraint requires the segments in the onset position to be labial in both representations. The fifth candidate gets eliminated by violating this constraint due to having a dental segment in the onset position in its UF. The trills in onset position of two other candidates are marked as violations as well, although they have already been eliminated. The IDENT (nasal) constraint is violated by the three last candidates that have a plosive instead of the corresponding nasal segment.

There are two DEP constraints. DEP (segment) counts segments both in SF and in UF. There are four segments in the SF string and three candidates only have three segments in their UF. This difference makes them violate this constraint. The winning candidate is among these three candidates, but it still remains the best UF in comparison to the others. The last DEP constraint counts syllables and is violated by two monosyllable candidates.

After all, Alejandra has found the optimal UF for the given SF to achieve comprehension of Marcel's utterance.

In Tableau 8, we find a real production event. This time, it is the previous addressee, Alejandra, a bilingual native in Spanish and highly proficient in Dutch, who is addressing Marcel, the previous speaker. She utters:

¡Hay mucho humo!

'There is a lot of smoke!'

The roles of the participants have been switched. This time, it is Alejandra who is in charge of producing such utterance. The given task is no longer a comprehension one, but a production one. This tableau presents a different set of candidates and constraints, although some of them remain the same as in the previous tableau.

The highest-ranked constraint is a semantic constraint that is not violated in this tableau, as all the nine candidates have meaning. The next high-rank constraint is DEP (rhotic), which is violated by all candidates that have a rhotic segment in their SF, which does not have a correspondent segment in the given UF. Thus, seven out of nine candidates get eliminated due to this major violation.

There are three IDENT constraints. The only consonant found in the SF is a bilabial voiced nasal, and the highest-ranked IDENT (voice) specifies that there should be a correspondent +voice segment in the SF. Three candidates violate this constraint due to having a velar voiceless plosive in the correspondent position in their SFs. The next IDENT (back) constraint compares both back vowels present in the UF to their correspondent vowels in the SF-candidates. The violations are marked twice (**) if the two correspondent vowels in SF are not back vowels, as in the fifth and ninth candidates. The last IDENT constraint regards the nasality of the only consonant in the given UF, to its corresponding token in the competing SFs. Thus, it is violated by all candidates, except those two that have a nasal segment in this position in their SF (first and third candidates). Note that there is a specific strategy followed in the constraint evaluation in this tableau in order to keep consistency and coherence throughout the whole process.

PRODUCTION TABLEAU 8

¡Hay mucho humo !

'There is a lot of ____!'

SEM:  |umo| UF Context L: Span Speaker: Alejandra Addressee: Marcel	* 'Ø '	DEP (rhotic)	IDENT (voice)	IDENT (back)	* AdjVerb	IDENT (nasal)	DEP(segment)	MAX (σ)	DEP (σ)	*Addressee: Marcel Language Level: Span	Context L: Span /SF/ in Context L	*Speaker: Alejandra Own Language Level: Dutch	*Speaker: Alejandra Own Language Level: Span	*Addressee: Marcel Language Level: Dutch
|umo| UF Span/fu.maɾ./SF 'to smoke'		*!		*	*		**			*			*	
|umo| UF Span/si.ga.ro./SF 'cigarrette'		*!		*		*	***		*	*			*	
☞ |umo| UF Span/u.mo./SF 'smoke'										*			*	
|umo| UF Span/en.sen.de.doɾ/SF 'lighter'		*!		*		*	*******		**	*			*	
|umo| UF Span/pu.ɾo./SF 'cigar'		*!				*	*			*			*	
|umo| UF Span /a.pa.gaɾ./SF 'to extinguish'		*!		**	*	*	***		*	*			*	
|umo| UF Dutch/rok./SF 'smoke'		*!	*			*		*			*	*		*
|umo| UF Dutch/ro.kə./SF 'to smoke'		*!	*	*	*	*	*				*	*		*
|umo| UF Dutch/ɑn.ste.ka./SF 'to light'			*!	**	*	*	****		*		*	*		*

Figure 12 : Production Tableau 8 - Humo

The structural constraint *AdjVerb eliminates all verb-form candidates. The following constraint is DEP (segment), which takes into account that the given UF has only three segments and looks for correspondence in the optimal SF. This constraint is violated for every added segment in the SF. Thus, the fourth candidates violates it seven times (*******) because its SF has ten segments in total (7+3=10).

There is also a DEP (σ) constraint, which specifies information regarding the number of syllables that the optimal SF should have. This constraint is violated for every extra syllable that SF has compared to UF. Thus, whereas the second candidate has one violation mark (due to having one more syllable than UF), the fourth candidate has two marks (due to having two more syllables than UF).

Between the DEP constraints there is a MAX (σ) constraint that specifies that every syllable that is present in the UF should also be present in the SF. Only the seventh candidate violates this constraint, as it is the only one that has less than two syllables in its SF. This candidate has one syllable in its SF (2-1=1) and is marked with one violation.

An optimal SF has been selected from all the generated candidates competing for the given UF. The linguistic production task has been efficiently solved by the constraint rankings computations in Alejandra’s bilingual brain. These rankings have also successfully solved the comprehension task. Both tableaux (7 and 8) aim to describe the multilevel constraint dynamics involved in both speech perception and production.

7. Discussion

Constraints are generated from both languages, that is, Lx and Ly are activated during bilingual tasks. Only activated candidates could get inhibited, if we understand that inhibition is a force that fights activation for regulation purposes. Thus, both languages seem to be available at all times for bilingual individuals, though one of them may be more activated than the other one, given a specific task (the language of context may cause the inhibition of the other one to a certain degree, still allowing the production and comprehension of mixed utterances or enabling code-switching). Thus, the selection of one language may not be necessary. It may be the case that the degree of inhibition of the non-used language is very high (at its highest) when the bilingual speaker is addressing a monolingual speaker in order to avoid lack of understanding.

Furthermore, evidence gathered from simultaneous interpreting events, indicate that both languages can be continuously activated at the same time. These events seem to point out at another important factor regarding regulation, which relates to the attainable language-specificity of the channels, as comprehension is engaged in Lx and production in Ly. This processing could be compared to a transformer, which is an electrical device that converts the incoming current of xV (volts) into an outgoing current of yV. Hence, the most intimate contact between Lx and Ly may happen at the highest level of representation, i.e. the conceptual-semantic ground, in which comprehended Lx tokens would ‘discharge’ their specifications in order to ‘charge’ or enable Ly tokens to take further action in the productive part. “Conceptually mediated translation may thus exploit the same underlying system(s) as used in common, intralingual comprehension and production […]” (De Groot and Christoffels, 2006, p.196). This finely tuned cooperation between the two languages may require extra resources (e.g., attentional, physical) and processing effort, that could explain why simultaneous interpreters work in shifts of 30 minutes, and then are obliged to take a rest before continuing. This break could be seen as a refractory period that would allow them to recover for further activity.

Another aspect to be taken into account is that it seems that it is more difficult to simultaneously interpret from the most dominant language to the less dominant. This evidence, suggests that the bi-directionality of the linguistic process is not symmetric, and is supported by the fact that production is harder than comprehension.

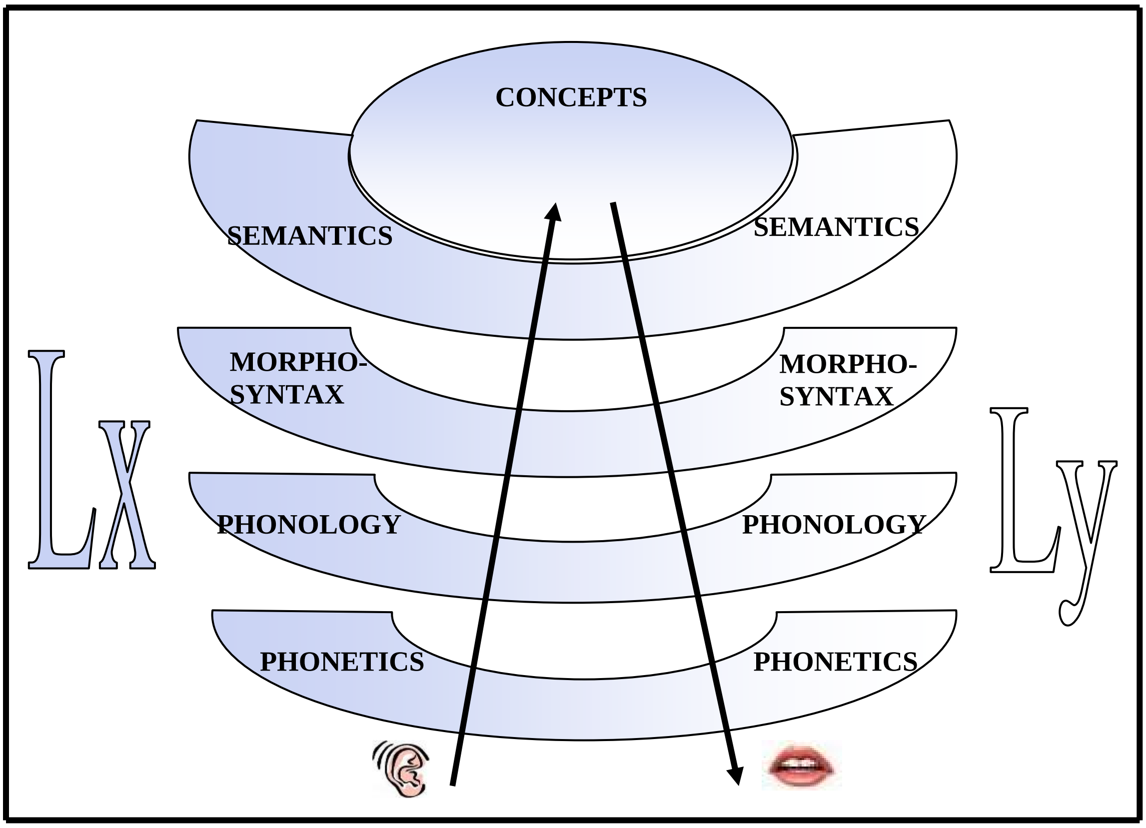

Figure 13: Lx ∪ Ly : Interaction of levels of representation

The linguistic events expressed in the OT tableaus suggest that there is an interaction between the different linguistic levels of representation, both in comprehension and production. It may be that the initial task demands are not processed the same way in the computations engaged during speech comprehension and speech production. This may be due to the directionality of the processing. In the case of comprehension, the input is perceived as articulatory and auditory material that has to be decoded through the representational levels in order to track down its correspondent underlying or lexical form. In production, the input's specifications relate to higher representational levels (concepts that contain specific semantic features) that are shaped by the dynamics of the other linguistic levels in order to find its best outcome form.

This activity across multiple levels does not necessarily mean that the processing of linguistic material is sequential or cascade-like. The generated candidates for a given task compete and are evaluated by constraints from different levels that seem to work in parallel, as their rank does not depend on the linguistic levels that they are engaged with, but on the language-specific hierarchy that establishes their position in the ranking.

The generator of the candidates may set off their activation, which is balanced by the inhibition caused by their violation of constraints. Thus, the most harmonic candidates could be seen as the most activated ones, whereas the most inhibited candidates would be the ones incurring in major violations (violations of high-ranked constraints).

Fabbro, among other scholars, provides excellent current data based on thorough research and clinical reports concerning normal and pathological use of languages in bilingual and polyglot individuals. This evidence sheds light on the way bilingual individuals handle their two languages in the brain. Candidates from both sources have to be evaluated, and in order to avoid a random mix up, and to enable the selection of the optimal outcome, control is successfully exerted. Both cerebral and linguistic representations seem to suggest regulation via activation and inhibition. Opposite forces seem to be able to keep the balance in a bilingual brain. That is, harmony overcomes conflict.

8. Conclusions

I suspect that control mechanisms are able to regulate the bilingual linguistic flow on the basis of both activation and inhibition, as it happens in the neural networks, in which language is processed. The evidence provided by the physiological locus of human language suggests that excitatory and inhibitory forces enable this system to function properly. However, within the OT framework, it seems to be that inhibition –and not activation- plays the decisive role in the regulation of the selection of the optimal output, as it determines the elimination of the competing candidates, due to the inhibition triggered by their constraints' violations. Then again, it is not clear how a non-activated token can be inhibited at all, because, if it is not activated, then it does not need to be inhibited. Thus, I presume that activation is fired into the tokens by the OT candidates generator, so that they can become competing candidates vulnerable to inhibition.

With regard to the dynamics involved in bilingual linguistic events expressed in the OT production (mainly) and perception tableaux, there seems to be an interaction of constraints from different linguistic levels, such as, semantic, structural and phonological, that jointly evaluates the candidates generated by both languages. Thus, there not only appears to be an interaction between the two languages, but also throughout their linguistic levels of representation. However, the evidence is not conclusive regarding the nature (sequential or parallel) of the computations engaged in bilingual perception and production. Although, I suspect that it is an online processing, as the ranks of the constraints (and thus, their role in the selection decision) do not depend on their locus in the linguistic system, but on their language-specific hierarchical relevance.

In addition, there are specific factors, such as the language dominance (i.e. language levels) of the speaker and the addressee, the context language, and other non-language-specific aspects (e.g., the attentional resources of the participants, the topic of the conversation), that crucially participate in the course of bilingual linguistic events. The evaluation and selection process of an adequate output resembles a round table of specialists that shape the best outcome form in respect of their given rank.

9. Further inquiries

A comparison between simultaneous bilingual subjects with typologically related languages (e.g., Spanish and Portuguese), and simultaneous bilingual subjects with typologically different languages (e.g., Spanish and Dutch) in the brain, during a recognition task, may provide some evidence regarding the interaction of the rankings in bilingual perception. The language-specificity of the rankings suggests that similar languages (e.g., Italian and Spanish) will have similar rankings. That is to say, that their constraints will be arranged in a similar way. Otherwise, their hierarchies of constraints will look different (e.g., Italian and Chinese). It would be interesting to find out whether there is a contrast in reaction time, if there is any and whether it is significant, in order to discover more about the dynamics of both rankings in a bilingual brain during both a monolingual and a bilingual task. The monolingual task may provide evidence for the regulation mechanisms involved: Does it take less time to select one of the languages if both rankings are very different from each other? Does it take more effort to activate one of the languages and inhibit the other when both are typologically similar?

Another important issue is the locus of storage of the information about the addressee. Is it stored in the explicit or implicit memory? And how was it learnt? As this information seems to be decisive in restricting speech to one language, e.g., when a bilingual speaker addresses a monolingual interlocutor, it seems relevant to know its location. Cases of bilinguals or multilinguals with brain damage (e.g. aphasic patients) may supply evidence to investigate this matter.

Last but not least, the question about how do two different language-specific rankings interact in order to solve bilingual tasks? Do they work together by relating their linguistic levels of representation and corresponding constraints? Or do they match their constraints by rank? Or both? If all candidates generated by both languages in a bilingual brain are evaluated by a ranking of constraints, is it a coordinated ranking, or two independent entities cooperating to solve one task? There may be an equation that explains how these two different arrangements of the same universal constraints interact in such a way that they effectively provide proper responses to bilingual phenomena tasks.

References

- Ansaldo, A.I. & Joanette, Y.

2002. Language mixing and language switching following aphasia. In: Fabbro, F. (ed.) **Advances in the Neurolinguistics of Bilingualism. Essays in Honor of Michel Paradis.** Udine: Forum.p.261-274.

- Banich, M.T. & Mack, M.A.

2003. **Mind, brain and language. Multidisciplinary perspectives.** Mahwah, NJ: Lawrence Erlbaum Associates.

- Boersma, Paul

1998. **Functional Phonology. Formalizing the interactions between articulatory and perceptual drives.** The Hague: Holland Academic Graphics.

- Costa, A. & Santisteban, M.

2006. The control of speech production by bilingual speakers: Introductory remarks. **Bilingualism: Language and cognition** 9, p.115-117.

- Costa, A. La Heij, W. & Navarrete, E.

2006. The dynamics of bilingual lexical access. **Bilingualism: Language and cognition** 9, p.137-151.

- Cutler, A., McQueen, J.M., Norris, D. & Somejuan, A.

2001. The roll of the silly ball. In: Dupoux, E. (ed.) **Language, brain and cognitive development. Essays in honor of Jacques Mehler.** Cambridge, MA: The MIT Press, p. 181-194.

- De Groot, A.M.B & Christoffels, I.K.

2006. Language control in bilinguals: Monolingual tasks and simultaneous interpreting. **Bilingualism: Language and cognition** 9, p.189-201.

- Dijkstra, T.

2002. The architecture of the bilingual word recognition system: From identification to decision. **Bilingualism: Language and cognition** 5, p. 175-197.

- Dupoux, E.

2001. **Language, brain and cognitive development. Essays in honor of Jacques Mehler.** Cambridge, MA: The MIT Press.

- Fabbro, F.

1999. **The Neurolinguistics of Bilingualism. An introduction.** East Sussex: Psychology Press.

- Fabbro, F.

2001. The bilingual brain: Cerebral representations of languages. **Brain and Language** 79, p. 211-222.

- Fabbro, F.

2002. **Advances in the Neurolinguistics of Bilingualism. Essays in Honor of Michel Paradis.** Udine: Forum.

- Finkbeiner, M., Gollan, T.H. & Caramazza, A.

2006. Lexical access in bilingual speakers: What's the 9hard) problem? **Bilingualism: Language and cognition** 9, p.153-166.

- Green, D.

1998a. Mental control of the bilingual lexico-semantic system. **Bilingualism: Language and cognition** 1, p. 67-81.

- Green, D.

1998b. Author's response. Schemas, tags and inhibition. **Bilingualism: Language and cognition** 1, p. 100-104.

- Grosjean, F.

1982. **Life with two languages.** Cambridge: Harvard University Press.

- Grosjean, F.

1998. Studying bilinguals: Methodological and conceptual issues. **Bilingualism: Language and cognition** 1, p. 131-149.

- Grosjean, F.

2003. Imaging bilinguals: When the neurosciences meet the language sciences. **Bilingualism: Language and cognition** 6, p. 159-165.

- Kager, R.

1999. **Optimality Theory.** Cambridge: Cambridge University Press.

- Kroll, J.F., Bobb, S.C. & Wodniecka, Z.

2006. Language selectivity is the exception, not the rule: Arguments against a fixed locus of language selection in bilingual speech **Bilingualism: Language and cognition** 9, p.119-135.

- Paradis, M.

1978. **Aspects of bilingualism.** Columbia: Hornbeam Press.

- Paradis, M.

1983. **Readings on aphasia in bilinguals and polyglots.** Quebec: Marcel Didier.

- Paradis, M.

1987. **The assessment of bilingual aphasia.** Hillsdale: Lawrence Erlbaum Associates.

- Paradis, M.

1993. **Foundations of Aphasia rehabilitation.** Oxford: Pergamom Press.

- Paradis, M.

2003. Differential use of cerebral mechanisms in bilinguals. In: Banich, M.T. & Mack, M.A.(eds.) **Mind, brain and language. Multidisciplinary perspectives.** Mahwah, NJ: Lawrence Erlbaum Associates.p.351-370.

- Paradis, M.

2004. **A neurolinguistic theory of bilingualism.** Amsterdam: John Benjamins.

- Pavlenko, A.

2000. New approaches to concepts in bilingual memory. **Bilingualism: Language and cognition** 3, p.1-4.

- Pavlenko, A.

2002. Conceptual change in bilingual memory: A NeoWhorfian approach. In: Fabbro, F. (ed.) **Advances in the Neurolinguistics of Bilingualism. Essays in Honor of Michel Paradis.** Udine: Forum.p.69-94.

- Prince, A. & Smolensky, P.

1997. Optimality: from Neural Networks to Universal Grammar. **Science** 275, p. 1604-1610.

- Prince, A. & Smolensky, P.

2004. **Optimality Theory. Constraint interaction in generative Grammar.** Oxford: Blackwell Publishing.

- Roelofs, A. & Verhoef, K.

2006. Modeling the control of phonological encoding in bilingual speakers. **Bilingualism: Language and cognition** 9, p.167-176.

- The concise Oxford dictionary.

1989. New York: Oxford University Press.

- The Netter Collection of medical illustrations. Volume 1. Nervous system.

2000. Teterboro, NJ: Icon learning Systems

- Van Dale Groot woordenboek Spaans-Nederlands & Nederlands-Spaans

2003. Utrecht: Van Dale Lexicografie bv

- www.diccionarios.com
- www.dictionary.cambridge.org
- www.freedict.com
- www.interglot.com
- www.spanishdict.com
- www.ultralingua.net
- www.usm.maine.edu
- www.wiley.com
- www.wikipedia.org
- www.wordreference.com