UNIVERSIDADE FEDERAL DO RIO DE JANEIRO
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COMISSÃO DE PÓS-GRADUAÇÃO E PESQUISA
PROGRAMA DE PÓS-GRADUAÇÃO EM LINGUÍSTICA

INVESTIGATING THE DISSOCIATION BETWEEN N_{400} AND P_{600} EFFECTS ON THE SYNTAX SEMANTICS INTERFACE: AN ERP STUDY

Juliana Novo Gomes

Rio de Janeiro
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Juliana Novo Gomes

Orientadora: Professora Doutora Aniela Improta França
Co-orientador: Professor Doutor Albert E. Kim

Tese de Doutorado submetida ao Programa de Pós-Graduação em Linguística da Universidade Federal do Rio de Janeiro – UFRJ, como parte dos requisitos necessários para a obtenção do título de Doutor em Linguística.

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Rio de Janeiro, Fevereiro de 2014

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Orientadora:
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Co-orientador:
Professor Albert E. Kim (Univ. of Colorado)

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ABSTRACT

INVESTIGATING THE DISSOCIATION BETWEEN N_{400} AND P_{600} EFFECTS ON THE SYNTAX SEMANTICS INTERFACE: AN ERP STUDY

Juliana Novo Gomes

Advisor: Professor Aniela Improta França, PhD
Co-advisor: Professor Albert E. Kim, PhD

Thesis submitted to the Faculty of the Graduate School of the Federal University of Rio de Janeiro, in partial fulfillment of the requirements for the degree of Doctor of Linguistics.

This thesis is concerned with the chronology of the steps involved in sentences processing. Using role-reverse sentences, recent ERPs studies under the light of Semantic Illusion Theory have challenged the assumption that syntactic and semantic processes are tightly coupled. We set off by trying to reestablish a direct correspondence between syntax-first models and on-line sentence processing, relating them to new neurophysiological findings of two processing pathways, a ventral and a dorsal, the first for words and coordinated items and the second for hierarchical structures. We used event-related brain potentials (ERPs) in role-reversed sentences both in the active and in the passive voices to investigate whether there are distinct types of processing within sentence derivation. We found evidence in favor of a syntax-first account during which lexical access would come before the merge of the VP. Infelicitous merge of the VP yields an N400, and in the 550-800 ms time window, difficulty in making the integration between the stored external argument and the VP complex yields a P600.

Keywords: Syntax, Semantics, Linguistics, Neuroscience of Language, ERPs, Sentence Processing Model.

RIO DE JANEIRO
FEBRUARY, 2014

RESUMO

INVESTIGATING THE DISSOCIATION BETWEEN N_{400} AND P_{600} EFFECTS ON THE SYNTAX SEMANTICS INTERFACE: AN ERP STUDY

Juliana Novo Gomes

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Co-orientador: Professor Doutor Albert E. Kim

Resumo da Tese de Doutorado submetida ao Programa de Pós-graduação em Linguística, da Universidade Federal do Rio de Janeiro - UFRJ, como parte dos requisitos necessários à obtenção do título de Doutor em Linguística.

Esta tese trata da cronologia das etapas envolvidas no processamento de sentenças. Usando frases com papéis temáticos invertidos, recentes pesquisa com Potenciais bioelétricos relacionados a eventos linguísticos (ERPs) sob a luz da Teoria da Ilusão Semântica, desafiam o pressuposto de que os processos sintáticos e semânticos estão fortemente acoplados. Com este trabalho procuramos reestabelecer uma correspondência direta entre os modelos Sintaxe-Primeiro e o processamento de sentenças on-line, relacionando-os com as recentes descobertas neurofisiológicas de que há duas vias de processamento, uma ventral e uma dorsal, a primeira para palavras e itens coordenados e a segunda para estruturas hierárquicas. Usamos a técnica de extração de ERPs de voluntários estimulados por sentenças com papéis temáticos invertidos tanto na voz ativa quanto na passiva, afim de investigar se existem tipos distintos de processamento que se sucedem durante a derivação de sentenças. Encontramos evidências em favor de um modelo Sintaxe-Primeiro durante o qual o acesso lexical aconteceria antes da concatenação do VP. A dificuldade de concatenação do VP gera um N400. Já na janela subsequente (550-800 ms) a dificuldade em fazer a integração entre o argumento externo armazenado na memória e o VP produz um P600 .
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Palavras-chave: Sintaxe, Semântica, Linguística, Neurociência da Linguagem, ERPs, Modelo de Processamento.

RIO DE JANEIRO
FEVEREIRO DE 2014

Dedication

To my family,

specially mom, daddy and little bro-

In memory of my grandpa, Pedro Dias Gomes.

ACKNOWLEDGEMENTS

Exactly one year ago today, I was unpacking from a 2-year lifetime experience abroad. I had arrived in the US a year and a half before, to experience a fully operational lab in neuroscience of language, but what I really experienced was way beyond that.

It is well known that studying abroad is the perfect opportunity to have a great cultural and academic experience, but I was about to find a life-changing experience.

I'll start from the beginning trying not to lose myself, while reliving this almost wrapped-up time.

I have a bachelor degree in Arts – Portuguese and German languages, a Masters degree in Linguistics, I always thought I would became a doctor, but I had never travelled abroad by myself. Actually, I had never travelled anywhere by myself. I was half way through my PhD when I realized I had yet so much to conquer, to know about, to discover, to gain, to achieve, to live. So I thought 3 months abroad would fulfill some of those inner desires.

I planned every step of my trip – NY, Boston, Washington and the West-Coast. Every destination had a business and a personal reason simultaneously. This way, I would have the chance to visit some of the best neuroscience of language-labs.

Here, I would like to take this opportunity to thank Aniela Improta França, my advisor, mentor and very good friend. Aniela has been an inspiration to me because of her passion for her work and her dedication to the advancement of the neuroscience of language field in Brazil, and to the people surrounding her. Without her considerable support, patience, guidance and love, I wouldn't have done any of those things. Thank you for your advice on my research, my career and life. Your 10-year dedication to me has been priceless!

I would like to thank Aleria as well, for all the counseling, encouragement and advice. Aleria taught me not to give up, never, ever! I probably shouldn't say this, but "you're always right". I also need to thank Professor David Poeppel for his support and guidance, specially planning my journey, and for receiving me in New York. Getting to know New York University and walking around the Department of Psychology and Neural Science was a dream come true.

In NY, it became clear to me how much I was willing to look around, to find new material to work with. And looking around, meeting new people, speaking another language, made me realize how much I was willing to learn from that experience. I was begging for an opportunity to work with my brain and I was ready to start peaking at someone else's brain. I left *the city that never sleeps*, to go to a Linguistics Meeting in a small city, tucked into a picturesque valley below the Flatirons on the West-coast, Boulder, Colorado. Days before, I had contacted a Professor from the Colorado University, where the LSA conferences were held, asking whether I could join the meeting and visit his Lab. I didn't know by then, that he would be one of the most important characters in the story I am sharing here. Dr. Kim, as I used to call him, is the co-advisor of this thesis and was my host during my Colorado life. I can't thank him enough for all the support, and for the many lab meetings and cube talks, linguistics discussions and stimulating brainstorming. Al is a bright scientist and a very open-minded person. "I would like to thank you for encouraging my research and for allowing me to grow as a research scientist". Al received me in Boulder and let me participate in his Lab's routine for the month and a half I still had in US.

I will have to stop here and acknowledge the fact that mom and my savings was paying for all of this, and that sooner or later, I would be returning home. Of course as soon as I started at Kim's Lab as a curious foreign student, everything I had been doing since I started as a research assistant with Aniela and Aleria, ten years before, made complete sense.

I've always been crazy about neuroscience of language research and being in a first world environment seemed almost like not real. I was eager to learn everything I could from that environment. Luckily, people around me were kind enough to let me in and help me whenever I needed. And it was not a couple of times. I needed guidance with almost everything but not twice. I studied hard, I learned a lot, I tried a lot, I got things wrong, I improved, but I never gave up.

The winter was kicking in and my time in US was running out. If I decided to stay longer there in Boulder, how would it be?! I called Aniela (one simply could not wish for a better or friendlier supervisor), mom, daddy, friends, and on my way back home from a Lab meeting, I looked up to the mountains and I realized, it was not my time to go back to Brazil.
Ten days later, I was on Skype with Aniela finishing up a proposal for a Capes Sandwich scholarship, that I was awarded 2 months later. I came back for the

Brazilian X-mas with family and went back to Boulder for another year-long research internship.

I packed all my belongings, found a place to live, this time, with a roommate. I bought a bike, a super-warm jacket, a pair of boots and thought I was ready for it.

It was already winter, one of the coldest ones, 20 degrees out – Fahrenheit, and I was still up for striking towards my goals. Which goals? I went to US for a 3 month trip and now I had the chance of my life, I would do part of my PhD research in a high-tech lab. That was the goal – to study the neural bases of real-time language processing and of course, take advantage of all of that involvement.

Almost immediately, I coupled with some of the lab assistants in order to come up with the stims for the experiments I would run.
Writing my conclusions and perspectives for future work was hard, but I came up with almost 300 role-reversed sentences in another language. Tell me about it…

So, I really need to thank the other members of the Lab, Leif Oines, Les Sikos, Nathan Venechuck, Jake Entin, Leslie Grush, Hamilton Foster, Christopher Hamill, Blake Wittenberg, Angela Friend, and everybody that helped throughout that time, for all their time, patience, and helpful comments. I truly owe you all. Besides everything else, I learned English from you. I would also like to give special thanks to Brendan Culverwell, who was always there for me, willing to help, guide and give his best suggestions. "My research would not have been possible without your help."

During my year in Boulder, I learned that we are never alone if we are open, if we want to share and learn. I tried different accents, different foods, I read new books, I shared tears, I climbed higher mountains, I felt alone and I got to know myself better. I had experienced fear but I had never doubted I was living it right.

I took three courses at the University of Colorado - statistical analysis, neuroscience and linguistics. I ran three experiments, I made thousands of mistakes, but I got back home full of happiness.

By the end of that year, I got my study ready, I learned how to process ERPs, I made my data analysis and statistical analysis. The latter, yet not enough to analyze all the data in this work. Be ready for it!
I thank specially Aline Gesualdi Manhães for her unbound dedication with my difficult statistical analysis and Doctor Alex Manhães for the knowledgeable advice

and guidance with SPSS.

I got my hands full of ideas and expertise in neuroscience of language. All the meetings and classes paid off. I am a way better researcher now, but still with a lot of room for improvement.

I still had a lot to do when I arrived in Brazil exactly a year ago. Of course, I had pictures, stories, things, high-tech apparatus and a super-white tan, but the most important thing was inside of me. I was used to work with this magical tool called brain and now, I had an improved one, working inside of a brand-new version of me. It's almost too hard to share how much I improved and learned from my experience working and living abroad. I had the time of my life working in a cognitive neuroscience of language laboratory and speaking a different language. And yet, I survived and I had my PhD experiment done! YAY!! And now, what? Well I can only thank. I got to Brazil and thanks to Aniela and Marcus Maia, the head of our Graduate program, the perspectives couldn't be better – they are building a new collaborative Lab at our University (UFRJ) – LER – an EEG/ERP Eye Tracking Laboratory, where we will be able to do some high-level research. Also, my friends and family were willing to hug me and I also found love.

I can only thank God and the people around me for the encouragement and support.

I have to thank all the friends that helped me out through this journey. The American ones: my dear friend Kalvis, Sandra, Kevin and Lisa, Steve, Sanne and the small Ellie, Jill, Scot and Aaron, Dulce and Derek, Kate, Mary (my yoga mentor), my softball team mates and all the colleagues I made. The not too American ones: Kyle, Umberto, Niloo and Belinda.

Of course, I need to thank my Brazilian friends too for all the Skype hours, for all the patience listening to my boring American stories and for ignoring all the code switching I've been doing - Dri, Thii, Andrea, Dani, Bruna, Michael, Fabi, Fe, Bruno, Pamela e Karina and all those people who made this thesis possible and an unforgettable experience for me. Thank you all for the friendship and love. It isn´t easy to be friends with a person that is writing a thesis. To all the 'not anymore that young' kids of my life: "Kevinzoka, Carol and Jucca. I love you!"

Thanks to Marije Soto, with whom I share various works. You are a very good friend and an indefatigable researcher. Also a great mom model!

I would also like to thank all of my Acesin colleagues, who supported me in writing, and encouraged me to finish this work: Alex Sander, Thiago, Fernanda, Dani, Liliane, Marília and Ana Luiza Tinoco, my first advisee.

Last, but by no means least, the most important ones. Words cannot express how grateful I am to my mom, little bro- and daddy. You are my basis, support and heart. I am grateful for the people who have been my greatest source of strength during the doctoral program as well as in life in general: Thank you, mom for all of the sacrifices that you've made on my behalf. You are the best mom on Earth!! Thank you, daddy for all the love and sweet words when I am feeling lost. Thank you, Rimão, for sharing this life with me.
Grandmas and grandpa, your prayers for me were what sustained me thus far.
A special thanks to Manuel Nunes, you are always there cheering me up. Thanks for giving me support and encouragement.

At the end I would like to express my love to Julius, my incredible partner with an emperor's name. You've been my support in the moments when there was no one to answer my queries. Juuu, thank you for coming back on that trail that day to talk to me. I want to spend a lot of sleepless talking nights by your side. Thank you for all the support and encouragement. It means everything to me.

I would like to thank the Capes Research Council and CNPq for their generous support. I am also deeply thankful to our informants. Their names cannot be disclosed, but I want to acknowledge and appreciate their help during this research. Their information helped me complete this thesis.

SUMMARY

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INVESTIGATING THE DISSOCIATION BETWEEN N_{400} AND P_{600} EFFECTS ON THE SYNTAX SEMANTICS INTERFACE: AN ERP STUDY

When asked "How many animals of each kind did Moses take on the Ark," most people respond "two," even though they know that it was Noah, not Moses, who took the animals on the Ark. When a term in a sentence or a question is replaced with a semantically similar but incorrect term, people have difficulty in detecting the distortion. This tendency to overlook distortions in statements is known as the Moses Illusion" (*ERICKSON; MATTSON, 1981, apud park, Reder 2004:2*75).

1. INTRODUCTION

Moses Illusion, cited in the epigraph, is a popular kind of pun that reveals a frailty of the listener. But what frailty is this? At first glance, what seems entertaining to the one who formulates the pun is to suggest that the listener is absent-minded and did not perceive that the person who took animals on the ark was Noah and not Moses, whose representations are perhaps both stored in adjacent memory locations under *biblical characters.*

Figure 1: Noah's ark, a lithograph by Al Hirschfeld, available at http://www.georgejgoodstadt.com/goodstadt/hf.dca?nf=75

Since, in the Moses Illusion case, the story teller brought up most of the fundamental elements of this well-known passage – *the animals, the ark* and *some biblical character*, the story is activated like the frame depicted in Figure 1, the overall meaning is well understood despite the flaw, and the pun is successfully structured[1].

Discrepancies between what is actually encoded in language and what is understood have been frequently pursued as a scientific investigation under the label of the Good Enough (GE) approach (FERREIRA; BAILEY; FERRARO, 2002). In short, GE defends that sentence interpretation is not always exact and algorithmic. Instead, it holds that sometimes comprehension is rather shallow or partial and that semantic representations are incomplete since, due to the pressure for fast linguistic decision-making, frugal heuristics can be often *good enough* to perform sentence interpretation tasks (FERREIRA; BAILEY; FERRARO, 2002; FERREIRA; PATSON, 2007).

The Good Enough Approach gave rise to a number of investigations that are not only restricted to comprehension, but that attempt to tap into sentence processing as a whole. They form a vast literature that often tests sentences with verb arguments with a specific role content, like *patient* and *doctor*, in reversed order like those in examples (i) and (ii).

(i) The patient examined the doctor.

(ii) The doctor was examined by the patient.

[1] Reder (2004) bases his explanation on a connectionist paradigm in which activation of a semantic network representation happens within knowledge frames. When a distorted term – here *Moses* - shares many semantic features with the target one – here *Noah* -, then its interpretation will share spreading activation with that of the target and the distortion will be able to achieve an activation, whose level is high enough to reach a threshold that deceives the listener towards the intended meaning.

To some authors these sentences cause *Semantic Illusions* (HOEKS; STOWE; DOEDENS, 2004; KIM; OSTERHOUT, 2005; KUPERBERG et al., 2006, 2007; VAN HERTEN; KOLK; CHWILLA, 2005a; VISSERS; CHWILLA; KOLK, 2007). To others, they cause *Grammatical Illusions* (CHOW; PHILLIPS, 2013; LAU et al., 2006; PHILLIPS; MATTHEW; LAU, 2011; PHILLIPS, 2012; STROUD; COLIN PHILLIPS, 2010)

Anyway, it is an undeniable fact that sentences, like (i) and (ii) may get a reading that somehow fixes the semantic flaw caused by role reversal: (iii) The doctor examined the patient; and (iv) The patient was examined by the doctor. Given this perceptual fact that it is possible to get one's idea across even with a role-reversed sentence, competing hypotheses appear in the market of ideas to explain this phenomenon.

On one end, scientists for the Semantic Illusion view purport two streams in which semantics may come in first, independently from syntax, simultaneously to it in processing. For these theories, the content of roots is immediately inspected and suffers attraction, rejection and other surface effects that may ultimately motivate syntax. So, in these accounts, semantics may generate syntax, or else, for all it is worth, "syntactic and semantic processing streams are fully interactive and information from one level can influence the processing of another one and the relative strength of the cues of processing streams determines which level is affected most strongly by the conflict" (KOS, VOSSE, VAN DEN BRINK, HAGOORT, 2010:1).

For instance, if the roots of the words in a sentence attract each other, like 'DOCTOR' and 'EXAMINE', a plausible interpretation can be construed, just by inspecting the surface meaning of the roots, even if there are formal marks that contradict this interpretation, such as word order. In this case, the acceptance of a semantically incongruous sentence could be explained by the semantic attraction that overrides syntax and causes an illusion that the sentence is right. Thus, according to this explanation, it would be *semantics*, and not syntax, the vector of the role-reversal pun in (i) and (ii).

Nevertheless, to explain the same phenomenon, another group of theories situated towards the opposite end, purport that, regardless of the kind of sentence – including Moses Illusion or Semantic Attraction ones – before any sentential meaning can be achieved, there is necessarily an intricate algorithm that secures structural hierarchy whirling around the verb. Thus, for a split of second, the processing of this algorithm makes the listener ignore the content of roots and mind only the assignment of theta roles. Once this is accomplished and felicitous, it creates the sensation that everything is right, that is, an agent is doing something to a theme, and so the sentence is good, even when there is role-reversal.

Under this one stream syntax-first view, the hypothesis is that the semantic anomaly captured in sentences like (i) and (ii) is the result of a mismatch in the encyclopedic content of the roots. The functional elements, however, checked first, were syntactically and semantically coherent, so that the sentences are perfectly interpretable at the conceptual-intentional interface (*Cf.* CHOMSKY, 1993).

In this case, the acceptance of a semantically incongruous sentence is supported by a syntactic constraint satisfaction. When the syntactic constraint is satisfied, the categorization grid is set and the theta roles are assigned, for some milliseconds, the semantic contents of roots are not checked, and for this time it is possible to make a listener fall into a pun. Thus, according to this explanation, it would be *syntax*, and not semantics, the vector of the pun.

It should be pointed out that there is a softer version of the syntax-first account, recently put forth in most part by Colin Phillips, known as the *Grammatical Illusion or Selective Fallibility*. Under this view, grammatical constraints are still presented as imposing the most relevant requirements in the relations between words and phrases in a sentence. Nevertheless, despite being very accurate, according to Grammatical Illusions view, these syntax constraints are attenuated and are not believed to be infallible:

> "Research on the on-line implementation of grammatical constraints reveals a strikingly uneven profile. The parser shows impressive accuracy in the application of some rather complex constraints, but makes many errors in the implementation of some relatively simple constraints. Just as the study of optical illusions has played an important role in the study of visual perception, the parser's highly selective vulnerability to interference and 'grammatical illusions' provides a valuable tool for understanding how speakers encode and navigate complex linguistic representations in real time" (PHILLIPS; MATTHEW; LAU, 2011:153).

We are embracing and developing here a harder version of the syntax-first account that will be fully discussed in the following chapters, but that supports a single stream, syntax all the way down, in two phases, that fully accommodates seamlessly the psychological commitments both of linguistic theory and of the neurophysiology of linguistic computation (CHOW; PHILLIPS, 2013; MARANTZ, 2005; PHILLIPS; LEWIS, 2009; PHILLIPS, 2012; STOCKALL; MARANTZ, 2006).

This thesis has the general objective of testing the harder version of the syntax-first account to contribute with cognitive facts in the search for the most suitable language architecture for sentence processing, in view of neuroscience of language alternatives that will be presented in Chapter 2. Its specific objective is to put together two experiments using role-reversed stimuli whose results can be clearly compared with those of the competing theories adding some light to a rather obtrusive literature.

In large part, the hard version of the syntax-first hypothesis pursued here is compatible and is a natural follow-up for the one I held during my Masters course (GOMES, 2009) and beyond (GOMES; FRANÇA, 2008, 2013). In such works, we had findings compatible with the hypothesis that processing is so syntax-driven that granted the right lexical features, even at the absence of theme and case assigners, two nouns presented in a priming paradigm may obtain a phrasal reading, that is, an underlying reading hierarchically construed. So, two words in a pair, for instance *scissors* /*paper*, might get the phrasal, hierarchically nested reading of *scissors to cut paper* or *scissors for paper*, while *scissors / pliers* will inhibit such reading and will activate a coordination reading: *scissors and pliers*. We expected to find facilitating priming in relation to the targets that underwent a hierarchical connection with primes, in contrast with those that entailed a word list, since syntactically organized words are processed faster than a word list (MILLER, 1956).

> "The span of absolute judgment and the span of immediate memory impose severe limitations on the amount of information that we are able to receive, process, and remember. By organizing the stimulus input simultaneously into several dimensions and successively into a sequence or chunks, we manage to break (or at least stretch) this informational bottleneck." (MILLER, 1956:96).

Thus, to test this idea of syntax-first whenever possible, in addition to monitoring the brain activation pattern in relation to the target-word in the two cited priming pairs, we used another condition that reversed the direction of the prime-target: *paper* /*scissors*; *pliers/ scissors*. If our hypothesis were right, the direction reversion would only upset the priming established by the pair that had the hierarchical potential and not the one that had the coordination potential. Otherwise, if a non-syntactic explanation were to be right – for example cloze, surface attraction, frequency of collective use, or a membership to the same semantic field – then directionality would not play a role in priming. That means that the targets in *scissors* / *paper* and in *paper* / *scissors* would get similar activation levels and timing.

In fact, our findings were compatible with the syntax-first hypothesis since there was a statistically significant difference favoring the activation of the target in *scissors* / *paper* when compared with the one in *paper* / *scissors* (GOMES, 2009).

Directionality in those priming experiments was used in a very similar fashion to the role reversal paradigm adopted by the Semantic Illusion literature, with the only difference that in (GOMES; FRANÇA, 2008, 2013) only loose words were tested giving rise to an understated syntax phrase in which the theme assigners were covert, while in the Semantic Illusion literature, the reported effects relate to sentential stimuli, where all words are openly stated.

Another coinciding feature of the past investigations with the current one is the use of neuroscience of language methodology, more specifically Event-related Brain Potentials (ERPs). In this methodology, the electric field of volunteers' brains being exposed to linguistic stimuli are recorded by an EEG (electroencephalogram). The EEG records all electrical potentials that are generated in the brain. Some are synchronized activation of neuronal networks that can be depicted because they are responses to external stimuli being manipulated. These are called signal. Others are not related to stimuli and are called noise. After the recording, all the raw electrical flow is processed in a special way so that it is possible to distinguish between what is electrical noise, unrelated to the experiment, and what is the electrical signal (ERP – Event related brain potential) related to the different stimulus conditions being tested. This methodology will be fully explained in Chapter 4.

Although theoretical linguistics has a long and successful history of enlightened research to support detailed and comprehensive language models, it was not until fairly recently that cognitive fields started to draw upon those theories and even more recently that neuroscience started to investigate the brain processes underlying language cognition. The field of neuroscience of language lies right in the intersection between at least three fields: neuroscience, biology and linguistics. These make up what Chomsky (2012) now calls the biolinguistic framework.

> “*The biolinguistic framework*, […] takes the faculty of language to be a component of the individual mind/brain, much like the modules of visual perception, organization of motor action, etc. The move from analytic procedures to the biolinguistic framework greatly enriches the variety of evidence that bears on the study of each individual language to include acquisition, neuroscience, dissociations, and much else, and also what is learned from the study of other languages, on the assumption that the capacity for language relies on shared biological properties.” (CHOMSKY, 2012:3 ms)

Thus, now it seems much more of a consensus that these fields ought to be together on a merger in order to handle all the questions still unanswered about language. The ultimate aim of this merger is that of embracing computations identified and explained by formal linguistic theories as hypotheses while trying to couple them directly onto brain mechanisms underlying the cognitive systems.

The ERP methodology in this thesis started being used in linguistics in the 80’s, and the first scientists that introduced it were psychologists. So this means that Neuroscience of Language inherited the robust experimental protocols that had been used in Psycholinguistics for decades and incremented them with neurophysiological monitoring, like the electromagnetic register of cerebral waves coupled to traditional linguistic stimulation, such as the one in the priming paradigm. Until the year 2000, two major ERPs were robustly elicited, the N400 and the P600. The N400 is a negative component. That is why it has an N starting its name. It peaks at around 400ms after stimulation. The P600 is a positive wave that peaks at around 600ms. The N400 has been mostly related to semantic processes and the P600 with syntactic processes.

> “[First], the processing of semantic information is found to influence the amplitude of a negative-going ERP component between roughly 250 and 550 msec, and with a maximal amplitude at about 400 msec (Kutas & Hillyard, 1980). This amplitude modulation is referred to as the N400 effect. [Secondly], a syntax-related ERP is a positive-polarity shift that starts at about 500 msec and can continue for another 500 msec. (…) The P600 effect is seen to a large series of syntactic violations, including phrase structure violations, subcategorization violations, and violations in the agreement of number and case (cf. Hagoort et al., 1999 for a review), but also to violations of syntactic preferences in syntactically ambiguous sentence structures.” (HAGOORT, 2003:884)

Recently, some Semantic Illusion ERP studies have shown results that seem to be outside the explanatory scope of the N400-P600 standard dichotomy, upsetting the apparently organized world of N400s associated with semantics and P600s, with syntax (HOEKS; STOWE; DOEDENS, 2004; KIM; OSTERHOUT, 2005; KOLK et al., 2003; KUPERBERG et al., 2003a, 2006, 2007; LAU et al., 2006; STROUD; COLIN PHILLIPS, 2010; VAN HERTEN; KOLK; CHWILLA, 2005a; VISSERS; CHWILLA; KOLK, 2007)

These studies claim that instead of the canonical N400, a P600 could be associated with *ill-fitted semantic* sentences given special conditions, mainly when the semantic *problem* involves the subject and not the object of the sentences. These studies prototypically encompass exactly the very role-reversed structures presented here in (i) and (ii) in the active and in the passive.

This work will attempt to revise the whole Semantic Illusion field, testing some of its predictions while conducting two linguistically controlled neuroscience of language experiments that present novel stimuli with active and passive conditions, that aim at disentangling the role-reversal paradigm competing explanations.

Note that this investigation is not trivial because there are scientific findings backing up both accounts:

> "If semantic anomalies elicit a P600 response only if a plausible non-surface interpretation is available, then this suggests that the non-surface interpretation plays a role in the processing of the sentence. On the other hand, if the P600 effect is elicited by semantic anomalies regardless of the availability of a plausible non-surface interpretation, then the observation of P600 effects in role- reversed sentences is compatible with accounts that assign no role to computation of non-surface interpretations." (CHOW; PHILLIPS, 2013:78)

Thus, this savory theoretical competition defines the valid goal of this investigation as that of offering evidence beyond the ones already presented to disentangle the facts concerning early sentence processing and its unfolding.

For this, this thesis will be divided into seven chapters. In this introductory chapter the problem was described along with our hypothesis, general objective and specific objectives that will be re-viewed in the conclusion. Chapter 2 will present a review of Sentence Processing Models and the linguistic architecture of the Language Faculty. A review of the Semantic Illusion Field will be presented in Chapter 3. Chapter 4 will show the basis of the ERP technique to read the neuronal systems. Chapter 5 will describe Experiment 1 and its results, followed by Chapter 6 featuring Experiment 2 and its results. Finally, Chapter 7 will present our conclusions and discussions for further work.

2. SENTENCE PROCESSING AND THE LANGUAGE ARCHITECTURE

"Glossary: A language is a set of sentences generated by a context-free grammar, namely, a grammar whose rules are all restricted to be in the form X → w, where X is a single phrase name (such as VP or NP), and w is some string of phrase names or words".(BERWICK et al., 2013)

Sentence processing; that is, the act of putting words together while thinking, speaking, listening, reading, signing or interpreting sign-language, is a task that never ceases to amaze any attentive observer. It is instantaneous, almost effortless and unconscious for the most part. It also might be seen as in the epigraph, to be *generated by context-free grammar*, holding some level of encapsulation, since it can be unaffected when performed together with other tasks, automatic or not, such as driving, eating, doing household chores, with or without support of ostensive context, such as illustrations, deixes etc. It frequently permeates complex reasoning, such as calculations and navigational efforts: in fact, it is supposed to help thinking. At the same time, it might be affected by many imperfections, escaping general economy and optimality criteria. There is internalized grammar and there is the usage one makes of it, which might or not establish a direct relationship with each other.

Another fascinating aspect of sentence processing is that during the time course of understanding language, perceivers have a range of different knowledge sources at their disposal: knowledge about the properties of words or the lexicon, knowledge about syntactic aspects, a grasp of the semantics and also of the pragmatics, that is the real life situations to which sentences refer. The big question is when and what triggers these pieces of knowledge to be deployed and used towards language understanding in the brain.

There are tons of pertinent and fascinating questions regarding sentence processing. Only a few will be pursued here to the extent that they can safely build a historical account of this fundamental field that started in Psycholinguistics and has been more recently undertaken by Neuroscience of Language. The goal of this chapter is to go from the traditional connection established between the Linguistic Theory and the human sentence parsing mechanism – be it more direct, as FRAZIER & FODOR (1978) advocate, or less direct as in (BEVER, 1970) – into the biolinguistic (parser-free) account, currently pursued by Neuroscience of Language.

Sentence processing is compositional, but it is interpreted by the particular way its words are combined. At the same time, it is incremental, so that means it must be constructed at the onset of each new syllable.

> "It is astonishing what language can do. With a few syllables it can express an incalculable number of thoughts, so that even a thought grasped by a terrestrial being for the very first time can be put into a form of words which will be understood by someone by whom the thought is entirely new. This would be impossible, were we not able to distinguish parts in the thought corresponding to the part of a sentence, so that the structure of the sentence serves as an image of the structure of the thought" (FREGE, 1948, *apud* FROMKIN *et al*., 2000).

Nevertheless, it can be easily observed that interpretation goes beyond the fregean adding of individual syllables and words, one by one. There are many syntactic constraints, principles, and levels of representation that determine how words must be combined, so that meaning is attained.

Even with all these factors guiding processing, arguably to a certain extent in a predictable manner, reaching the intended meaning is not full proof. In Chapter 1, the Moses Illusion Paradigm was cited, in which even with mistaken or less data than necessary, the overall sentence meaning was achieved. Contrastingly, at times, with all the necessary elements, the overall sentence meaning is not reached so readily. For instance, observe (iii) again and (v), (vi) and (vi') minding their incrementality, vis-a-vis their syntactic structures sketched in Figures 1, 2 , 3 and 4 respectively:

(iii) The doctor examined the patient

(v) The doctor examined the patient child

(vi) The doctor examined the patient walking

(vi') The doctor examined the patient walking

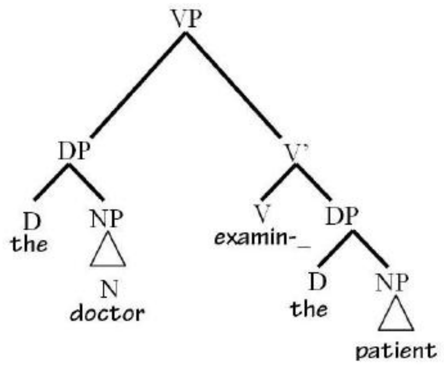


Figure 2: Tree structure showing a DP as the verb complement

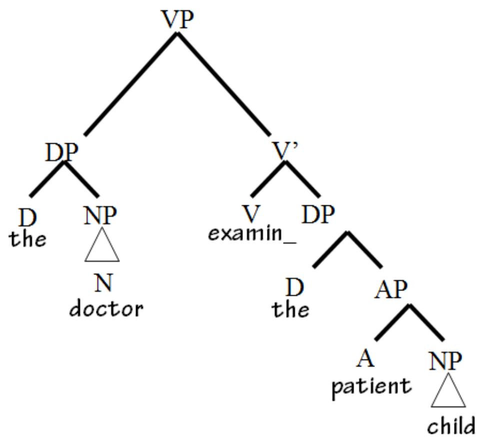


Figure 3: Tree structure showing lexical ambiguity: parts of speech (adjective or noun?)

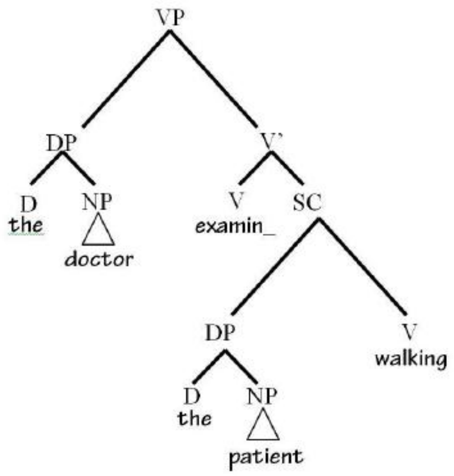


Figure 4: Tree structure showing a syntactic ambiguity: proposition attached low

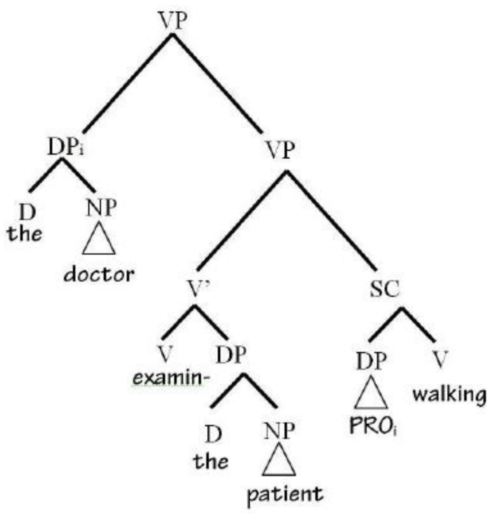


Figure 5: Tree structure showing a syntactic ambiguity: proposition attached high

Regardless of the theory one embraces, the human capacity to predict the words that will come up, one after the other, is a basic assumption of the field, which explains the efficiency of the task to meet the time pressure restrictions of sentence processing. After all, "every language has a Canonical Form that characterizes the surface properties and a standard semantic interpretation" (BEVER; POEPPEL, 2010:194). Then a possible anticipation guideline is probabilistic cues. Another one might be structural, that is, identifying the outputs of syntactic rules and use such outputs to infer the inputs. These two might come separate or combined. Syntax might indicate system preferences, or a bias for the simplest, most economic structures. Holding minimal assumptions at this point, processing might take the following route:

As it will be clear, the first assumptions in relation to the four sentences presented could be the same until a certain processing point, when the words *the patient* come in. Working from the beginning of the sentence, imagining auditory input, upon hearing the determiner phrase *the*, one already expects a noun coming up. Beyond this, if it is an SVO language, such as English, expect that the Determiner Phrase + the NP make up the sentence subject. After the subject, expect a verb, and in fact there is one: *examined*. After the verb, expect the object and the simplest most direct and economical assumption is that it will be another DP. Indeed, this is what you get in (iii): *the patient.* But this bet on the simplest form is not contemplated in the other sentences.

In (v) the listener falls into what is called lexical ambiguity. The bet for a noun phrase is frustrated. The reader in fact got an adjective *patient* that has the same surface appearance of the noun *patient*. Thus, upon hearing the DP after *patient*, the listener has to readjust the part of speech attributed to *patient*, since (v) in fact presents an adjectival phrase that selects a determiner phrase to modify: *the child*. In (vi) an (vi') the sentence could have come to an end at *the patient*, and yet more input comes up, and it becomes clear that the object doesn't have a nominal nature, but a propositional one. In (vi) *the patient walking* is a small clause selected by the verb *examined* as its internal argument. It is a low attachment proposition. In (vi') *PRO walking* is a small clause selected by the verb *examined,* co-indexed to its external argument. It is a high attachment proposition.

The observation of language flaws, like ambiguities, in an experimental setting has, in fact, turned into a rich knowledge source about language processing. For the sake of illustration, some of the most productive findings appeared during the assessment of the following aspects of language cognition: spoonerisms or slips of the tongue (FROMKIN, 1999); tip-of-the-tongue effects (GOLLAN; ACENAS, 2004) language acquisition (CRAIN; PIETROSKI, 2002); memory (MILLER, 1956); reading strategies, lexical access (FROST et al., 2003; MARSLEN-WILSON, 1987; NORRIS, 1994) , and sentence processing (FRAZIER; CLIFTON, 1997) to name just a few.

The fact that sentence processing is not devoid of imperfections gives rise to scientific speculation about the very architecture of the Language Faculty and it fosters the rich psycholinguistic tradition to understand language by cracking these system flaws.

Aside from the points about which there is a general consensus, theories can vary a great deal in terms of how modular or interactive they are and how parallel and serial they are, dynamically combining these possibilities, as it can be depicted in Table 1 below:

Table 1: Classes of sentence processing theories. Adapted from (TANENHAUS; BROWN-SCHMIDT, 2008:1106)

Classes of theories	*Parallel*	*Serial*
Interactionist	Parallel / Interactionist When multiple structures are computed using multiple sources of information	Serial / Interactionist When one structure is computed at a time, but using multiple sources of information
Modular	Parallel / Modular When multiple structures are computed using a single source of information	Serial / Modular When only one structure is computed at a time using a single source of information

The question of the information flow, that can be depicted on the horizontal dimension of Table 1, contrasts theoretical beliefs between parallel or serial computation. According to serial theories, a single syntactic analysis of the sentence is initially provided. If this analysis proves unworkable, then, at some point, another analysis is selected and so on. In contrast, it is assumed in parallel theories that multiple syntactic analyses should all be considered together, at the same time (EYSENCK; KEANE, 2000).

The serial versus parallel contrast has arisen in the literature for over a century, since the monumental publication – Principles of Psychology (1890) – by William James, the foremost American psychologist of the XIX century. In this book, James discusses the concepts of pragmatism and functionalism as the direct result of adaptation of living beings to their environment. Thus, parallel processing enters as an epiphenomenon of functionalism since, according to James, the actions in which we choose to engage, bring out emotions, and we deal with these engagements, motor and emotional, all at the same time, in parallel. For instance, in face of danger, the most functional or pragmatic attitude is to engage in an escape motion. Thus, we infer that we are feeling fear because we run from danger. *Inferring about fear* and *running* happen simultaneously and are handled by the brain in parallel, and one affects the other (FOSS; HAKES, 1978).

As of James, the notion of dual or parallel processing start appearing in several works related with monitoring of attention tasks that could be sensed by multiple sensory channels (ATKINSON; SHIFFRIN, 1968; SHIFFRIN; GARDNER, 1972; SHIFFRIN; MCKAY; SHAFFER, 1976).

As to the degree of dedication, that is, the vertical dimension in Table 1, the relevant point is to know what kind or kinds of information should be resorted to during processing. If only one kind of information is recruited, then the system is dedicated or modular. If several types are needed, then the system is interactive. Looking at the degree of dedication, we get to a continuum between assuming complete dedication for the strong modularist version, or overall dynamism for the strong interactionist version.

Now examining the cells in Table 1, we get to the possible blends among the two dimensions: information flow and degree of dedication. As a first comment, as it might be expected, serial theories are nearly always modular, whereas parallel theories are mostly interactive (EYSENCK; KEANE, 2000).

Starting with the theories in the Parallel – Interactionist cell, there are the Connectionist Models that compute multiple structures using multiple sources of information. These models view processing as a wide-spreading of information that activates nodes in all directions. There are different levels, but since they are not modular, one can receive feedback and feed forward data from all the levels: from the sentence, from the contents stored, from the articulatory level, from the phonological segments, from morphology and even from syntax. In this way, the levels of these models are considered to have interacting activity. Thus, they assume that syntax does not have a major role and is not recruited directly in language perception (Figure 6).

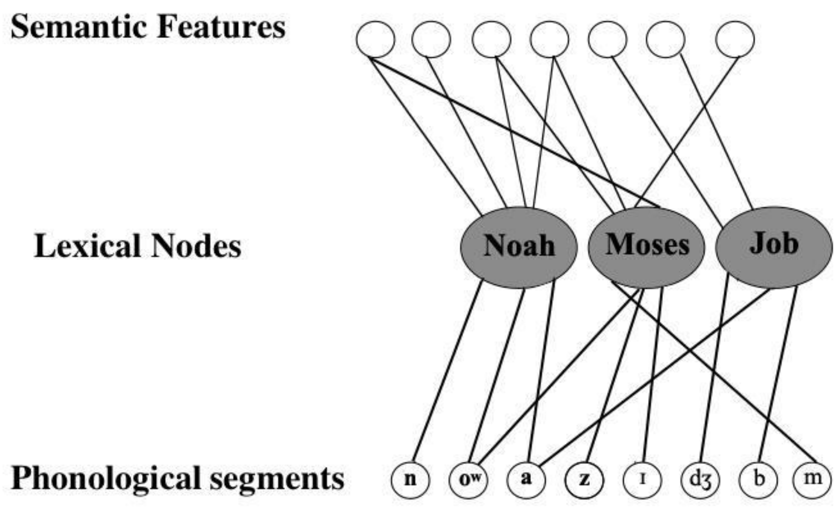


Figure 6: Spread Activation from parallel-interactionist models, adapted from Dell and O'Seqghdha (1994: 413)

Thus, whenever a word is selected, the nodes representing its constituents - the phonemes, morphemes, semantics and syntactic structures - are activated and this activation contaminates adjacent nodes until one node, the one that gets the greatest activation, becomes highly salient and is selected for the output string. In this process, a hand full of wrong nodes are often activated. At this point, there is the need of suppressing activation, so that there is an appropriate matching between stimulus and representation. Note that frequency effects greatly apply in this model. A very frequent word will generate more spreading activation onto many unwanted representations that will have to be canceled.

Concerning connectionist models a basic distinction is between models that learn on their own and models that don't. Among examples of the latter, more applied to human cognitive systems, the most influential one that accounts for written input is the (MCCLELLAND; RUMELHART, 1981; RUMELHART; HINTON; MCCLELLAND, 1987), named Interactive Activation and Competition. The most influential one for auditory input is the TRACE model (MCCLELLAND; ELMAN; DIEGO, 1986).

In the TRACE, the basic unit for activation is also the phonological segment that enters the competition. In TRACE all words have a different activation resting level, according to their frequency: a high frequency word has a high activation resting level; a low frequency word has a low activation resting level. When an input is presented, words that are partially consistent with that phonological segment start being activated. As the segments get into the system continuously, words that carry these segments are activated. Words that don't are inhibited: an effect known as lateral inhibition or peer inhibition. Thus, competition is due to intra-level inhibition that operates between activated lexical entries, while activation of lexical items is due to excitatory input from the phoneme layer. Activation and inhibition take place cyclically affecting a network of words until the activation of a given word (target) rises above a threshold and is recognized. It follows from this model that high frequency words, that share dense neighborhoods, are very inhibited because they suffer the effects of competition among similar sounding words more intensely.

The theories in the two Serial-Interactionist cells are those that consider that multiple structures are computed using a single source of information. The most well-known representatives are the constraint-based approaches (MACDONALD; PEARLMUTTER; SEIDENBERG, 1994; TARABAN; MCCLELLAND, 1988). For these theories, the processor uses various sources of information, including syntactic, semantic, discourse, and frequency based called constraints. A construction that is most strongly supported by these multiple constraints gets to be most activated, although less plausible alternatives might also remain active. Ambiguities are dealt with by back-tracking.

In the 1980's, interactionist models and behavioral associationism started being criticized, specially as neuroscience started providing evidence of modularity. Different areas of neuroscience published formative work to the effect that no matter how complex a natural behavior might seem, one can always be confident that there is a modular neural circuit with a dedicated algorithm designed to mediate it. So, the more one knows about one specific circuit, the clearer will the behavior that springs from it be (SHEPHERD, 1994).

For instance, in the early 80s, Croatian Pasko Rakic, Director of the Kavli Institute for Neuroscience at Yale, published the results of experiments supporting the view that the cerebral cortex is comprised of distinct, orderly regions or modules that subserve very particular cognitive functions of vision, hearing, movement, language and others. The function of every neuronal cell depends on its position and pattern of connectivity. How this complex neuronal map arises from a single fertilized cell during development is a mesmerizing puzzle in science. Rakic's most interesting research projects focus on a Condition of in vitro and in vivo studies, that unveiled evidence that there are several genes specific for signaling and making regulatory molecules, involved in neuronal migration to regions that are organized in vertical modules. Such modular receptors coordinate the condition of events that will give rise to neuronal proliferation, phenotype determination, and proper neuronal migration (LENT, 2008).

Other fundamental research in cognitive processing appeared to complement these neurodevelopmental findings. To cite one of them, awarded with the Nobel prize in 1982, is Hubel & Wiesel's research on the topography of the visual cortex. They inserted microscopic electrodes into the visual cortex of experimental animals to read the activity of single cells in the visual cortex while presenting various stimuli to the animal's eyes. They found a topographical mapping in the cortex. Each cell responded to a specific orientation of the visual stimulus they were presented to. Also nearby cells in the cortex represented nearby regions in the visual field, so that the visual cortex represents a spatial map of the visual field. They identified specific cells which would fire only in the presence of a vertical edge at a particular location in the visual field, while other nearby cells responded to edges of other orientations in that same region of the visual field. This suggested micro modularity on the reception level and on the processing level as visual information was carried from the primary visual cortex into the visual paths that process the representations until the final image is properly computed (BEAR; CONNERS; PARADISO, 2006).

The established view in neuroscience is to view human cognition as a major result of computational routines being applied to deal with input, since the brain operates by performing purely formal and symbolic operations on representations. So the agenda of the area is to cultivate research that tries to tap onto symbolic language, that is, language of thought. This trend tends to support serials models, that occupy the last two cells in Table 1 since they follow algorithms that are serial per nature (FODOR, 1975, 1983; SHEPHERD, 1994).

A theory that explores the middle way between serial Vs parallel and interactionism Vs modularism is Townsend & Bever's Model (2001). They developed a symbolic-computational and associative-connectionist approach. The symbolic-computational aspect emphasizes the formal manipulation of symbols that underlies creative aspects of language behavior. The associative-connectionist flavor accounts for the intuition that most behaviors consist of accumulated habits. According to these authors the associative and the symbolic information merge at the sentence level during comprehension (TOWNSEND; BEVER, 2001).

> "No one can deny that a vast proportion of everyday life is based on habits (…).But to claim that such [habits] show we can account for actual categorical syntactic structure is not warranted. It would be like claiming that the amazing height of a medieval church spire shows that humanity can reach the heavens. (…) One of the arguments against the idea that absolutely everything is based on associative habits is the complexity of normal behaviors, such as comprehension of language. Furthermore the existence of inner levels of representation would seem to defy the association explanation. (…) So, we have two phases in comprehension: an initial analysis of a likely meaning, and the recapitulation of the complete derivational syntactic structure consistent with the form and meaning" (TOWNSEND; BEVER; CROCKER, 2001:148-149).

In practice this model implies that sentence processing is always processed twice as per the slogan "we understand everything twice" in the sense that the authors believe that the first pass is unconscious and heuristic and therefore we have imperfections like garden paths, semantic illusions, slips of the tongue and so on. So they purport a combination between surface associationism and ingrained computation applied in series.

Going one step ahead from Bever & Townsend's hybrid model are the theories in the Parallel-Modular cell. They support that multiple structures are computed using a single source of information. But these theories also ponder that syntactic analysis of a sentence is not a freely interactive process, but rather a modular one. Thus, it is essential to determine exactly when the syntactic processor shares its product with other components (CRAIN; STEEDMAN, 1985).

The Bock and Levelt Model (1993) falls within this classification (Figure 7). This model consists of four levels of processing in a series, but it has some internal parallel processing which makes it a hybrid. On the first level - the Message level - the main idea is generated. Then, on the Functional Level, two stages take place in parallel. The first, the Lexical Selection stage, is where the conceptual representation is turned into a lexical representation, as words are selected to express the intended meaning of the desired message. Then on the second stage, the syntactic role of each word is assigned on the

Function Assignment stage. On the third level, the Positional one, the order and inflection of the morphological slots are determined. Finally, the Phonological encoding level ends processing with the assembling of sound units and intonation contours to form lexemes, which are sent to the articulatory or output system.

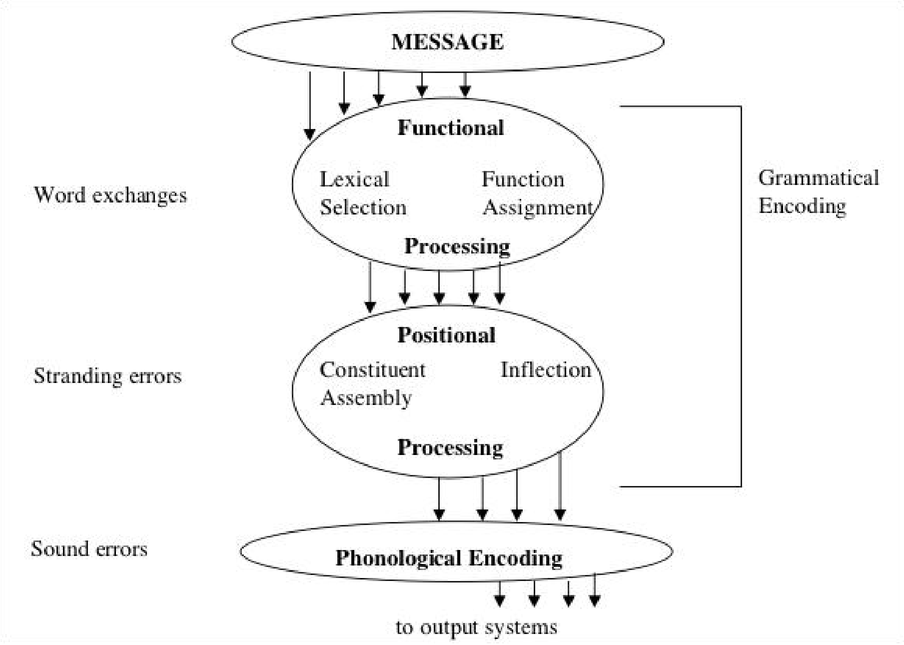


Figure 7: Bock and Levelt Model, adapted from Garrett (1980:23)

Finally, as to the theories in the Serial-Modular cell, only a single source of dedicated information is used. A fundamental Model that falls into this category is the Garden Path Model by Frazier & Fodor (1978). It is a two-stage system – syntax first, serial model in which first a limited set of phrase structure rules and basic grammatical category information about the word is computed from a single syntactic representation of the input. Then, on a second stage, the output of this first one is integrated and checked with the lexical specific knowledge and contextual information. If it is necessary, the structure interpretation can be revised and rechecked (FRAZIER; FODOR, 1978).

According to such theory, syntactic processing is, at some level, independent from lexically and contextual influences in the earlier stages. The expectation created with the surface structure cues can't override the syntactic structure processing.

A natural consequence of betting on a serial stream right from the beginning is the garden-path effect (FRAZIER; FODOR, 1978) a processing hesitation that arises whenever new input cannot be integrated in the structure being formed by the listener, as we analyzed in (iii), (v) (vi) and (vi').

When the garden-path effect was identified by psycholinguists, many experiments were structured to analyze the nature of this hesitation. Data were ingeniously constructed to test the alternatives being pursued by listeners to anticipate incoming language, and the time it took listeners to repair previously built structures. Findings gave rise to three strategies that were proposed as being language universals: Minimal Attachment, Late Closure, (FRAZIER; FODOR, 1978) and Minimal Chain Principle (VINCENZI, 1991).

The Minimal Attachment is a strategy motivated by the economic requirements of computation of the Faculty of Language. The need to be minimal leads listeners to adopt the analysis that postulates the simplest structure or fewest structural nodes. For instance, examine (vii).

(vii) The horse raced past the barn fell.

Looking at Figures (8) and (9), the tree structures show two possible interpretations that led perceivers of (vii) into the garden-path, because they strategically bet first on the analysis that would derive the minimal number of attachments. Then, when (8) proves to be wrong, they hesitate, think and reformulate their analysis to the more complex structure in (9).

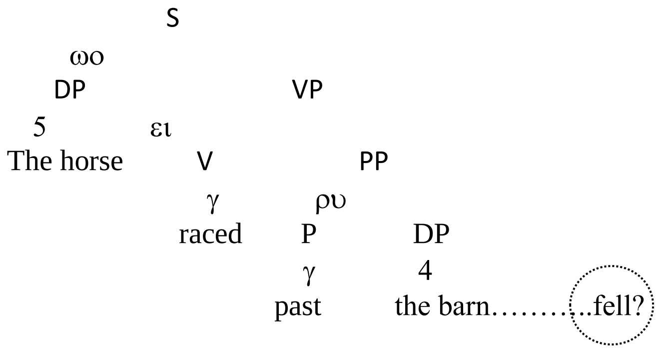


Figure 8: First analysis, based on minimal attachment

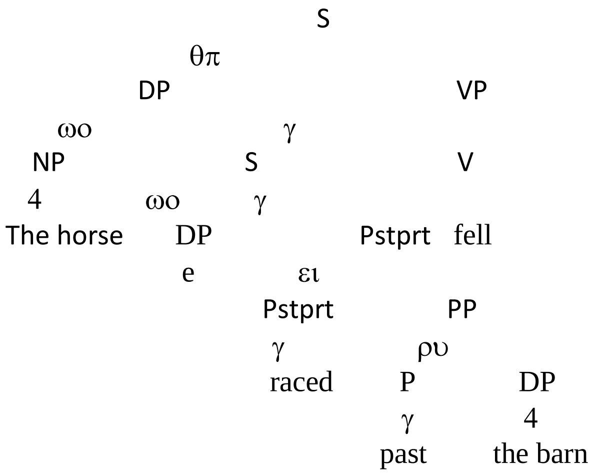


Figure 9: Garden Path

While the structure in (8) is clearly more economical than that in (9), there are cases in which the number of nodes is the same and still there is room for ambiguity. Let's examine (10).

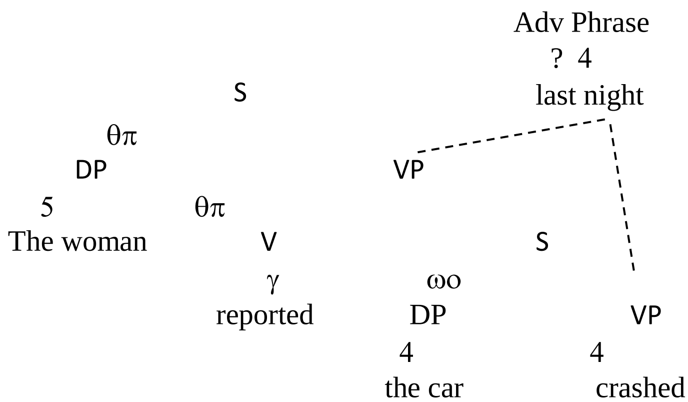


Figure 10: Late Closure

In (10) the adverbial phrase *last night* may be appended either to the lower or to the higher VP. The case was reported last night or the car crashed last night? The number of nodes will be the same in either case. So, the strategy of Minimal Attachment cannot hold here. To cases like this, Frazier and Fodor (1978) proposed a second-resort universal alternative named Late Closure or Right Association, also guided by a single, least-effort processing tendency. This strategy states that, preferentially, the listener will attach structures for incoming lexical items to structures that have been built more recently. Thus, in (10) *last night* should be appended to the lower clause. In fact, this preference has been verified in many languages.

However, when the ambiguity involves a complex NP, like in (viii), the preference for the structure that has been built more recently does not seem to hold universally. For instance:

(viii) They shot the servant of the actress who was on the balcony.

Who was on the balcony, the servant or the actress? While the late closure strategy seems to be preferred in English (Frazier and Fodor, 1978), there are reports of a preference for appending adjuncts to the higher clause in languages like Spanish, Portuguese, Japanese, and Dutch (CUETOS; MITCHELL, 1988; KAMIDE; MITCHELL, 1997; MAIA; MAIA, 2004). So, for these languages, the interpretation seems to be that *the servant was on the balcony*.

However, those in favor of the universal power of the Late Closure strategy argue that prosodic rules that are processed in parallel with syntactic processing may neutralize the otherwise universal structural preference for low attachment (FODOR, 2002).

Another well studied principle, specially in romance languages is the Minimal Chain Principle (VINCENZI, 1991) that has as its main prediction that the parser will always postulate a single chain instead of multiple ones. For instance, note that because in Italian it is possible to have post-positioned subject, (ix) becomes an ambiguous construction with pro[2] between versions (a.) and (b.).

(ix)		Ha	chiamato	Gianni
a.	pro	has	called	Gianni
	he/she/it	has	called	Gianni
b.	pro_i	has	called	$Gianni_i$
	'Gianni has called'			

According to this Principle, version (a.) will be preferred over (b.) because it promotes a single chain that receives case and thematic role locally:

> "Notice that [ix a-b] involve choosing between two different empty pro subjects: (a.) is a context-linked full pro with specific case and thematic role, like any other explicit pronoun (he, she, etc), which therefore forms a singleton chain by virtue of the fact that it is in a position where it can directly receive such case and thematic role (say, $Mary_i$ got the phone; pro_i (she) has called Gianni); and (b.) is an expletive (dummy) pro which forms a chain with the inverted subject to which it transmits case and thematic role, (hence the shared index and the complexity of the chain). The first kind of pro gap amounts to an instruction saying: 'subject missing because you know who I am talking about'. The second, expletive pro entails a different instruction: 'subject missing but it is a new entity: wait for it until after the verb'. In the Government & Binding terms that de Vincenzi uses, the first pro has content (like other pronouns: he, she, etc.); the second is just a place-holder for the moved subject (like the first 'there' in there is a book there)" (MESEGUER; ACUÑA-FARIÑA; CARREIRAS, 2009:767).

These three performance Principles – Minimal Attachment, Late Closure and Minimal Chain Principle – are all under the umbrella of a serial-modular model. Many syntax theories are also under this same model. For instance, the Minimalist Theory (CHOMSKY, 1993) and the Distributed Morphology (HALLE; MARANTZ, 1993) – a

[2] pro (read little pro), is the Generative Grammar notation attributed to an abstract, null subject of a tensed clause.

non-lexicalist version of Generative Grammar, are nourished by serial-modular ideas respecting principles of economy that take the pressure of performance into account. All of these new ideas that got into theoretical linguistics about how language is represented and processed tended to situate performance much closer to competence.

> “The competence/performance distinction is meant to emphasize that a grammar is about the representation and computation of language, not about sentences per se – not directly about the utterances and behaviors of speakers. But one gains the impression from much linguistic writing that grammars in fact are descriptions of data rather than hypotheses about computation and representation. (…) [Nevertheless] progress in linguistics has made it less rewarding recently to rely on standard distributional evidence.(…) Our understanding of linguistic representations currently emphasizes the dynamic nature of such representations such that the computations involved in their generation are crucial to their well-formedness. Evidence about dynamic processing, then, becomes more central to the questions of categories and their distribution than previously thought.” (MARANTZ, 2005:437)

This turn of events provoked crucial impact on the concepts that started being purported by Neuroscience of Language after the year 2000. On their turn, these concepts had had momentous early enunciations in the 60’s with George Miller’s DTC (Derivational Theory of Complexity) and in the 70’s with David Marr.

At the onset of the Generative Theory, the DTC sought to prove that linguistic competence should be a strong basis for testable models of linguistic performance, meaning that linguistic theory could be psychologically real, having computations correspond with the time course of derivations. Nevertheless, soon the DTC, was plunged into the center of a crisis in science, since for some complex linguistic computations used as input in experiments, volunteers did not seem to suffer compatible delay. Correlations seemed erratic.

Some years after the fast rise and the decay of the DTC, other attempts to draw a close relationship between computations and the chronology of cognitive processing were more successful in other cognitive fields such as vision.. According to David Marr, a cognitive scientist specialized in vision, sensory input of one sort, be it visual, auditory, olfactory, linguistic, or of any other origin, gets into the brain as rather raw representations. Then, from this basic-level representations, other levels increasingly complex and abstract are achieved. For instance, raw and sketchy, two-dimensional visual forms assembled at the retina can be ultimately perceived in the brain as refined 3-D representations.

Note that Marr's account holds fundamentally different beliefs from those in Townsend & Bever (2001) and Bever & Townsend, (2001) that "a quick and dirty parse is initially elicited" (TOWNSEND; BEVER; CROCKER, 2001:163). Marr does not talk about a "surface schemata" but about specific foveal rod and cone cells that can only gather certain kind of input in the first milliseconds to send to the primary visual cortex where a specific *computation* applies to generate brain representations that will serve as input to other *computations,* until a 3-D image is reached. No reference is made in Marr neither to heuristics, but to a simplified processing of a few items in the visual field.

A much closer corollary of Marr's view got to linguistics with the development of a non-lexical version of the Generative Grammar, which is the Distributed Morphology (HALLE; MARANTZ, 1993) and with all the neuroscience of language research that started from this theory specially in lexical access (EMBICK et al., 2001; PYLKKÄNEN; MARANTZ, 2003; PYLKKÄNEN; STRINGFELLOW; MARANTZ, 2002) .

> "The strongest tradition in psycholinguistics, one stemming in part from Fodor, Bever and Garrett (1974), supposed that although the linguistic representations supported in linguistic theory were "psychologically real", the generative mechanisms proposed to create these representations (…) did not constitute the sole computational means available to speakers for creating the representations of their language. Rather there might be psycholinguistic *strategies* for structure-building that to some degree by-passed the syntactic rules and computations of linguistic theory. (…) Today, for the Minimalist Program (Chomsky 2000, 2001) there is only one generative engine of language – the syntax – and only one route to grammatical representations – through the computational mechanisms of syntax" (MARANTZ, 2005:436).

Halle and Marantz (1993) defend that there actually is no correspondence between phonological words and some type of indecomposable meaning. The relations between the minimal elements within words are exactly the same as those between words that form phrases and sentences. Consequently, for them sentence processing is “syntactic hierarchical structure all the way down” (MARANTZ, 1997).

In all of its versions (HALLE; MARANTZ, 1993; MARANTZ, 1997, 2005), the Distributed Morphology supports a strong modularity hypothesis, according to which the cognitive module of the language system consists of interrelated sub-modules, similar to the Minimalist proposal (CHOMSKY, 2005). However, the Distributed Morphology takes modularity even further, believing the system to be built up of an enormous quantity of sub-modules and phases, which makes them more specialized and its constituents more atomic (LAGE, 2006; LAGE et al., 2008). This concept of sub-modules and short phases implies in rich a computational engine that can be tested in its neurophysiological reality. This is a quality of the model that is attested even by proponents of other architectures.

> The concept of phases is an interesting hypothesis, that specifies the orderly stages in which syntactic/lexical information is transferred to semantic representation of a sentence, as the computational structure is computed. In this way, it may ultimately be demonstrable that the duality of language reflected in how it is learned and processed, will also provide a deep explanation of some aspects of syntactic architecture itself. (BEVER; POEPPEL, 2010:195)

The Distributed Morphology is a derivational model that is distributed in three lists. In the first of those lists, *List 1*, morphemes (abstract features) are inserted into syntax. It is based on these features that derivation occurs. The set of morphosyntactic features present in the bundles of features that go into derivation is determined by Universal Grammar (UG). Thus, each language selects only a subset of these features made available by UG. The ways in which these features assemble in bundles are the particularities of languages.

During the derivation, the information contained in the nodes resulting from the syntactic operations is sent to Logical Form (LF) and to the morphological component of the computational system (MS – Morphological Structure, which interfaces between syntax and phonology). In the morphological component, another set of operations is applied onto the syntactic nodes creating new nodes, deleting some, moving, copying features, etc. The nodes resulting from morphological operations then undergo *spell-out*: that is, at this moment the Vocabulary items are inserted (phonological fragments containing the syntactic and semantic information required for their insertion) which will instantiate the terminal nodes of syntax/morphology. The insertion of Vocabulary items is based on a competition amongst them (MEDEIROS, 2008:194).

The computation of functional categories happens in separate modules of the language system. Firstly, abstract features are selected from this inventory of features, which is *List 1*. These features are understood to be reserved positions for roots (*place holders*), others might be number, person, tense, nominalizer, gender, etc. The computation of these functional categories occurs by way of the syntactic operations *merge*, *move*, and *copy*. In the derivation process, the information contained in the nodes resulting from the syntactic operations is sent to other language modules in cycles or phases. The operation known as *spell-out* is responsible for sending these interpretable features to the Phonological Interface and Logical Form simultaneously (Figure 11).

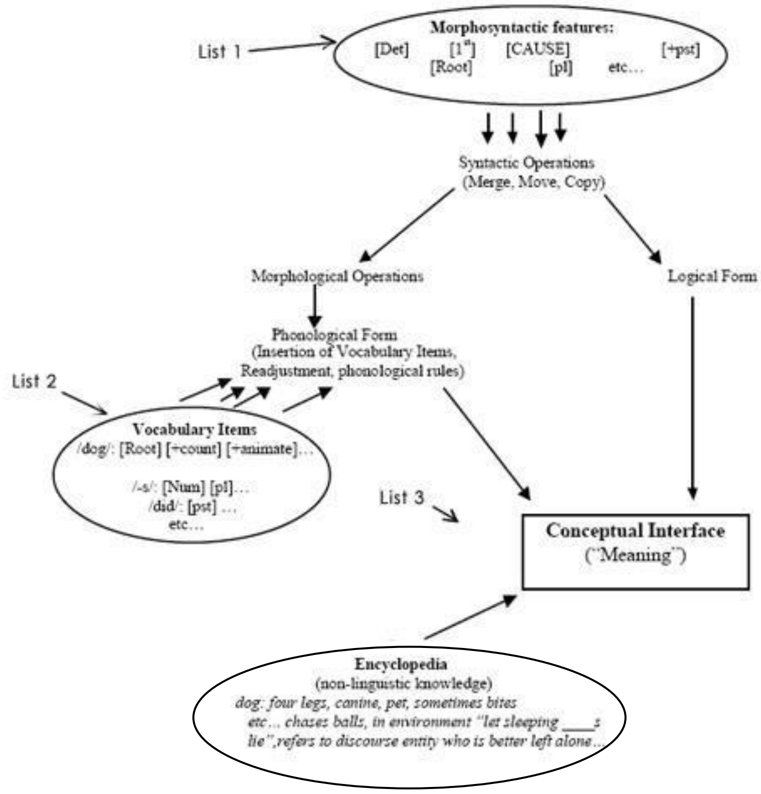


Figure 11: Model of Distributed Morphology (HARLEY; NOYER, 1999:4)

The Distributed Morphology makes it clear, through its short phases, that it is possible to serially connect representation, processing and performance in a way that every small phase undergoes syntactic computation all the way down, with no heuristics of any sort.

> "Therefore, were there in fact *psycholinguistic support* (i.e., evidence of any sort) for *strategies* for building linguistic representation without using the computations of syntax, these would constitute an alternative hypothesis about linguistic knowledge, not a supplement to the generative theory. That is, if the strategies are right, then the theory is wrong (in need of modification) (MARANTZ, 2005:437).

More recently even authors that used to purport an initial surface parse, like Tom Bever are now retracting in part from that initial hard position[3] into a new version of analysis by synthesis that identifies computational stages in all processing phases:

> "Recent research in cognitive neuroscience of language has reopened the debate on the DTC (see, e.g., Marantz 2005). Methodological progress and theoretical shifts suggest that something like a mapping from representational complexity to number of computational steps may be on the right track, and such a perspective is implicitly at the basis of much work in experimental language research. For example, experimental research on lexical structure (morphology) as well as on lexical semantics suggests that structural complexity is associated with changes in processing cost as reflected in both behavioral and neurophysiological indices (see, e.g., Gennari & Poeppel 2003 regarding lexical semantics, where more hypothesized structure correlates with longer reaction times, or see Fiorentino & Poeppel, 2007 and Zweig & Pylkkänen, 2009, regarding lexical structure, where neural data from MEG distinguish between simplex and complex words)". (BEVER; POEPPEL, 2010: 181)

As much as the neurophysiological experiments of lexical access have been successfully tapping directly onto the theoretical framework of the Distributed Morphology since the early 2000's, the field of sentence processing had not been vastly tested yet.

Nevertheless, more recently, using another research platform that works with brain imaging accessed through hemodynamics of the brain (fMRI-DTI[4]), there has been significant progress in conceiving the architecture of the language faculty through sentence processing. Such research has been able to tease apart underlying functionalities of the

[3] In the 50's, at the onset of the Cognitive Revolution, the established version of Analysis by Synthesis focused restrictively on bottom-up, feed-forward, inductive mechanisms, both for speech production and language comprehension.

[4] Functional Magnetic Resonance Imaging (fMRI) allows the mapping of neuronal activity relative to some event (e.g. the presentation of a sentence) measuring the blood flow that supplies neuronal areas with oxygen right after activation. This is done by creating magnetic force fields that destabilize certain atomic elements in the blood, and by measuring these elements' return to their stable state. Experiments designed for BOLD (blood oxygen level dependent) contrasts present subjects with conditions involving similar cognitive tasks except for one feature constituting the variable of interest, whose correlated activity will be left after two conditions are subtracted. The DTI (Diffusion Tensor Imaging is an implementation over the fMRI that allows the fMRI images to be treated in a way that the connections (capsule fibers) between remote cortical locations can be visualized. Thus it is possible to know what area receives input from what area.

N400 response to sentence processing component (for a review, BAUMGAERTNER; WEILLER; BÜCHEL, 2002; LAU; PHILLIPS; POEPPEL, 2008).

According to the image findings of such experiments, lexical access and coordination are processed in different cortical sites from sentences that have hierarchical processes. Thus, a recent model put forth by Angela Friederici defines the two distinct processing streams: two sets of ventral streams connecting brain areas BA 45, via BA 47, to the aTL (anterior temporal lobe) and the MTG (mid temporal gyrus); and a dorsal stream connecting BA 44, to the pTG (posterior temporal gyrus) (FRIEDERICI et al., 2011; BERWICK et al., 2013; FRIEDERICI, 2011) (Figure 12).

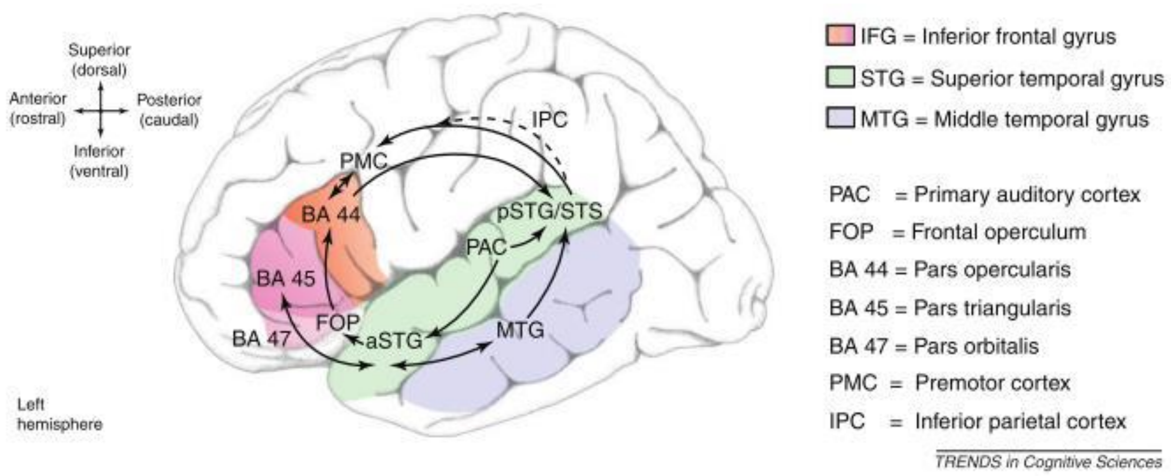


Figure 12: Language processing circuits (FRIEDERICI et al., 2011:263)

The sets of ventral streams are used for lexical access of words or phrases that do not have thematic roles assigned to them, like those in coordination processes. The linguistic body of stimuli tested so far does not allow the conclusion of the exact nature of the items in the ventral stream, but once it is clear that there is computation and embedding within words for the morphological processes, we launch the hypothesis that the ventral stream performs simple merge operations within words and phrases that do not entail thematic role assignment, that is, that do not involve an assigner such as a verb or preposition. Contrastingly, the dorsal stream carries hierarchical processes with complex embedding directly related with the event.

The two ventral streams located closely together, are connected through the uncinate fasciculus and run from the frontal operculum to aTL to the mid temporal gyrus. Dorsally, BA 44 is connected to the posterior temporal gyrus through the arcuate fasciculus (AF) (Figure 12)

Our work hypotheses is that for a language like English, that is SVO, the DP that will come first (the future subject) will be processed as a separate phrase on a list without being assigned a theta role (ventral stream). Then, after it, the verb and object will be processed on the hierarchical stream (dorsal stream) and only then will the first DP be integrated by the hierarchical algorithm.

Thus, for the sake of an early understanding of the semantic illusion sentences with role reversals, treated in our test, observe Table 2:

Table 2: Active stimuli

1. Active Conditions	Stimuli Examples
1a. Control	The bear **attacked *the audacious hiker*** on the trail.
1b. Role Reversed	The audacious hiker **attacked *the angry bear*** on the trail.
1c. Incongruous	The bear **attacked** ***the large battery*** on the trail.

For (1a), (1b) and (1c) the DP in the subject position will be processed as an athematic phrase and will be kept in memory. Then the verb and the object will be processed together. For (1a) and (1b) this processing will not generate an N400, since the verb and object are congruous. But (1c) should yield an N400 for the semantic incongruence. Then, as to the integration of the subject, we would expect a P600 just on (1b), since an angry bear could be attacked, but not so easily by a hiker. Thus, the fact that we expect (1a) and (1b) can be paired for the object but not for the subject would imply that if the subject were integrated later only one would show a larger potential after the N400.

Now, observe Table 3 for the sake of an early understanding of the semantic illusion sentences with role reversals in the passive, treated in this test:

Table 3: Passive stimuli

2. Passive Conditions	Stimuli Examples
2a. Control	***The audacious hiker* was attacked** by the bear on the trail.
2b. Role Reversed	***The angry bear* was attacked** by the audacious hiker on the trail.
2c. Incongruous	***The large battery* was attacked** by the bear on the trail.

For (2a), (2b) and (2c) the DP in the future subject position will be processed as an athematic phrase and will be kept in memory. Then upon the morphology of the passive they will be integrated with the verb since in the passive, the subject is the internal argument of the verb. For (2a) and (2b) this processing should not generate an N400, since the verb and the internal arguments (subject) are congruous. But (2c) should yield an N400 for the semantic incongruence. Then, as to the integration of the PP with the agent of the passive within, we should expect a P600 just on (1b), since an angry bear could be attacked, but not so easily by a hiker. Thus, the fact that we expect (1a) and (1b) can be paired for the internal argument but not for the agent of the passive would imply that if the agent of the passive were integrated later only one would show a larger potential after the N400.

A detailed account of the results can be found in Chapters 5 and 6.

3. REVIEW OF THE SEMANTIC ILLUSION FIELD

Since the early 2000's new findings concerning the N400-P600 dichotomy have challenged the assumption that semantically anomalous sentences can only elicit an N400 response. Recent studies have shown that role-reversed sentences that are fully grammatical but clearly anomalous, semantically speaking, failed to elicit the canonical N400 response and instead, have consistently elicited a P600 response. Those studies named this effect as "the Semantic P600" and this ERP started characterizing the "Semantic Illusion" field.

An interesting instance of piecemeal language processing, that taps into ambiguity and garden path is that advanced by Ferreira (2003), focusing on language comprehension. She proposes that when the semantics of verbs and nouns can be combined in a plausible manner, that is, suffer attraction, "people [do] use simple heuristics to process those sentences, in addition to the syntactic algorithms" (FERREIRA, 2003:169). [EXEMPLO]

Ferreira adds that in those cases, the system can pursue a semantically attractive interpretation even when it contradicts unambiguous syntactic cues – it's the *Good Enough* approach to language understanding. In this view, if a mental representation is good enough to be understood, then no more effort needs to be invested in making it more complete or coherent.

Another early finding that helped build the field of sematic illusion came out in Kolk *et al*. (2003). They reported a P600 effect relative to semantic role-reversal anomalies in Dutch active relative clauses, such as (xi) compared to controls, such as (x), below:

(x)	De	muizen	die	voor	de	kat	*vluchtten*	renden	door	de	kamer.
	The	mice	that	from	the	cat	*fled*	ran	across	the	room.[A]
	The	mice	that	*fled*	from	the	cat	ran	across	the	room.[B]

(xi)	*De	kat	die	voor	de	muizen	*vluchtte*	rende	door	de	kamer.
	*The	cat	that	from	the	mice	*fled*	ran	across	the	room.[A]
	*The	cat	that	*fled*	from	the	mice	ran	across	the	room.[B]

[A] gloss
[B] translation

Note that in (xi) the stimuli used in such experiment are syntactically perfect, but semantically implausible: it might be the case that *cats* would be the agent of *flee*, but it is much less likely that cats would flee from mice. Concurrently, the authors treated their stimuli so that they would not incur in attraction nor in animacy violation. So the P600 was unexpected vis-à-vis the literature because the semantic malformation did not overlap with attraction or animacy. They had stimuli semantically ill-formed. It's also interesting that although the sentences are semantically not expected, there was no N400 effect in response to them; thus, these results raise the question of how the subject-verb merge, that comes linearly before that of the verb-complement, can yield a later component, the P600.

The authors interpreted this result as a mismatch between the semantic interpretation and the syntactic expectation. According to them, "the semantically anomalous sentences, although they are not ambiguous syntactically, still take the participant to a kind of conflict, similar to what happens in garden-path sentences" (Kolk et al., 2003: 30). They proposed that in their experiment, the P600 was related to a conflict between the predicted and the presented syntactic structure. In sentences such as (xi) *The cat that fled [3p sing] from the mice, ran [3p sing] through the room*, the authors analyze that "if the first thematic interpretation the participant considers is the mice that fled from the cat, the syntactic prediction derived from this interpretation is that the main verb should carry the plural inflection. So, the mismatch could be between the inflection 'predicted' by the dominant interpretation and the real one, the one encountered in the sentence. And this mismatch could be the trigger of the reanalysis process in the semantic condition" (Kolk et al., 2003: 30).

Thus, they proposed that whenever the participant encounters an unexpected linguistic event, the brain re-attends the unexpected unit to check upon its veridicality. In their model, the algorithmic stream arrives at a sentence interpretation that is always in line with its syntactic structure. This framework can be called generically *Monitoring Theory* to encompass syntactic theoretical engines that combine instances of top-down monitoring with bottom-up algorithms interspersed (VISSERS; CHWILLA; KOLK, 2007; YE; ZHOU, 2009).

Contrastingly, Kuperberg *et al*. (2003) proposes a different view of semantic illusion that deals with bottom-up and top-down courses but not interspersed: one follows the other. The authors examine thematic role animacy violations, using sentences such as:

(xii) For breakfast the boys would eat toast and jam.
(xiii) *For breakfast the eggs would eat toast and jam.
(xiv) *For breakfast the boys would bury toast and jam.
(xv) *For breakfast the boys would eats toast and jam.

In relation to (xiii) they reported a P600 effect attributed to sentences with animacy-violation in which the verbs assign a wrong thematic role to their arguments (*eggs* as the agent of *eat*) and an N400.

In sentences such as (xiv), that exhibit a classic mismatch between the verb and the internal argument but no animacy violation, the authors found an N400 response, as expected. However concerning sentences with morphosyntactic violations, such as (xv), a large P600 was found in response, when compared to controls such as (xii).

The authors argue that the P600 effect found in (xiii) happened because the semantic processor was "biased towards an interpretation that was contradicted by the syntax and this cost is manifested by a P600 effect". (KUPERBERG et al., 2003:32). Hence, the authors supported the idea of a parallel processing system, in which the semantic and syntactic information are activated simultaneously. Note that undermining the *Monitoring Theory* and the *Good Enough* approach, this account predicts finding both an N400 and a P600 in relation to (xiii): the N400-effect would be due to a difficulty in semantic integration, and the P600-effect, due to the conflict between the streams. As to (xiv), the authors only predict an N400 because of the integration efforts but no P600 because there is no conflict between the streams. It is important to note that there is possibly an overlap of conditions between the role reversal and the animacy in the arguments. With the kind of protocol the authors assumed, it was difficult for them to isolate variables and tease them apart.

Notice that so far no groups have reported a biphasic finding of N400-P600 related to sematic illusion sentences. In 2004, Hoeks *et al.* reported a biphasic N400/P600 effect, when comparing congruous passive sentences, such as (xvi) to semantically anomalous active sentences, such as (xvii), aiming at reaching role-reversed interpretation.

(xvi)	De	speer	werd	door	de	atleten	*geworpen.*
	The	javelin	was	by	the	athletes	*thrown.* [A]
	The	javelin	was	thrown	by	the	athletes. [B]
(xvii)	*De	speer	heeft	de	atleten	*geworpen.*	
	*The	javelin	has	the	athletes	*thrown.* [A]	
	*The	javelin	has	thrown	the	athletes. [B]	

[A] gloss
[B] translation

Contradicting both, the predictions from the *Monitoring Theory* and that from the *Good Enough* approach, for these sentences, the authors observed that no conflict between the algorithmic processor and the plausibility heuristic should be expected – both streams were expected to agree on the implausibility of sentences, such as (xvii), thus an N400 response was elicited. Also, a P600 effect was found, reportedly due to the "effortful syntactic processing invested in trying to make sense of an implausible sentence" (HOEKS; STOWE; DOEDENS, 2004:72). The authors also predicted that the more plausible thematic alternatives competing with syntax-based structure, the bigger would the P600 effect be.

Nevertheless, the authors failed in proving that the volunteers reacted toward (xvii) as a role-reversed. They might have read it as a reanalyzed passive.

Van Herten *et al.* (2005) developed a monitoring theory in which they play with veridicality by altering the feasible quantity of items. They tested center-embedded relative clauses, also in Dutch, a language that interprets the subject in initial position only (SOV). Thus, with this characteristic, the authors designed a crossed manipulation between number and acceptability, in syntactically well-formed sentences. One condition (XXXX) would have singular subject and object, *same number condition*, allowing for the ambiguity in role-reversed sentences, and the other (XXXXX) would have number differences minimizing the ambiguity. Note that in the *different number condition*, the unacceptability pointed out by the authors is strictly pragmatic or relative to world knowledge.

Examples of sentences in the semantic reversal condition

Condition:	**Different number:**
(xviii) Acceptable	De stropers die op de vos joegen slopen door het bos.
	The poachers$_{[plural]}$ that at the fox$_{[singular]}$ hunted$_{[plural]}$ stalked through the woods.[A]
	The poachers$_{[plural]}$ that hunted$_{[plural]}$ the fox$_{[singular]}$ stalked through the woods.[B]
(xix)Unacceptable	De vos die op de stropers joeg sloop door het bos.
	The fox $_{[singular]}$ that at the poachers $_{[plural]}$ hunted$_{[singular]}$ stalked through the woods.[A]
	The fox$_{[singular]}$ that hunted$_{[singular]}$ the poachers$_{[plural]}$ stalked through the woods.[B]

Condition:	**Same number:**
(xx) Acceptable	De stroper die op de vos joeg slopen door het bos.
	The poacher$_{\text{[singular]}}$ that at the fox$_{\text{[singular]}}$ hunted$_{\text{[singular]}}$ stalked through the woods.[B]
(xxi) Unacceptable	De vos die op de stroper joeg sloop door het bos.
	The fox$_{\text{[singular]}}$ that at the poacher$_{\text{[singular]}}$ hunted$_{\text{[singular]}}$ stalked through the woods.[A]
	The fox$_{\text{[singular]}}$ that hunted$_{\text{[singular]}}$ the poacher$_{\text{[singular]}}$ stalked through the woods.[B]

[A] gloss
[B] translation

In the design of this experiment, sentences (xx) and (xxi) in the *same number* condition were created based on the authors' assumptions that once *fox* is processed as the subject, it could not trivially *hunt* more than one *poacher*. If a sentence stated that a *fox* hunted one single *poacher*, then it might be processed just as a semantic problem – *a poacher* was mistakenly put in the object's position instead of *a rabbit* – and this would yield an N400 (*fox-hunt*/*poacher* Vs. *fox-hunt*/*rabbit*). But with sentences (xviii) and (xix), in the *different number condition*, a plausibility criterion would state that the event *fox-hunt* should not have as a theme two entities, thus role reversal would then be conjured and a P600 would come out. It is not a *fox-hunt event* but a *poacher-hunt event* that has the *fox* as a theme.

Nevertheless, the authors reported a P600 effect in both unacceptable stimuli in *same* and *different number* conditions attributing the effect to a later plausibility checker that has semantic components modulating the amplitude of the wave. For them, the P600 "reflects a monitoring process that checks upon the veridicality of one's analysis" (VAN HERTEN; KOLK; CHWILLA, 2005a:254)

Note that in semantic anomalous sentences, such as (xix) and (xxi), the anomaly only becomes apparent through a violation of world knowledge and not through animacy violation as in Kuperberg *et al.* (2003) and Hoeks *et al.* (2004).

It is important to realize that the celebrated mismatch between once prediction and input that has been proven to elicit a P600 in semantic illusion sentences, was not honored in Van Herten et al (2005):

> [Thus, this P600 effect] "cannot be attributed to syntactic mismatch between an observed and an expected, even if a semantic processor produces an interpretation that is not in line with the syntactic structure [as predicted by the *Good Enough* approach]" (BROUWER; FITZ; HOEKS, 2012:3).

As in Van Herten et al (2005), the semantic predicate-argument combination was also tested in Nieuwland and van Berkum (2005), but in a contextualized experiment with auditory stimuli. Nieuwland and van Berkum (2005) used a prior context story, such as below, and reported a P600 effect for the target word, in sentences, like (xxii) vs. (xxiii):

Prior context story: "A tourist wanted to bring his huge suitcase onto the airplane. However, because the suitcase was so heavy, the woman behind the check-in counter decided to charge the tourist extra. In response, the tourist opened his suitcase and threw some stuff out. So now, the suitcase of the resourceful tourist weighed less than the maximum twenty kilos." (Approximate translation from Dutch, Nieuwland and van Berkum, 2005:692)

(xxii) Next, the woman told the *tourist* that she thought he looked really trendy. The *tourist* grabbed the woman's hand and eagerly asked her for a date. But the woman reprimanded the *tourist* for being pushy and told him to just get on the plane right away.

(xxiii) *Next, the woman told the *suitcase* that she thought he looked really trendy. The *suitcase* grabbed the woman's hand and eagerly asked her for a date. But the woman reprimanded the *suitcase* for being pushy and told him to just get on the plane right away.

The authors claimed that since the context activated words like *suitcase* beforehand, it was easy for the listeners to take the right referential having the illusion that everything was right, because they already had an understanding of the verb arguments, just by having listened to the prior story. Thus, when the listeners realized that there was a mistake in the commentary sentence, there was a cortical reaction to it in the shape of a P600.

This study, however, fails to control semantic variables. It is not possible to understand why the volunteers' reaction did not happen in the N400 time frame, as predicted for all multi-stream models. For all it is worth, pre-activation should equal a faster answer (N400), due to difficulties in semantic processing.

The authors tried to respond to criticism just as the one stated before by arguing that the late reaction could be due to a semantic illusion that provokes a delay in relation to the actual words. But if that was the case, an N400 should have been found in relation to the NP that triggered the illusion, so that the reanalysis could be given as a feasible P600 account.

An influential study by Kim and Osterhout (2005) examined ERP responses to semantically anomalous verb-argument combinations, that elicit the so-called "semantic P600" rather than N400 effects. See sentences (xxiv, xxv, xxvi and xxvii) below:

(xxiv) The hearty meal was devoured by the kids.
(xxv) The hungry boy was devouring the kids.
(xxvi) *The hearty meal was devouring the kids.
(xxvii) *The dusty tabletops were devouring the kids.

The authors argued that if syntax drives sentence processing, then the verb *devour*, in (xxvi), would be perceived to be semantically anomalous, as *meal* is a poor agent for the verb *devour*, and therefore an N400 response would be expected. On the other hand, *meal* could be a good theme for *devour* (as in xxvi, *the hearty meal was devoured*). Thus, if semantics drives the sentence processing, the verb *devouring*, in (xxvi), would be perceived as in the wrong syntactic form, and a P600 response should be expected.

The authors reported no N400 effect in (xxvi) compared to both controls (xxiv and xxv). Instead, they found a P600 response, when comparing (xxvi) to both controls. They argued that "the strong semantic attraction between the subject and the verb can drive the sentence processing, even if it contradicts unambiguous syntactic cues" (OSTERHOUT; KIM; KUPERBERG, 2006:13).

Thus, for the vast literature, the fact that there is attraction between the verb and its internal argument in the position of the subject of the passive voice will preclude the existence of an N400 effect. Conversely, the semantic anomalous sentences, such as (xxvii), in which there is no attraction between the subject noun and the verb, elicited the canonical N400 response.

Consequently, these authors support a model of sentence comprehension in which semantics and syntax are processed autonomously. They suggested a two-stream processing model, running in parallel. According to this view, during sentence processing, a syntactic mismatch, such as the wrong verb inflection in (xxvi) triggers a P600 effect.

However, a straight-forward limitation of this model of semantic attraction and parallel streams, is that the authors cannot explain the P600 effect found by Van Herten et al. (2005) cited before. Notice that Van Herten's results (The $fox_{[singular]}$ that $hunted_{[singular]}$ the $poachers_{[plural]}$ stalked through the woods) also had to do with world knowledge mismatches. Therefore, the P600 effect could not be attributed to a syntactic mismatch of expectation, since there was attraction between the subject, verb and complement in Van Herten et al's study. So the P600 must be due to something else.

To test world knowledge expectation versus attraction effects, Kolk, Chwilla and Vissers (2006) recorded ERPs while participants read high-cloze sentences, such as (xxviii), in which words resembled the expected target words orthographically and phonologically, in comparison to low-cloze sentences, such as (xxix):

(xxviii) *In that library the pupils borrow <u>bouks</u>.

(xxix) *The pillows are stuffed with <u>bouks</u>.

Authors found a widely distributed P600 effect, only with pseudohomophones in high-cloze sentences, and no P600 effect with pseudohomophones in the low-cloze sentences. Thus, according to the authors, these results support the view that "there is a process of monitoring that takes place in language perception which is reflected by the P600. It occurs whenever a conflict between a strong tendency to accept and one to reject a word brings the cognitive system in state of indecision" (VISSERS; CHWILLA; KOLK, 2006: 150). Also, the lack of N400 effects reflect that comprehenders initially consider the interpretation that fits their world knowledge best.

If that is true, a role reversed sentence, such as, *the patient examined the doctor* or *the doctor was examined by the patient*, would be initially interpreted as the doctor is examining the patient, as it is "a far more plausible real life event" (VAN HERTEN; KOLK; CHWILLA, 2005:252).

As reported before, Kuperberg *et al* (2003) had tested sentences like, (xiii) *For breakfast the eggs would eat toast and jam, and (xiv) *For breakfast the boys would bury toast and jam. The authors ran a follow-up study, Kuperberg (2007), which tested sentences, such as (xxx- xxxiii):

(xxx) For breakfast the boys would *eat* toast and jam.
(xxxi) For breakfast the boys would *plant* flowers in the garden.
(xxxii) *For breakfast the eggs would *eat* toast and jam.
(xxxiii) *For breakfast the eggs would *plant* flowers in the garden.

The authors compared semantically implausible sentences (xxxi) with sentences that carried animacy violations in the subject position and that this subject would be semantically related the verb-argument combination (xxxii). Finally the authors also compared (xxxi) with sentences that carried animacy violations in the subject position but this time this subject would not be semantically related the verb-argument combination (xxxiii). All experimental sentences were also compared with sentences in the control condition (xxx).

Authors found a P600 effect in response to sentences containing a thematic violation, such as (xxxii) compared to Control (xxx). Also, a P600 and not an N400 was evoked by (xxxiii) relative to the same Control (see also, Paczynski and Kuperberg, 2011 for similar results).

These results are tricky for the semantic attraction account. As there is no attraction between *eggs* and *plant*, it predicts that the critical verb will only generate an N400 effect reflecting difficulty in semantic integration. The results are also difficult for the monitoring theory, as this account would predict both the algorithmic stream and the plausibility heuristic to agree on the implausibility of the sentence, thus no P600 effect since there's no conflict between the streams.

Kuperberg et al. (2007) proposes a model with fully interactive streams. The Continued Analysis Account assumes that there are several independent, interactive processing streams working in parallel: the semantic memory-based mechanism, the syntactic driven stream and the thematic-role based instance. The latter two streams are referred to, as combinatory streams and "the full semantic analysis, indexed by the N400 can be switched off when a readers' animacy-based expectations are violated" (KUPERBERG et al., 2007: 37). Thus, the author supports the idea that the processor can be temporarily blind to the semantic anomaly and, experiences no difficulty in semantic interpretation, even when it contradicts the syntactic structure.

According to the authors, sentences like (xxxiii) do not produce an N400 because the semantic processor is blocked as soon as a conflict between the combinatory streams is apparent.

However, as pointed by Brouwer et at. (2012), it is unclear how this model would explain the biphasic N400/P600 effect found by Hoeks et al. (2004).

All of the studies shown above provide support to the idea of an independent semantic analyzer, characterized by the absence of an N400 effect and the presence of a P600 as evidence that the semantic interpretation can override the syntactic surface structure. Note that two important characteristics are being held by all these authors in order to explain the “semantic P600” in role-reversed predicate-argument sentences. First, the absence of an N400 effect, as a measurement of the semantic plausibility. This absence, according to them is due to semantic attraction (KIM; OSTERHOUT, 2005; KOLK et al., 2003; VAN HERTEN; KOLK; CHWILLA, 2005a; VISSERS; CHWILLA; KOLK, 2006); or to the ‘turning off’ of the processor in cases of animacy-violations (KUPERBERG et al., 2003b, 2007).

The second characteristic of the “semantic P600” effect appointed by these authors is the presence of a P600 effect in role-reversed sentences due to the initial commitment with a semantic analysis of the predicate-argument combination (semantic attraction) that is frustrated as the sentence flows. When the semantic interpretation doesn’t match with the syntactic cues, it generates a syntactic related potential, the P600 effect. Note that this assumption contradicts the theory that online semantic composition depends on surface syntax. It is also important to point out that although these theories do not purport that the verb internal argument is merged before the vP complex with subject, the stimuli used is always in the passive which reverses the order of the argument. For this reason, one of the experiments that will be presented in this thesis will be in the active voice to guarantee that we test a condition that has both internal and external arguments.

Nevertheless, more recently, believing that compositional semantics is built on top of syntactic structures, Stroud (2008) investigated whether the evidence for an independent semantic composition is as strong and widespread as it had been previously claimed.

The author confronted role-reversed stimuli versus animacy violations in Spanish, and suggested that "the effect of thematic attraction found in previous studies may be due to lower-level lexical association effects" Stroud & Phillips (2012:45). Again, in a follow-up study, Stroud & Phillips (2012) did not find evidence that the language processor considers interpretations that are not licensed by the syntactic structure of a sentence. Based on evidence from both studies, the authors proposed that the P600 effect is sensitive to surface syntactic features and semantic analyses, such as restrictions involving animacy. Nevertheless, the authors interpreted their results in a different fashion from those of the Semantic P600 cited before. They suggested that rather than an independent semantic compositional analyzer, the language processor is indeed highly interactive and rapidly integrates information from multiple sources (e.g., syntax, semantics, discourse, lexical probabilities) to continuously update the interpretation of an incoming sentence, which is a form of monitoring theory.

In a recent review paper, Brouwer et al. (2012) will argue in favor of a biphasic N400/P600 language processor in a single-stream processing occurring for every word (the Retrieval Integration Account). On this account, "the N400 and the P600 component reflect two successive processing stages, in which the output of the retrieval phase (N400 amplitude) serves as input for the integration (P600 amplitude)" Brouwer et al. (2012:14).

Chow and Phillips (2013) tested the role of 'semantic attraction' by contrasting animacy violation cases and semantic attractiveness ones with role-reverse congruence in two experiments; see (xxxiv – xxxvii) and (xxxviii – xxxix) below:

Experiment 1:

(xxxiv)	The student *solved* the math problem.	Control
(xxxv)	The student *baffled* the math problem.	Animacy-violation/role reversed
(xxxvi)	The student *hung* the math problem.	Animacy congruous / not reversed
(xxxvii)	The student *restrained* the math problem.	Animacy-violation / not reversed

Experiment 2:

(xxxvii)	Inspector Chen *arrested* the suspect.	Control
(xxxix)	The suspect *arrested* inspector Chen.	Animacy congruous / role reversed

The aim of both experiments was to draw upon the role of the N400 and the P600 effects, by investigating the two central pieces of argument in favor of the independent semantic analyzer, the lack of an N400 and the presence of a P600 effect.

Chow and Phillips (2013) have found interaction between animacy and combinability (the role reverse possibility). Authors reported a larger P600 effect for (xxxiv) and a larger N400 effect for (xxxvii) in Experiment 1, and a P600 for (xxxix) in Experiment 2. But their results are no different from those of previous reports: role reversed sentences, even syntactically well-formed and semantically incongruous, elicit a P600 effect.

They also reported an N400 and a P600 for (xxxix), showing that the presence of a P600 response to semantic anomalies was not necessarily conditioned by the absence of an N400, and this was shown in other studies as well (FRIEDERICI et al., 1998; KOLK et al., 2003; VAN HERTEN; KOLK; CHWILLA, 2005b). Therefore, Chow and Phillips will argue against the existence of an independent semantic processor on these grounds.

As seen in this chapter, the studies about Semantic Illusion do not provide a unified account for all the instances of the N400/P600 dichotomy. We argue that they do not provide clear evidence to the modulation of the N400 effect, or to the presence of the later component (P600) in the role-reversed sentences.

The idea of this review Chapter was to set the landscape of the semantic illusion field and the usual stimuli of the research conducted in this field. In the next chapter the ERP techniques that were used in most of the studies reviewed in this chapter will be described, so that a full appreciation of the two experiments in Chapters 5, 6 and 7 can be achieved.

4. THE ERP TECHNIQUE READING OF NEURONAL SYSTEMS

> "The distributed nature of the cortical processing is underscored when you consider that the output of a million ganglion cells can recruit the activity of well over a billion cortical neurons throughout the occipital, parietal, and temporal lobes! Somehow, this widespread cortical activity is combined to form a single, seamless perception of the world." (BEAR; CONNERS; PARADISO, 2006:269)

4.1 Neuronal Systems

The main task of neuronal systems is to construct in the brain a reliable representation of the world, captured by the senses, so that this representation can be manipulated by cognitive processes.

The first stage of this task consists in translating the physical phenomena into "the language of neurons". The great diversity of physical stimuli must be reduced to a unique code, the action potential, which is the variation in electric potential of the membrane of receptor neuronal cells. The sensory translation is the process of transforming the electricity that is present in the plasma membrane of the sensory receptors. Thus, physical stimuli will be re-codified in terms of synaptic effects (LENT, 2008).

Synapses hold the mechanism that is responsible for the transmission of impulses between one nervous cell and the other, that is, between one neuron[5] and the other, or between a neuron and a motor end plate. Most of the synapses of the human nervous system are chemical, and the impulse in the presynaptic axon causes the release of a neurotransmitter in one of its presynaptic terminals. This chemical mediator is released in the synaptic cleft, the space between the pre- and postsynaptic membranes, and it binds to

[5] The neuron can be considered the basic structural unit of the brain and the nervous system. It is the cell in the nervous system that is responsible for transmitting the nervous impulse. There are approximately 100 billion neurons in the human nervous system. Neurons consist of the following parts: (i) cell body – where the cell nucleus is; (ii) dendrites – extensive branches that come from the exterior membrane of the neuron and receive electric signals from other neurons; (iii) axon – an extension of the neuron; (iv) telodendrion – a terminal branch of the axon where the impulse goes from one neuron to the other or to another organ.

specific receptors in the postsynaptic cell (Figure 13). In some synapses, the transmission is purely electric and in others it is mixed, or rather, electrochemical.

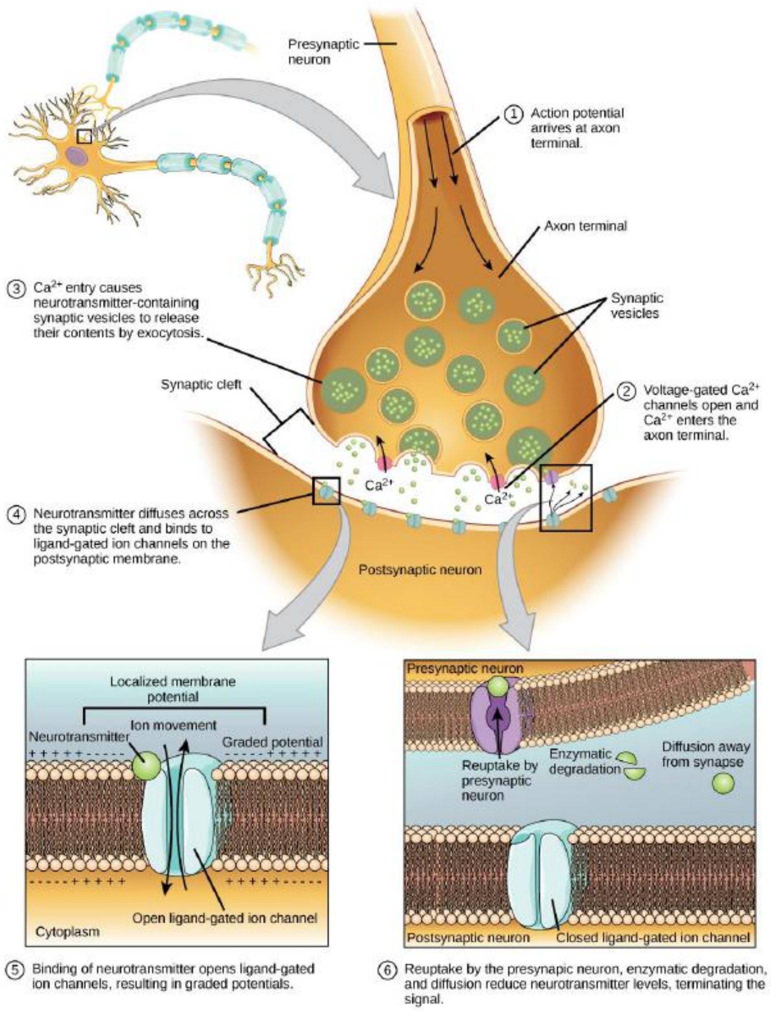


Figure 13 – Chemical synapse (University of Georgia Concepts of Biology http://cnx.org/content/m44748/latest/)

In order to communicate, chemical synapses requires release of neurotransmitters. When the presynaptic membrane is depolarized, voltage-gated Ca^{2+} channels open and allow Ca^{2+} to enter the cell. The calcium entry causes synaptic vesicles to fuse with the membrane and release neurotransmitter molecules into the synaptic cleft. The neurotransmitter diffuses across the synaptic cleft and binds to ligand-gated ion channels in the postsynaptic membrane, resulting in a localized depolarization or hyperpolarization of the postsynaptic neuron.

Through the synaptic effect the action potential is set off and travels in direction of the terminal axons. The arrival of the action potential at the axon terminal triggers the release of neurotransmitters. Different neurotransmitters are released under different conditions. Also, depending on the released neurotransmitter, the action potential that will flow to the next neuron may be propagated, inhibited or modified. It is this rich diversity in the synaptic interaction that allows for the complex behavior caused by just one stimulus.

In fact, after a millisecond, the postsynaptic neuron may already be ready to transmit another action potential. These potentials are like digital codes to be deciphered by cortical processing. From a micro-perspective, this process is responsible for the functioning of the brain (BEAR; CONNERS; PARADISO, 2006)

4.2 An outlook on EEG-ERP in linguistics

It took a long time in the history of neurology for the electricity in the brain to be monitored and understood. The first technique used for this purpose was the electroencephalography (EEG). Created in the 20's by the German psychiatrist Hans Berger (1873-1941), the EEG was quickly adopted by medicine for clinical diagnostic exams. Being quite precise and offering low cost and quick diagnoses, it still is much used and widespread in the medical field.

Electroencephalography allows for the acquisition and storage of bioelectric signals, executing the continuous registration of electro-cortical activity by means of electrodes fixed to the scalp. Each one of these electrodes is placed at a specific point, which is directly related to an area of the cerebral cortex. These points on the scalp are called derivations. The tip of the electrode captures the electric activity of thousands of neurons, as described in the previous section. Any voltage fluctuation (μV) captured between pairs of electrodes, or rather, between two derivations, is registered by the EEG, enabling the measurement of electric activity at the derivations, which is a reflection of the electric activity in the brain (BEAR; CONNERS; PARADISO, 2006).

Therefore, the electric signal of the EEG captured on the scalp is an oscillatory signal, stemming from the spatial-temporal sum of inter-neuronal synaptic potentials with two major components: the background or continuous or base signal[6]; and the set of discontinuous (or transient) signals (RIEKE, F., WARLAND, D., DE RUYTER VAN STEVENINCK, R., AND BIALEK, 1999)

As such, the fact that EEG measures the electric current that flows during the synaptic neuronal excitation, and that excitation occurs invariably in subcortical areas[7] contributes to the low efficiency in terms of space-signal. In other words, capturing the electric current in these subcortical areas implies in a loss of electric conduction, as the electricity must go through many layers of non-neuronal tissue on its way to the surface of the cortex. That is why the electric signals that are captured during the exam or experiment must be amplified and digitized technically by way of the grand-average technique in order to suppress noise and enhance electric potentials (PULVERMÜLLER, 2003).

ERPs, responses of the nervous system to motor or sensory stimulation, are composed by a sequence of waves characterized by its latency, amplitude, and polarity. ERPs usually present an instantaneous value of 10 to 1000 times less than the background EEG, which is why it cannot be visualized. For them to be visualized, the average of various epochs[8] needs to be calculated. This procedure is justified by considering spontaneous EEG as zero-mean white Gaussian noise and the ERPs as the only responses, which are really synchronized with the stimulus. This way, the effect of the grand-average is to increase the signal/noise ratio (SNR), thus allowing for the visualization of the specific effect of the – in this case - linguistic stimulus.

[6] In the visual analysis, the background signal is usually described by characteristics of amplitude and frequency. In the temporal domain, the EEG signal is a function of time in which the amplitude may be described numerically (5, 10, 60 microvolt, for example) or nominally (small, medium, large, for example), the same occurs for frequency (1, 4, 12 Hz, for example; or slow, fast, for example). The EEG background signal is not a stationary signal. Quite the contrary, it is rather complex, undergoing synchronization/desynchronization processes over time, randomly or due to a specific event. The reactivity of the alpha rhythm is a classical example of this, in that it desynchronizes with stimuli provoking alertness and synchronizes in a state of rest.

[7] Subcortical areas are those localized below the cortical level. They are deeper regions in which there is a higher cell density.

[8] Epochs are functional time windows in the EEG continuum marked out for further study.

ERPs provide a continuous sampling of the brain's electrical activity. This sampling can come from different sorts of linguistic phenomena produced in the cortex of volunteers performing linguistic tasks, while monitored by the electroencephalograph – EEG (OSTERHOUT; HOLCOMB, 1993). The ERP involves a signal amplification that adds up and averages specifically time-locked epochs (Figure 14) that may present a lower signal-to-noise ratio (SN) than those of the original waveforms (GESUALDI; FRANÇA, 2011)

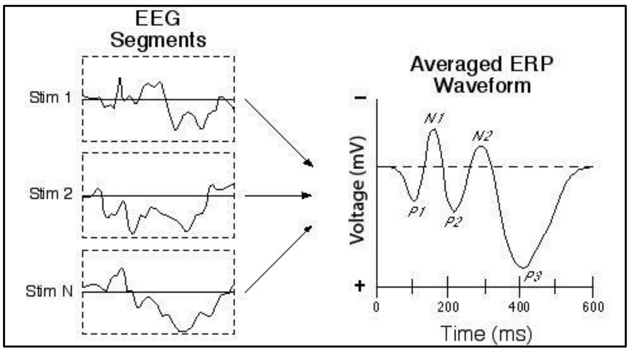


Figure 14: The averaging of several EEG segments into the averaged ERP waveform

The Grand-average is the technique that is used to achieve a coherent average of exactly the same time-locked stretch of signal for all the stimuli. Thus, random noise, such as the noise resulting from muscular movement, blinking of the eyes or even from an electric interference caused by some equipment, competing with the event related signal under study is eliminated. The noise being random, the average in the grand-average converges to zero. That is why at the end of this operation only the event related signal stands out; in this case the relevant event is the linguistic event linked time-locked to the presentation of the stimuli prepared for this study (LAGE et al., 2008).

As ERPs provide a chronometric measurement of the electro-cortical effects related to the processing of linguistic information distributed over the time course of a sentence processing, the EEG paradigm was the type of test chosen for this thesis, because this experimental method allows for a tight correlation between the cognition of language and its manifestations in the brain, allowing one to track changes in the brain activity over time with great temporal resolution. As ERPs might be ideal for isolating the neural responses to particular critical words in sentences, we used those multidimensional measures scalp-recorded to contribute on the discussion about the architecture of language processing.

If, in the early nineteen hundreds, linguistics gained its first main thoughts as a system on its own from Ferdinand de Saussure[9], currently neuroscience of language owes its engrossing interest and property to the availability of non-invasive methods of brain measures[10] that allow cognitive science to seek for the answers about the brain mechanisms during online language processing.

With not only the EEG-ERP but also methods such as PET, fMRI, and MEG, the cognitive neuroscience of language field acquired the necessary tools to try to answer questions like where and how is a specific linguistic computation processed in the brain? And from this knowledge even more complicated questions arise, like how different cognitive areas are related to one to another and, if that's the case, can we map language and its sub-processes in the brain?

The possibility of mapping sub-processes and seeing what parts of the human brain are activated for a given computation, while tracking the neuronal areas in millimeters as they get involved in processing is one of the most important contributions of the hemodynamic methods[11] to the neuroscience of language field.

Likewise, the possibility of seeing how a human brain works on-line, being able to track processes with millisecond resolution is one of the most important contributions of the electromagnetic methods to the neuroscience of language field. With methods like

[9] Swiss linguist and philosopher Ferdinand de Saussure (1857-1913), provoked a significant impact on the scientific thought of early XX century through the advent of his conception that linguistics should be a science free from a merely historical and comparativist approach. His book, published posthumously, *The Cours de linguistique generale,* reconstructed from students' notes after Saussure's death in 1913, founded modern linguistic theory by presenting Saussure's new method, Structuralism, which has since been applied to many diverse areas as art, architecture, anthropology, literary criticism, and philosophy. His main contribution was to state that the real task of a linguist was to describe and compare language, not to follow prescriptivism.

[10] Electromagnetic methods: EEG, MEG; Hemodynamic methods: PET, fMRI, CAT

[11] Hemodynamic methods – PET, fMRI

these, used in this thesis, it is possible to follow the electrical response to linguistic stimuli and many correlations have been made between special cortical waves – ERPs (Event-related brain potentials) – and linguistic phenomena, especially if the problem being faced has to do with the chronology of the different computations in language processing and to the choice of the best language architecture, the most suitable assessment method is the EEG-ERP.

Since the early 80's, with the advent of one investigation by Marta Kutas and Stephen Hillyard, a famous ERP was brought to the attention of the scientific community. It seems that during language processing whenever an incoming noun failed to meet the processing expectation, as in the classic – I like my coffee with cream and socks – a special wave, with a high amplitude and a negative voltage, plotted upwards by convention, appeared as the cortical response, around 400ms post critical stimulus, here the word socks (Figure 15).

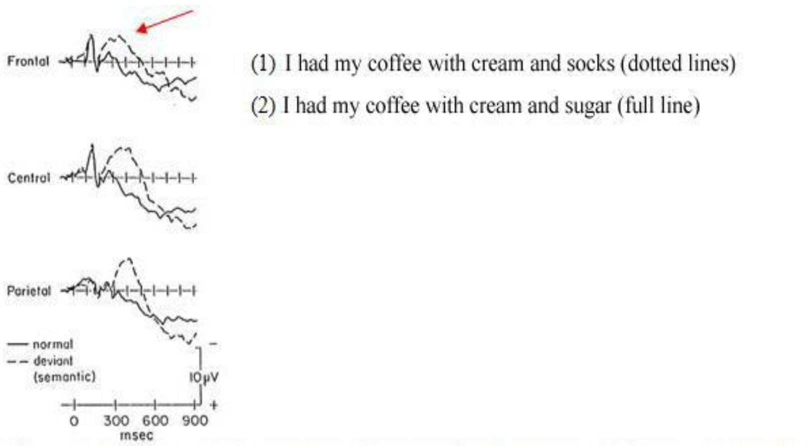


Figure 15: Classic N400 experiment (KUTAS; HILLYARD, 1980) showing a high amplitude N400 in three different derivations (scalp locations): frontal, central and parietal.

After nearly three decades of robust testing of N400 in a great variety of languages and using different protocols, the electrical effect was consolidated as the cortical signature of semantic incongruence. The effect could be observed in cases where a separate word is semantically incongruous given a priming situation or whenever it has a poor semantic fit in the sentence and this fit has been described by some authors as the impossibility of theta role assignment by the preposition or by the verb (GOMES, 2009; KUTAS; FEDERMEIER, 2000, 2011; LAU; PHILLIPS; POEPPEL, 2008b). A decade after the N400 had appeared; another cortical ERP started being connected to linguistic ungrammatical stimuli. (OSTERHOUT; HOLCOMB, 1992, 1993) tested ungrammatical sentences – *The broker hoped to sell the stock was sent to jail* Vs. **The broker persuaded to sell the stock was sent to jail* – and obtained a large amplitude ERP at around 600ms post-stimulus. This was a positive downward wave, associated in this case with the ill-fitted categorization grid of the verb *to persuade*. After these first experiments a number of others appeared in many languages and another electrical signature, the P600, started being strongly related with ungrammatical effects of different sorts (Figures 16a and 16b).

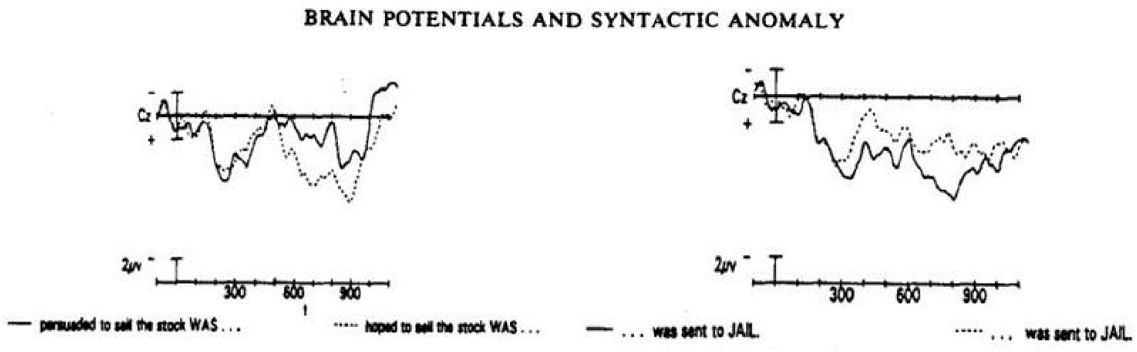


Figure 16a: ERPs (CZ) to auxiliary verbs ('was') in long transitive-verb ('The broker persuaded to sell the stock was…') and intransitive-verb ('The broker hoped to sell the stock was…') sentences.
Figure 16b: ERPs (CZ) to sentence-ending words ('jail') in long transitive-verb and long intransitive-verb sentences. (OSTERHOUT; HOLCOMB, 1992)

In the current experiments, whole sentences within the semantic illusion paradigm will be tested and the prediction here is that in a situation in which the hierarchy is right on the surface structure, the findings will support a syntax-first, bottom-up account of the tested conditions.

Priming studies testing the semantic relationship between words compared unrelated targets to related ones. The N400 was elicited by the unrelated targets (star-HOUR) compared to related ones (peace-WAR) (BROWN, C. HAGOORT, 1993; GOMES; FRANÇA, 2008). Studies in the sentence level, also elicited N400 responses to low cloze continuations (i.e. Don't touch the wet dog / paint) (KUTAS; HILLYARD, 1980, 1984) and recent studies showed that an N400 response can be elicited by a congruous word in the sentence level, but that was an incongruous completion within the context of the whole discourse (i.e. The mouse quickly / slowly returned to its hole) elicited an even smaller N400 if they were coherent (quickly) as opposed to incoherent (slowly) with extant discourse level constraints (i.e. The cat entered the room suddenly, startling a mouse which had found a bit of cheese in the corner) (HAGOORT; BROWN; OSTERHOUT, 1999). Moreover, studies have been suggesting that the N400 is also sensitive to the organization of semantic memory during online processing (KUTAS; FEDERMEIER, 2000). As we can note in figure 1 (KUTAS; FEDERMEIER, 2000: p 465), the N400 is a general brain response to words, and its amplitude is sensitive to whether it occurs in a word level, context level or discourse one, and is believed to reflect costs of the word meaning integration into the overall meaning representation and the ease with which the information can be accessed from semantic memory (KOS, VOSSE, VAN DEN BRINK & HAGOORT, 2010).

The P600 effect whereas, is believed to be elicited by syntactic processing, due to syntactic violations, such as agreement violation (i.e. Most cats like / likes to play outside) (OSTERHOUT; MOBLEY, 1995) and (i.e. Emily wonders whether the performers in the concert imitate / imitates a pop star for the audience's amusement) (PHILLIPS; KAZANINA; ABADA, 2005). Although it is commonly assumed that the P600 response reflect syntactic unification and its amplitude is modulated by the competition between alternative unification options, some studies suggest that this response reflects syntactic reanalysis or repair (FRIEDERICI, 2002).

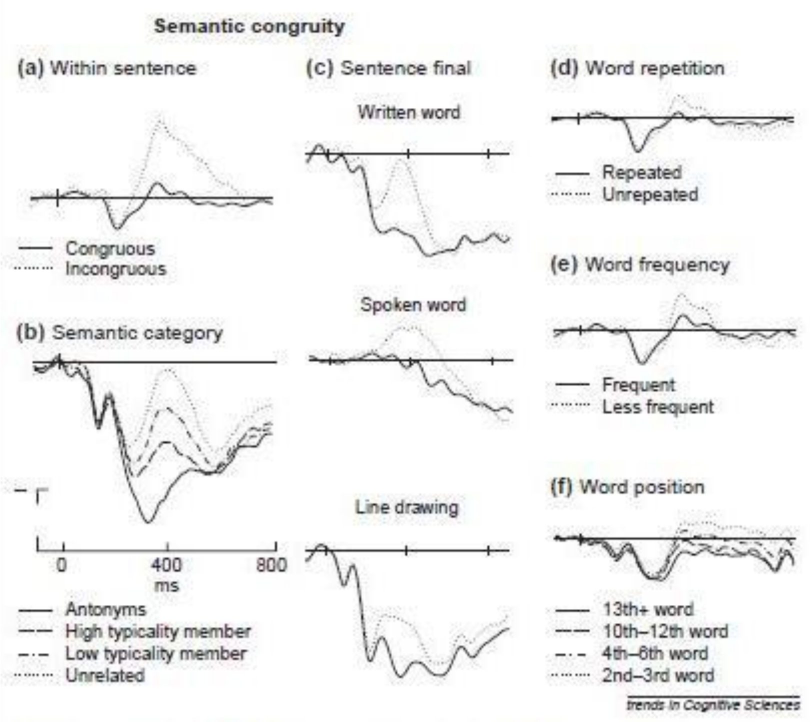


Figure17: **Factors influencing the N400 response.** N400 amplitudes are influenced by a number of different factors, several of which are shown here at a right-hemisphere site approximately over Wernicke's area (homologue). The N400 is highly sensitive to semantic (though not just semantic) relationships of various kinds. **(a)** Incongruous words elicit large N400 amplitudes relative to words that are congruous in their context, whether these items occur mid-sentence or in sentence final position. As shown in **(c)**, this effect can observed in all modalities, including written and spoken words, and line drawings (here, all using the same experimental material). **(b)** The N400 is similarly sensitive to varying degrees and types of semantic relationships in more minimal contexts, including word pairs. Shown are responses to highly constrained antonyms (e.g. *the opposite of black… WHITE*), high typicality category members (e.g. *A type of bird… ROBIN*), lower typicality category members (e.g. *A type of bird… TURKEY*) and to unrelated/mismatched items. **(d)** Midsentence words that are repeated in on-going text and show reduced N400 amplitudes, as do mid-sentence words that are more frequent in the language in general **(e)**. The amplitude of the N400 also reflects the build-up of contextual constraint over the course of a sentence **(f)**. Not shown here, the ERP to a word during the N400 epoch (200–500 ms) is also sensitive to relationships at the level of orthography, phonology and morphology.

Studies about semantic violations elicit a negative wave that peaks around 400ms after word onset. Semantically anomalous words show an N400 effect (KUTAS; HILLYARD, 1980), as it is called, while syntactically anomalous words elicit a positive

ERP that onsets around 500ms after the word appears. This wave is called P600 and can be elicited by syntactic violations (HAGOORT, P.; BROWN; GROOTHUSEN, 1993).

The neurophysiological responses reflecting syntactic and semantic processes seemed to be quite clear and simple, N400 effects are believed to be elicit due to semantic incongruences and P600 effects, due to syntactic ones. However, some very recent ERP studies, as shown before, seemed to contradict this general consensus.

In light of these studies, we aim to contribute to the investigation of whether the N400 and the P600 responses are modulated by thematic role reversals, analyzing electrocortical manifestations of the time course of syntactically and semantically well-formed sentences in two experiments.

The following experiments, that will be presented in Chapters 5 and 6, aim at verifying these recent findings. We are going to present both Experiments 1 and 2 individually, as well as the stimuli and predictions for each experiment.

5. THE ERP EXPERIMENT 1: ACTIVE VOICE

The aim of this first study was to use Event-Related Potential measurements (ERPs) to address the problems associated to role-reversed sentences, containing plausible semantic interpretation but unrelated syntactic structure: *The audacious hiker attacked the bear*. We were concerned with the modulation of two distinct ERP effects, the N400 and the P600, that have been associated with semantic and syntactic processes, respectively.

Given that there are discrepancies in the literature as to which types of anomalies elicit which type of ERP responses (Cf. Chapter 4), our results hope to contribute to this discussion by deepening the understanding about the semantic and syntactic processes involved in role-reversed sentence processing.

5.1 Methods

We recorded ERPs to critical words while participants read sentences in three different conditions. We contrasted three groups of English sentences: (1a) grammatically well-formed sentences with plausible semantics (e.g. the bear attacked the audacious hiker), (1b) role-reversed grammatically well-formed sentences (e.g. the audacious hiker attacked the bear) and (1c) incongruous sentences (e.g. the bear attacked the large battery).

The independent variables in this study were the thematic roles and the plausibility rates, while the subject response times, error rates and the ERPs were the dependent variables.

5.2 Participants

A total of 15 paid subjects (7 males) undergraduates from the Colorado University at Boulder, US took part in these experiments. Participants aged 18-34 (mean: 25.7). All participants were right-handed. Selection criteria required all participants to have normal or corrected-to-normal vision and to be native speakers of American English. A written consent form was obtained from all subjects before participation.

5.3 Stimuli

In Experiment 1, the stimulus set was divided into three experimental conditions in the active voice. Condition (1a) stimuli were congruous and work as the control. Condition (1c) stimuli were incongruous and Condition (1b) was the role-reversed one.

Each stimulus exemplar consisted of the following sequence: a determiner phrase, as the subject (e.g., the bear), a verb (e.g., attacked), a determiner phrase as the complement (e.g., the audacious hiker) and a prepositional or adverbial phrase (e.g., on the trail). The trigger was set right at the onset of the second determiner phrase (e.g., the audacious hiker). Examples of these types of stimuli are shown in Table 4.

TABLE 4 –Experiment 1: Active Conditions

1. Active Conditions	Stimuli Examples
1a. Control	The bear **attacked** ***the audacious hiker*** on the trail. The zookeeper **fed** ***the cuddly chimpanzee*** with love.
1b. Role Reversed	The audacious hiker **attacked** ***the angry bear*** on the trail. The cuddly chimpanzee **fed** ***the sad zookeeper*** with love.
1c. Incongruous	The bear **attacked** ***the large battery*** on the trail. The zookeeper **fed** ***the stinky bathroom*** with love.

Stimuli of (1a) type were used as the control Condition. The two arguments in this condition are suitable for the semantics and syntax that whirl around the verb. Stimulus type (1a) was the most plausible version of this set. In (1a), the DP in the subject position can affect the event entailed by the verb in relation to a great number of complements, since there is a vast number of animate beings that can be *attacked* by a *bear*. This resulted in highly plausible active-voice sentences in this condition, with the verb felicitous assignment of the theme role to the complement and the agent role to the subject.

Stimuli in the (1b) condition had the roles reversed in relation to those in (1a): the theme in (1a) became the agent in (1b) and vice-versa. We controlled the role reversal structure to entail a counter fan effect: given the two determiner phrases, in (1b), the agent would always be more plausible as an object and the object would be more plausible as an agent. For instance, there are fewer beings that can be attacked by a hiker than by a bear and among the ones that a hiker can attack, an angry bear is not a highly plausible one, although still possible.

Condition (1c) was incongruous. Sentences in the (1c) stimulus type were identical to the control version (1a) up to the critical verb (e.g., the bear attacked), but further on, the sentence wrapped up with a completely implausible complement (e.g., the large battery). This resulted in a plausible active sentence, but only up to the critical verb. When *the large battery* comes in, it is not possible to integrate it, since it is not a good theme for the event requirements of the verb to *attack*. This is the typical setting for the N400 effect (CAGY et al., 2006; KUTAS; HILLYARD, 1984; OSTERHOUT; NICOL, 1999), so our prediction was to find an N400 in relation to this stimulus type.

Since (1b) is the middle between the control (1a) and the incongruous (1c), our aim was to assess if (1b) would be processed in a more similar way to (1a) or to (1c) and why. If (1b) ended up being more similar to (1c), which is an incongruous sentence, that would mean that the semantic information entailed by the subject would be very present right from the first moment, while processing this sentence. (1b) is only implausible if the semantic features of the agent are taken into consideration. Although the event of *attacking a bear* is plausible, *a hiker* is not a very plausible agent for it. Since towards the end of the sentence both the verb and complement in (1a) and (1b) are plausible (there are beings that may attack an audacious hiker and others that may attack a bear), then, if (1b) is more similar to 1c than to (1a), it would have to mean that the information given by the subject is integrated immediately as processing starts.

Contrastingly, if (1b) ended up being more similar to (1a), which is the congruous condition, that would have to mean that, crucially, the semantic information entailed by the subject would not be present right from the start, while processing this sentence. Remember that the integration between the verb and its complement is plausible in (1b): there are beings that may attack the bear, namely the hyena, the hunters, the sea lion etc. The only problem in this condition is with the given subject, *the hiker*, and with the other subjects that we used for this condition.

A total of 243 sentences were created and 261 fillers were used across three lists. Each list had 81 experimental items of the three different conditions exemplified in Table 1, and 87 fillers of three types: control (e.g., The cats won't eat the food that Mary gives them), syntactically anomalous (e.g., The cats won't eating the food that Mary gives them) and semantically anomalous (e.g., The cats won't bake the food that Mary gives them). Fillers were extracted from Osterhout & Nicol (1999).

Stimuli were pseudo-randomly ordered, subject to the following constraints: (1) experimental stimuli were separated by at least one filler; (2) each third of the list presented from 10 to 12 targets of each condition. This was done so that there was no accumulation of experimental stimuli in any part of the test.

The 81 stimulus exemplars were created varying two types of closures, each for half of the stimuli: 50% of prepositional phrases (e.g., …on the trail) and 50% of adverbial phrases (e.g., …rapidly). This manipulation followed the critical segment, and therefore did not directly affect the processing response on a given trial. Its purpose was to reduce the habituation effect in our experiment and to make it harder for the subjects to discriminate between experimental and distracting conditions. Thus, by eliminating regularities, participants should not, implicitly or explicitly, get biased towards one particular manipulation.

TABLE 5: The standard 4 x 4 Latin Square design.

List 1	List 2	List 3
1a. Control	1b.	1c.
2c. Incongruous	2a.	2b.
3b. Reversed	3c.	3a.
4a.	4b.	4c.
5c.	5a.	5b.
6b.	6c.	6a.
7a.	7b.	7c.
8c.	8a.	8b.
9b.	9c.	9a.
10a.	10b.	10c.
11c.	11a.	11b.
12b.	12c.	12a.
13a.	13b.	13c.
14c.	14a.	14b.
15b.	15c.	15a.
16a.	16b.	16c.
17c.	17a.	17b.
18b.	18c.	18a.
19a.	19b.	19c.
20c.	20a.	20b.
21b.	21.c	21.a
…	…	…
81b.	81.c	81.a

5.4 Procedures

Each test started by a training session with 8 sentences mixing the three experimental conditions and fillers. The training session could be reiterated in case the participant was not completely sure of the procedures.

The test came immediately after the training, following a within-subject experimental design. Participants were tested in a single session lasting about 1 hour (including about 30 minutes of experimental preparation). Participants were randomly assigned to one of the three lists used, so as not to repeat tests across participants and to counterbalance participants across lists.

Participants sat in a comfortable chair, in a dimly lit room, separate from experimenter and computers, as it can be seen in Figure 18. They were instructed to read the computer screen as normally as possible and to try to understand the sentences.

Figure 18: The experimental setting in 360^{0}: on the left, the acquision and stimulus presentation unit; on the right, the processing and data analysis lab.

Sentences were presented on a computer screen, phrase by phrase, following the events depicted in Figure 19.

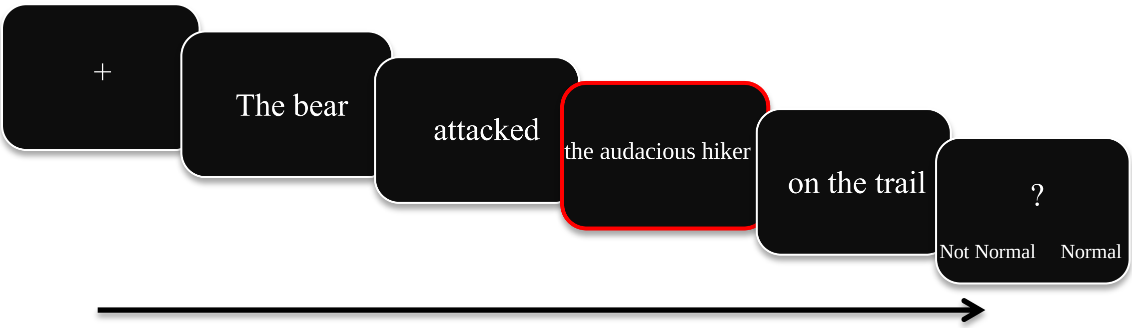


Figure 19: Sentence Presentation – Experiment 1, Active Voice.

The presentation began with a fixation cross at the center of the screen for 700ms, followed by a blank screen of 125ms. Then each phrase was presented for 280ms plus a jitter of 20ms/character. The verb was presented for 250ms followed by a 140ms of a blank screen.

A 100ms blank screen was presented after the very last word of each sentence. A response screen would then appear with the prompts *normal* and *not normal.* The prompts would be on until the subject made his/her judgment by pressing one of two buttons in a button-box, according to the desired answer. The buttons in the button box were counter-balanced (left and right) across participants. After each trial, a 1000ms blank screen was on until the next trial.

5.5 Data Acquisition and analysis

The EEG signals were recorded continuously from 64 sintered Ag/Ag–Cl electrodes attached to an elastic cap (Neuroscan QuikCaps) in accordance with the extended 10-20 system (Newer et al., 1998), as illustrated in Fig. 20. Several of these electrodes were placed in standard International System locations, including five sites along midline (FPz, Fz, Cz, Pz and Oz) and sixteen lateral/ temporal sites, eight over each hemisphere (FP1/ FP2, F3/ F4, F7/ F8, C3/ C4, T3/ T4, T7/ T8, P3/ P4, and P7/ P8). Also, another 43 extended 10-20 system sites were used (AF3/ AF4, F1/ F2, F5/ F6, FC1/ FC2, FC3/ FC4, FC5/ FC6, FT7/ FT8, C1/ C2, C5/ C6, CP1/ CP2, CP3/ CP4, CP5/ CP6, TP7/ TP8, P1/ P2, P5/ P6, P7/ P8, PO3/ PO4, PO5/ PO6, PO7/ PO8, CB1/ CB2, O1/ O2. Electrodes were also placed above and below the left eye and at the outer canthus of each eye to monitor vertical and horizontal eye movements. EEG was also recorded over left and right mastoid sites.

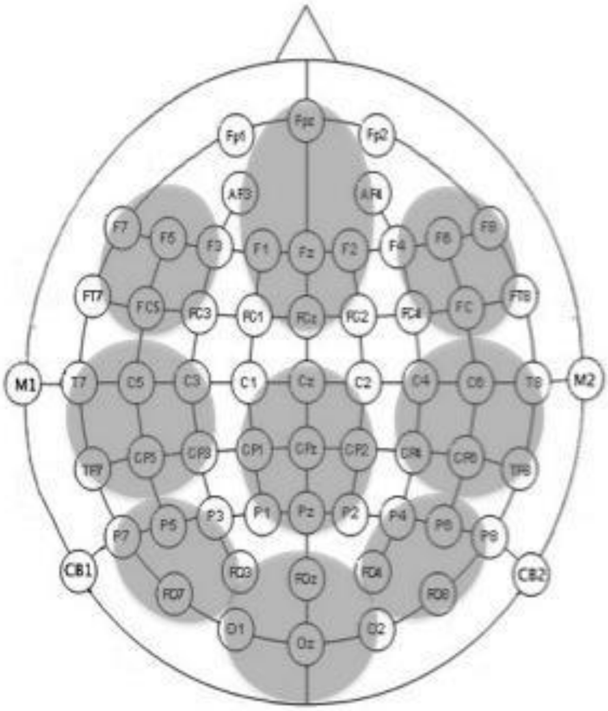


Figure 20: 64-Channel scalp-electrode array, with gray shading highlighting the six channel-groups used for visual inspection and statistical analysis: frontal-left, frontal-mid, frontal-right, central-left, central-mid, central-right, parietal-left, parietal-mid, parietal-right.

EEG was referenced on-line to a vertex electrode and later re-referenced to an average of the left and right mastoid channels. Impedances were maintained below 10 kΩ. EEG was amplified and digitized at a sampling frequency of 1000 Hz (Neuroscan Systems). After recording, data was *down-sampled* to 250 Hz and filtered with a bandpass of 0.1–30 Hz. ERPs were averaged off-line within each experimental condition (control, role reversed and incongruous) for each subject at each electrode site in epochs spanning −200 to 1000ms relative to the onset of the target stimulus. Epochs characterized by eye blinks or excessive muscle artifacts were rejected by Neuroscan System depending on the experimenter's visual inspection. Accuracy was computed as the percentage of correct responses (min 95%).

ERP components of interest were identified based on visual inspection of ERPs, ROIs and topographic maps, as well as prior findings. For each of the channels, we quantified ERPs for analysis as mean voltages within windows of 350–550ms (capturing a broad negativity); and 550–800ms (capturing a broad positivity) after stimulus onset. Grand-averages were formed by averaging over participants.

These dependent measures, that is, the voltages within the N400 mean voltage time-window and P600 mean voltage time-window, were analyzed with repeated measures analyses of variance (ANOVA). ANOVAs were performed separately at each electrode site. A two-way ANOVA model was used, and the factors were sentence-type (control, role-reversed, incongruous) and electrode position (anterior, posterior).

The Greenhouse and Geisser (1959) correction for inhomogeneity of variance was applied to all ANOVAs with greater than one degree of freedom in the numerator. In such cases, the corrected *p* value was reported. Significant main effects were followed by simple-effects analysis.

Voltages were also averaged for analysis within six-channel-groups (Figure 20): frontal-left, frontal-mid, frontal-right, central-left, central-mid, central-right, parietal-left, parietal-mid, parietal-right. For each of these channel-groups, we quantified ERPs as mean voltages within the windows of 350–550ms (capturing a broad negativity); and 550–800ms (capturing a broad positivity) after stimulus onset. Grand-averages were formed by averaging over participants.

These dependent measures, that is, the voltages within the N400 mean voltage time-window and P600 mean voltage time-window, were analyzed with repeated measures analyses of variance (ANOVA). ANOVAs were performed separately at each channel-group. A two-way ANOVA model was used, and the factors were sentence-type (control, role-reversed, incongruous), hemisphere (right-mid-left) and position (frontal, central, parietal).

The Greenhouse and Geisser (1959) correction for inhomogeneity of variance was applied to all ANOVAs with greater than one degree of freedom in the numerator. In such cases, the corrected p value was reported. Significant main effects were followed by simple-effects analysis.

5.6 Results

This project was made in collaboration with the *Cognitive Neuroscience of Language Laboratory*, in the University of Colorado at Boulder, US. The data collection and all phases of signal processing and part of the data analysis were performed at the Cognitive Neuroscience of Language Laboratory as a joint project. The completion of the data analysis and the interpretation of the findings were performed at ACESIN LAB, at the Federal University of Rio de Janeiro, Brazil. The statistical analysis were performed in association with Professor Aline Gesualdi Manhães, from the Digital Signal Processing, Pattern Recognition Department at the Federal Center of Technological Education in Rio de Janeiro, Brazil.

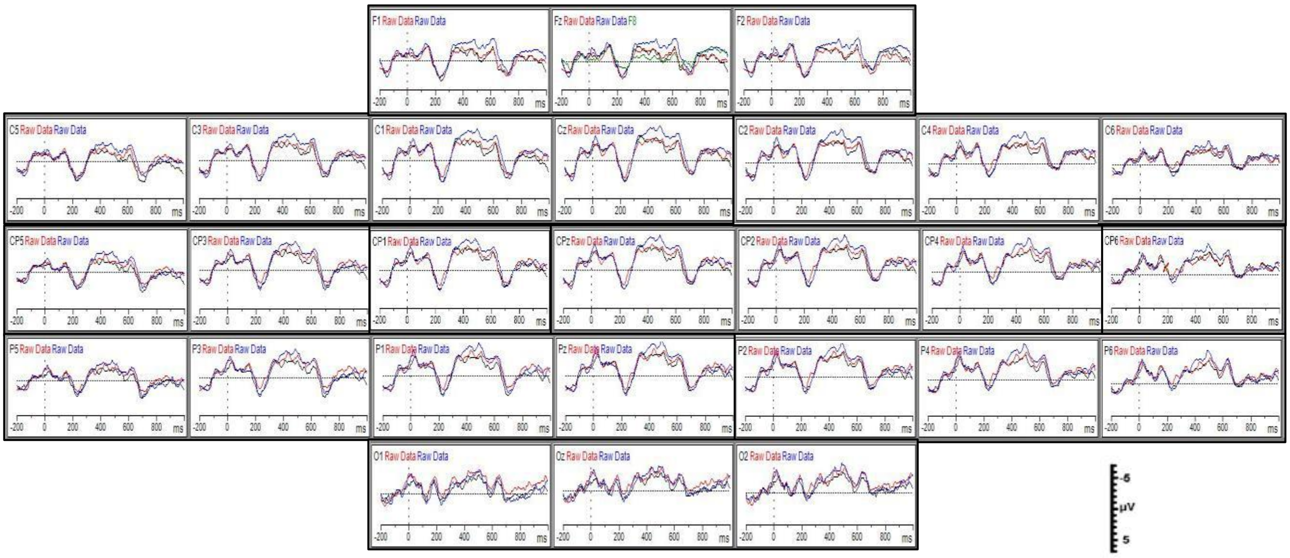
The results and statistical analysis from the present experiment will be shown in the next section, as well as the conclusions and further steps.

5.7 Acceptability judgments

Participants judged the stimuli to be acceptable at the following rates: Role Reversed condition, 3%; Incongruous condition, 5%; syntactically or semantically anomalous fillers, 2%; and plausible, well-formed stimuli (controls or fillers), 96%. For all of the stimuli together, participants agreed with the intended acceptability judgments at a mean rate of 95%, with individual participants ranging from 85 to 98%.

5.8 ERPs

The Grand-average ERPs to the critical determiner phrase in each sentence type are shown in Figure 21.



The bear attacked ***the audacious hiker*** on the trail.
The audacious hiker attacked ***the angry bear*** on the trail.
The bear attacked ***the large battery*** on the trail.

Figure 21: Grand-average ERPs recorded at five midline sites and five medial–lateral sites to Active Control DPs (solid black line), Active Role Reversed DPs (red line) and Active Incongruous DPs (blue line). Onset of the critical DPs is indicated by the vertical bar. Each has mark represents 100ms of activity. Positive voltage is plotted down.

A clear negative-positive ongoing wave pattern was visible in the first 300ms following the segment onset (the N1-P2 complex). These potentials were followed by a negative-going component with a protruding peak around 400ms (N400) and a positive-going component with a profound peak around 600ms (P600).

As we can see in Fig. 21, the comparison between the Control condition (black line) and the Incongruous condition (blue line) was dominated by N400 responses. On the other hand, the comparison between the Control condition (black line) and the Role Reversed one (red line) didn't behave the same way in the overall channels.

Topographic maps are shown in Figures 22 and 23. Figure 22 shows the difference between the Active Control and the Active Role Reversed conditions in the N400 and P600 time-windows. Figure 23 shows the difference between the Active Control and the Active Incongruous conditions also in the N400 and P600 time-windows.

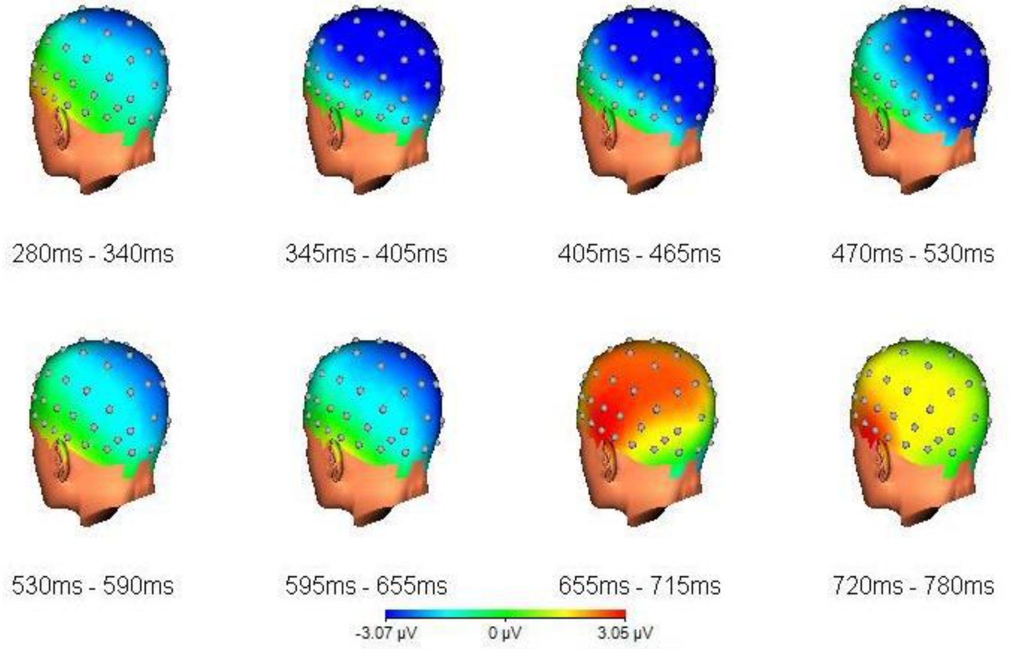


Figure 22: Topographic maps of the differences between the ERP response to the Active Control condition and Active Role Reversed condition.

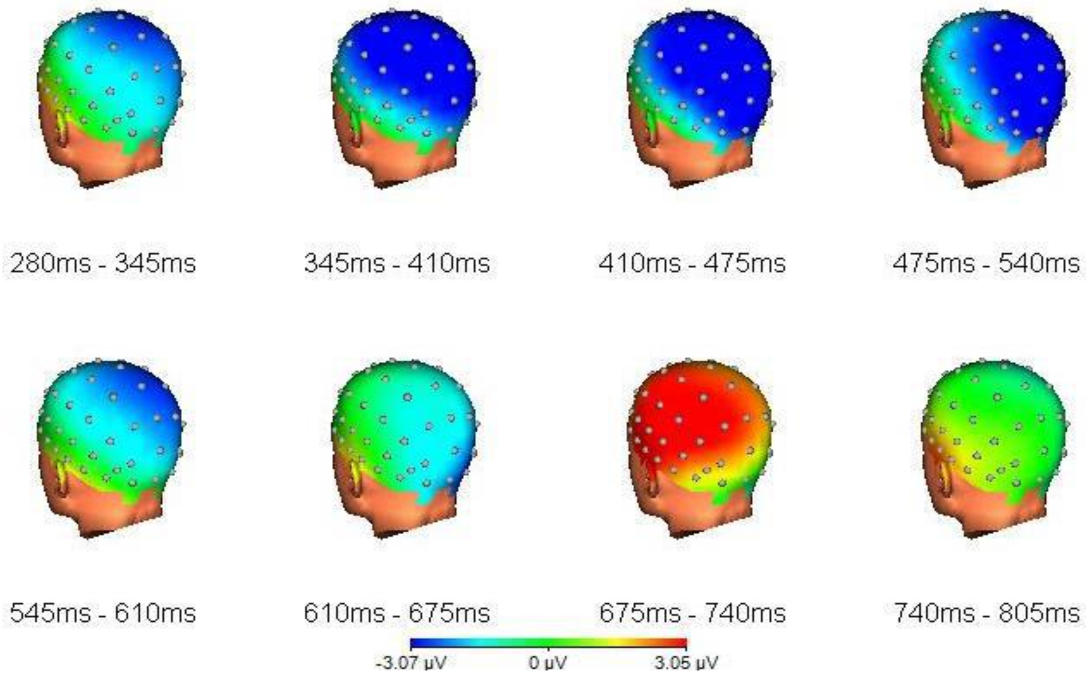
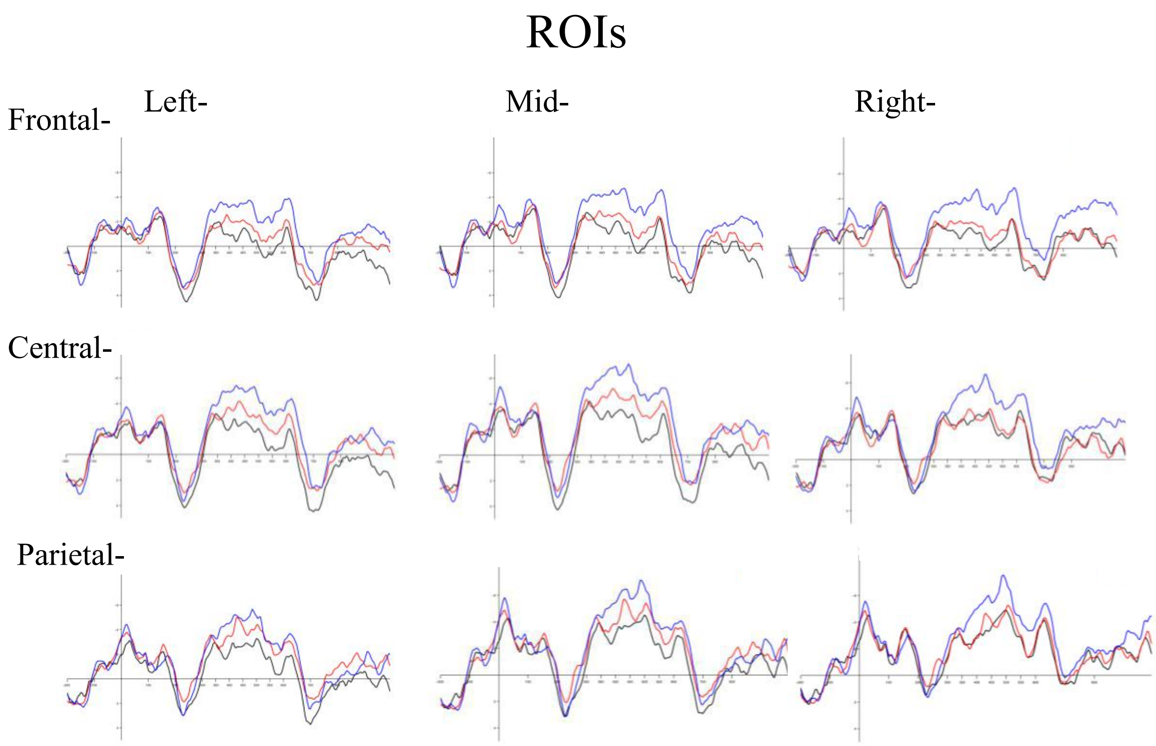


Figure 23: Topographic maps of the differences between the ERP response to the Active Control condition and Active Incongruous for the N400 – P600 time-window. Blue areas indicate negative voltages and red areas indicate positive voltages. Thus the N400 can be seen in blue and the P600 in red.



The bear attacked ***the audacious hiker*** on the trail.
The audacious hiker attacked ***the angry bear*** on the trail.
The bear attacked ***the large battery*** on the trail.

Figure 24[12]: Grand-average ERPs at 36 selected channel locations (6 ROIs) for Active Control DPs (solid black line), Active Role Reversed DPs (red line) and Active Incongruous DPs (blue line). Onset of the critical DPs is indicated by the vertical bar. Each has mark represents 100ms of activity. Positive voltage is plotted down.

With these results three comparisons were made in both the N400 and the P600 time-window – (1) Active Control condition versus Active Incongruous condition; (2) Active Role Reversed condition versus Active Incongruous condition; (3) Active Control condition versus Active Role Reversed condition.

Comparison 1 - Active Control condition versus Active Incongruous condition

1a The bear attacked **the audacious hiker**…
1c The bear attacked **the large battery**...

N400

In the 350 – 550ms window, ANOVAs revealed a statistically meaningful effect of stimulus type, voltages in the Active Incongruous condition (1c) were more negative than

[12] We thank Professor Aline Gesualdi Manhães for the unbounded help with the high-resolution graphs.

those of the Active control (1a), reflected in almost all channels in central and parietal sites: [CZ: $F(2, 13) = p* = .007$; C1: $F(2, 13) = p* = 0.011$; C2: $F(2, 13) = p* = 0.007$; C3: $F(2, 13) = p* = 0.004$; C4: $F(2, 13) = p* = 0.006$; C5: $F(2, 13) = p* = 0.05$; CPZ: $F(2, 13) = p* = 0.013$; CP1: $F(2, 13) = p* = 0.024$; CP2: $F(2, 13) = p* = 0.011$; CP3: $F(2, 13) = p* = 0.027$; CP4: $F(2, 13) = p* = 0.013$; PZ: $F(2, 13) = p* = 0.011$; P1: $F(2, 13) = p* = 0.013$; P3: $F(2, 13) = p* = 0.017$; P4: $F(2, 13) = p* = 0.007$; POZ: $F(2, 13) = p* = 0.044$; PO4: $F(2, 13) = p* = 0.006$; PO6: $F(2, 13) = p* = 0.022$]. Simple effect analysis at midline sites also showed that ERPs to the Active Incongruous condition were more negative than those of the Active control [$F(1, 7) = p* = .01$].

Still in the N400 window, Pairwise comparisons showed that the Active Incongruous condition was more negative than the Active Control (1a), in both central- and parietal channel groups [central-left: $F(1, 7) = p* = .021$; central-mid: $F(1, 7) = p* = .017$; central-right: $F(1, 7) = p* = .013$; [parietal-left: $F(1, 7) = p = .080$; parietal-mid: $F(1, 7) = p* = .026$; parietal-right: $F(1, 7) = p* = .023$]. This effect was left-lateralized, reflected in an interaction between hemispheres (left-right) and sentence-type at the lateral channel groups [$F(1, 7) = p* = .004$].

This widespread statistically significant N400 response in the single electrodes and in the arrangement per ROI (regions of interest) in relation to (1c) was already expected because (1c), in relation to the control, promotes the perfect set up for the large amplitude N400. Thus, according to our predictions (cf. p. 57) comparing the two showed the possibility to eliminate the null hypothesis, meaning that the participants were sensitive to the incongruous endings of the (1c) type. The account we want to advance is that *The bear* is programed to be accessed, via ventral stream, as a loose word and it is kept as such. The reason for this is that its standing in the sentence is dependent upon the semantics of the verb with its internal argument. When the verb appears, it is processed along a dorsal route. This route performs the hierarchical computation to embed the internal argument. Since with (1c) it is an incongruous selection, it elicits the large N400 as the first potential to be seen on parietal and central derivations. This suggests that the N400 appeared without the intervention of the semantics of the subject, that is only taken into sentential account in the next window from 550 – 800ms.

P600

In the 550 – 800ms window, ANOVAs revealed no statistically meaningful effect of stimulus type in any electrode [CZ: $F(2, 13) = p= .39$; CPZ: $F(2, 13) = p= 0.40$; PZ: $F(2, 13) = p= 0.33$] or channel-group of interest [parietal-left: [$F(1, 7) = p= .341$]; parietal-mid: [$F(1, 7) = p= .163$]; central-right: [$F(1, 7) = p= .141$].

In this time window no P600 was expected, and no P600 was found. Our explanation for that is that, in fact, for (1a) and (1c) we have exactly the same subject *the bear,* but with different integration histories. In (1a) there is no P600 because there is no difficulty to integrate *the bear* which had been kept in the memory with *attacked the audacious hiker*. In (1c) there is no attempt to integrate *the bear* because *attacked the battery* is irreconcilable. So, efforts are dropped after the N400 potential. Which does not mean that there won't be extemporaneous integration, between the subject and the verb-argument complex, but that would be out of the studied windows. Nevertheless, it is important to pursue further insight on a few lingering cases. What would be the N400-P600 effect relative to a sentence such as *the termites devoured the dirty tabletops*[13]? In this sentence we would have the N400 effect for the incongruous VP, but it should be possible to save the sentence within the P600 window, and not after it, with the integration of the material previously stored: *the termites.* After all, we readily understand the sentence *the termites devoured the dirty tabletop.* How is this possible, then? For the sake of speculation, that

[13] We thank Professor Letícia Sicuro for bringing up this sentence during the Prelim Exam (*Qualificação*). It provided great food for thought.

should be seriously pursued in further studies, the ventral stream is probably much more likely to be affected by frequency effects than the dorsal stream. Thus, the low frequency and the kind of animacy (animacy of a collective word) of *termites* probably makes it highly salient in the memory (much more than bear), and with this salience instead of simply dropping the material stored after the VP, *devoured the dirty tabletops,* is condemned, there is a felicitous integration that does not yield a P600 because this integration presents no difficulty. If this is the case, there should be a LAN[14] marking the special storing of such word with a peculiar semantics that can only affect a few number of events. Notice that this is not the case of *bear*. Unfortunately this was not a condition in this test and therefore could not be verified.

Comparison 2 - Active Role Reversed condition versus Active Incongruous condition

1b The audacious hiker **attacked** **the angry bear**…
1c The bear **attacked** **the large battery**…

N400

In this comparison, ANOVAs revealed a statistically meaningful effect at specific derivations characteristic of N400; voltages in the Active Incongruous condition (1c) were more negative than those of the Active Role Reversed one (2a) at the midline sites: [CZ: $F(2, 13) = p^{*}= .019$; C6: $F(2, 13) = p^{*}= .032$; C4: $F(2, 13) = p^{*}= .010$; C3: $F(2, 13) = p^{*}= .033$; C2: $F(2, 13) = p^{*}= .023$; C1: $F(2, 13) = p^{*}= .030$]. And there were other marginally meaningful statistical effects at the central-parietal sites [CPZ: $F(2, 13) = p= .096$; CP1:

[14] LAN – Left anterior negativity is in the same window of the N400 but plots a frontal topography. It has been associated with morphosyntactic violations and semantic oddness and atypical lexical senses (FRIEDERICI et al., 2001).

$F(2, 13) = p= .1$; CP2: $F(2, 13) = p= .070$; CP3: $F(2, 13) = p= .078$; CP4: $F(2, 13) = p= .059$;].

Simple effect analysis at central sites also showed that ERPs to the Active Incongruous condition were more negative than those of the Active Role Reversed [$F(1, 7) = p^{*}= .007$], reflected in a statistical difference at all central channel-groups [central-left: [$F(1, 7) = p^{*}= .004$]; central-mid: [$F(1, 7) = p^{*}= .003$]; central-right: [$F(1, 7) = p^{*}= .024$].

The account we want to advance is that, after being accessed via ventral stream the DP *the audacious hiker* and *the bear* are and kept in the memory during the hierarchical processing of the VP in (1b) and (1c).

Our prediction was that in this comparison, in terms of the N400 window, (1b) should be similar to (1a) and therefore different from (1c). This in fact was the finding we obtained. *Attacked the angry bear* is plausible and yielded a low N400 while attacked the *large battery is incongruous* and yielded an N400. On one hand, the N400 of (1c) is excellent to prove the test is sensitive to the major effect of integration between the verb and the internal argument. On the other hand, since (1b) paired with the control (1a), and not with the incongruous (1c), assures us that the event of some agent attacking an *angry bear* is plausible on all counts in the 400 time window. Being congruous in the N400 window this sentence is supposed to continue being checked further in the P600 time window.

P600

In the 550 – 800ms window, there was a P600 statistically meaningful in its overall effect in the parietal sites [$F(2, 13) = p^{*}= .048$]. Moreover, in the single electrode analysis, ANOVAs also revealed a statistically meaningful difference, at some typical derivations of P600 effects (parietal and temporal): [C1: $F(2, 13) = p^{*}= .53$; P03: $F(2, 13) = p^{*}= .03$; T8:

F(2, 13) = *p**= .056] and in some other derivations, this difference was marginally significant [CZ: *F*(2, 13) = *p*= .080; C5: *F*(2, 13) = *p*= .09; P3: *F*(2, 13) = *p*= .09].

This comparison is rather revealing and it casts very interesting hypotheses concerning the P600. The first it is that it is a component that is connected with the N400 in a kind of system. It will mostly happen when there is no N400 or in the few cases when there is an N400 that needs repair (*the termites devoured the table tops*). Secondly, it is that if P600 is really sensitive to the integration of the previously stored subject with the VP, then we can say that the P600 is less local than the N400. It is sensitive to the overall structure of thematic grid, which includes a hierarchy in which the N400 comes first with the perception of the verb-complement fit only, and the P600 comes next with the verification of the distribution of the theta roles. Thus, in this case, the attraction hypothesis could not hold because at the 400ms time window no modulation could be sensed, meaning that right after the presentation of the object (but also after the subject had been already presented) the ERP responded similarly to that of the control condition. Only in the advent of a hierarchy that could assign preference to the object-complement computation could this result be attained. A complement that was sensed as congruous at 400ms may later, at 600ms affect the perception of the theme assigned to the subject only if it was blind to its semantics all the way prior to the integration of the complement. This ultimately means that there is subject computation being held after that of the complement, that is: P600 is sensitive to the order or hierarchy of the thematic chain. The simple semantic attraction between the roots of the verb and its arguments could explain our results.

Comparison 3 - Active Control condition versus Active Role Reversed condition

1a The bear **attacked the audacious hiker**…
1b The audacious hiker **attacked** **the angry bear**…

N400

No statistically reliable differences were observed in the N400 time-window in this comparison, at any electrode [CZ: *F*(2, 13) = *p*= .99; CPZ: *F*(2, 13) = *p*= .99; PZ: *F*(2, 13) = *p*= .96] or channel-groups of interest [central-left: [*F*(1, 7) = *p*= .137]; central-mid: [*F*(1, 7) = *p*= .131]; central-right: [*F*(1, 7) = *p*= .875].

Attacked the angry bear is sensed as a congruous event. Thus, sentences of the (1b) type, were sensed as congruous in this first time window and therefore more similar to (1a) than to (1c).

P600

In the P600 time-window, ANOVAs revealed a statistically meaningful overall effect of stimulus type in the parietal sites [*F*(2, 13) = *p**= .030] and ANOVAs revealed a statistically meaningful difference between the Control condition (1a) and the Role Reversed condition (1b) at some typical derivations of P600 effects (parietal and temporal): [C3: *F*(2, 13) = *p**= .057; P3: *F*(2, 13) = *p**= 0.059; P05: *F*(2, 13) = *p**= 0.04].

As it can be seen in the 600 ms time window, there is a statistically meaningful difference, setting a more profoundly positive ERP for (1b) than for (1a). As much as *attacked the angry bear* does not entail an N400, when *the hiker* is integrated as the subject, it turns the overall meaning of the sentence to an unreliable semantic path. The difficulty in the syntactic integration of the external arguments yields the P600. Notice that Kim & Osterhout (2005) found a P600 in a similar situation:

(xxiv) The hungry boy was devouring the cookies
(xxv) The hearty meal was devouring the kids

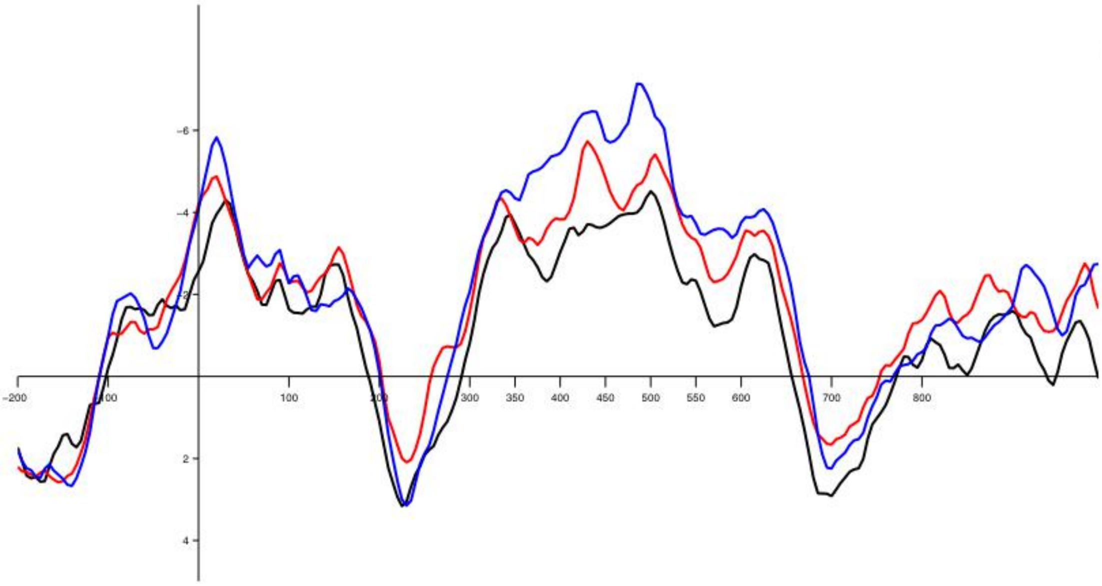
Nevertheless, the explanation provided by the authors was the Attraction Theory. Since there is strong attraction between *hearty meal* and *devouring* there is no N400 and the way to fix the sentence would be through syntax. For them, syntax is to blame and therefore the perceiver operates a syntactic maneuver that turns the active sentence into passive:

(xxv') The hearty meal was devoured by the kids.

We believe that a better explanation for their finding would be a modulation of animacy. It is also odd that no N400 was found in the VP *devouring the kids,* which is not exactly incongruous, but it is too marked as a semantic idea. On an earlier ERP experiment on semantic priming effects in Portuguese (Gomes, 2009), there was an N400 in relation to the word *slip* (*cueca*) as it was too salient in relation to the other stimuli.

These three comparisons can be visually inspected in Figure 25 and 26 below:

Central-Mid ROI



The bear attacked ***the audacious hiker*** on the trail.
The audacious hiker attacked ***the angry bear*** on the trail.
The bear attacked ***the large battery*** on the trail.

Figure 25: Central-mid ROI comparing Active Control condition (black line), Active Role Reversed condition (red line) and Active Anomalous condition (blue line). Each has mark represents 100ms of activity. Positive voltage is plotted down.

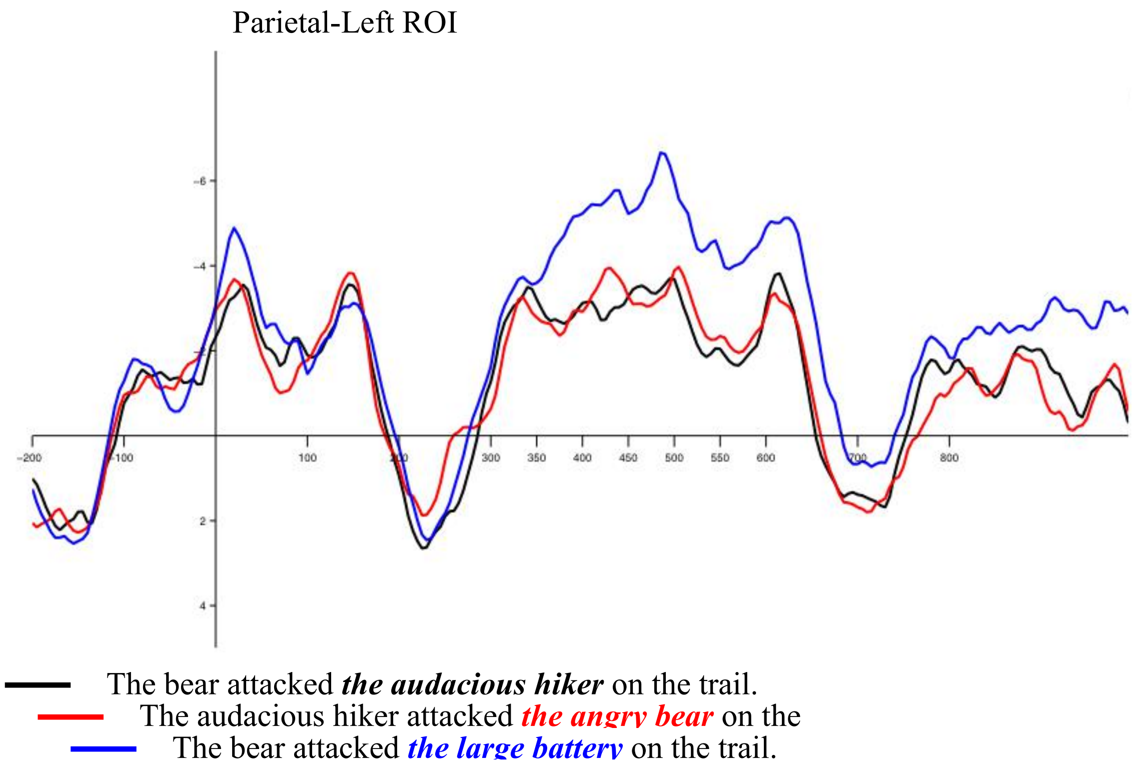


Figure 26: Parietal-left ROI comparing Active Control condition (black line), Active Role Reversed condition (red line) and Active Anomalous condition (blue line). Each has mark represents 100ms of activity. Positive voltage is plotted down.

6. THE ERP EXPERIMENT 2: PASSIVE VOICE

Granted the results of Experiment 1, the aim of Experiment 2 was to continue on the investigation about the role reversed sentence, adding to it an additional complexity, the passive structure, in which there is an inversion that upsets the canonical expectation for SVO order. Since heuristics does not help in this case, then it is either attraction or hierarchy functioning as a guiding line. In this experiment, we measured ERPs to critical words in a three condition paradigm with sentences in the Passive Voice.

6.1 Methods

We recorded ERPs to critical words while participants read sentences of three different conditions in the Passive Voice. As in the first experiment, we contrasted three groups of English sentences: grammatically well-formed sentences (e.g. the audacious hiker was attacked by the bear), role-reversed grammatically well-formed sentences (e.g. the angry bear was attacked by the audacious hiker) and incongruous sentences (e.g. the large battery was attacked by the bear).

The 'thematic grid' and the plausibility rates were the independent variables in this experiment, and the subject response times, error rates and the ERPs were the dependent variables.

6.2 Participants

A total of 15 paid subjects (6 males) undergraduates from the Colorado University at Boulder, took part in the second experiment. Participants aged 17-35 (mean: 24.8). All participants were right-handed. Selection criteria required all participants to have normal or corrected-to-normal vision and to be native speakers of American English. A written consent form was also obtained from all subjects before participation.

6.3 Stimuli

In Experiment 2, stimuli were in the Passive voice. During the processing of passive sentences, such as *the angry bear was attacked*, the verb complement, *the angry bear*, is the first to be read, so it is possible that the reader believed that the subject was the agent. But as soon the verb structure of the passive came in, the reader could understand that the subject took on the *patient* role of the main verb.

Experiment 2 had the stimulus set divided into three experimental conditions. Each stimulus exemplar consisted of the following sequence: a determiner phrase, as the subject and patient (e.g., the audacious hiker), a critical passive voice structure (e.g., was attacked), a prepositional phrase with the agent of the passive (e.g., by the bear) and post-verbal material (e.g., on the trail). The trigger was set right at the onset of the verb structure. Examples of these types of stimuli are shown in Table 6.

TABLE 6 –Experiment 2: Passive Conditions

2. Passive Conditions	Stimuli Examples
2a. Control	***The audacious hiker*** **was attacked** by the bear on the trail. ***The cuddly chimpanzee*** **was fed** by the zookeeper with love.
2b. Role Reversed	***The angry bear*** **was attacked** by the audacious hiker on the trail. ***The sad zookeeper*** **was fed** by the cuddly chimpanzee with love.
2c. Incongruous	***The large battery*** **was attacked** by the bear on the trail. ***The stinky bathroom*** **was fed** by the zookeeper with love.

Condition (2a), stimuli were congruous and functioned as the control condition. Condition (2b) was the role reversed one and (2c) the incongruous.

As in Experiment 1, Condition (2a) was the most plausible version of the stimuli set, having a well-formed and highly plausible predicate-argument combination, *hiker* -

attacked- by bear. In (2a), the DP in the subject position could be a good patient to a great number of agents, since there is a vast number of animate beings that could attack a hiker. This resulted in highly plausible passive-voice sentences, with the verb felicitous assignment of the patient role to the subject and the agent role introduced by the prepositional phrase.

Condition (2b) is the role reversed condition. In order to create the stimuli in this condition, the agent and the theme arguments were switched: the theme in (2a) became the agent in (2b) and vice-versa, so then, the roles were reversed. The role reversed sentences were created with plausible predicate-argument combination; *bear* can be a plausible theme to the verb *attack*, but not a highly frequent one.

As for the third condition, (2c), the combination between predicate and its internal argument is not plausible, *battery–attack*, making (2c) the incongruous condition and the typical setup for the N400 effect (Kutas & Hillyard, 1908, 1984; Osterhout &Nicol, 1999; França *et al*, 2004)

In the Role Reversed condition, (2b), readers are expecting *the angry bear* to be an agent. As the sentence is processed the passive voice structure appears - *was attacked* - and the readers realize that *the angry bear* is in fact, the theme of *attack* and not a very common one since there are not so many agents to attack such a theme. Our aim was to assess if (2b) would be processed in a more similar way to the Control condition, (2a), or to the Incongruous condition, (2c), and why.

If (2b) ended up being more similar to (2c), which is an incongruous sentence, that would mean that the semantic information entailed by the subject would be very present right from the first moment, while processing the sentence. That's because (2b) is only implausible if the semantic features of the agent are taken into consideration. The event of *a bear being attacked* is plausible, but one can observe that *a hiker* is not a very plausible agent for it. On the other hand, *a large battery* is not a plausible subject of an *attack*. Since right in the beginning of the sentence processing, the subject of (2b) is a plausible one and the subject of (2c) is not (an angry bear can be attacked by some beings but a large battery cannot) then, if (2b) is more similar to (2c) than to (2a) (Control condition), it means that the information given by the subject is integrated immediately as processing starts.

Contrastingly, if (2b) ended up being more similar to (2a), which is the congruous condition, that would mean that the semantic information entailed by the subject would not be present right from the start, while processing this sentence. Remember that the integration between the verb and its complement (passive subject) is still plausible in (2b): there are beings that may attack a bear, although they are just a few.

Experiment 2, also had a total of 243 sentences and 261 fillers across three lists. Each list had 81 experimental items and 87 fillers of three types, control (i.e., the cats won't eat), syntactically anomalous (i.e., the cats won't eats) and semantically anomalous (i.e., the cats won't bake). Fillers were extracted from Osterhout & Nicol (1999).

Stimuli were pseudo-randomly ordered, subject to the following constraints: (1) experiment stimuli were separated by at least one filler; (2) each third of the list contained between 10 and 12 targets of each type.

The 81 stimulus exemplars in each list were created varying two types of closures, each for half of the stimuli: 50% of prepositional phrases (e.g., …on the trail) and 50% of adverbial phrases (e.g., …rapidly). This manipulation followed the critical segment, and therefore did not directly affect the processing response on a given trial. Its purpose was to reduce the habituation effect in our experiment and to make it hard for the subjects to recognize the experimental conditions. Thus, eliminating regularities, it would not allow participants to, implicitly or explicitly, get biased towards one particular way.

6.4 Procedures

All procedures were the same as in Experiment 1. Except for the sentence presentation that can be seen in Figure 27.

Figure 27: The experimental setting

Sentences were presented on a computer screen. Each sentence was presented phrase by phrase.

Figure 28: Sentence Presentation Experiment 2, Passive Voice.

The presentation began with a fixation cross at the center of the screen for 700ms, followed by a blank screen of 125ms. Then each phrase was presented for 280ms plus a jitter of 20ms/character. The verb was presented for 250ms followed by a 140ms of a blank screen. A 100ms blank screen was presented after the very last word of each sentence. A response screen, in which the words normal and not normal could be read, stayed on until the subject made his/her judgment by pressing one of two buttons according to the desired answer. After each trial a 1000ms blank screen was on till the next trial.

The subject's task was to decide whether or not each sentence was a normal sentence in American English or a not normal one. The subject's decision was done by pressing one of two buttons on a response box, which were counter-balanced (left and right) across participants As training, each subject was given 15 trials at the start of the experiment.

6.5 Data Acquisition and analysis

Data acquisition and analysis were the same as in Experiment 1, except that the stimulus-type variable had the two levels: passive control, passive role reversed and passive incongruous.

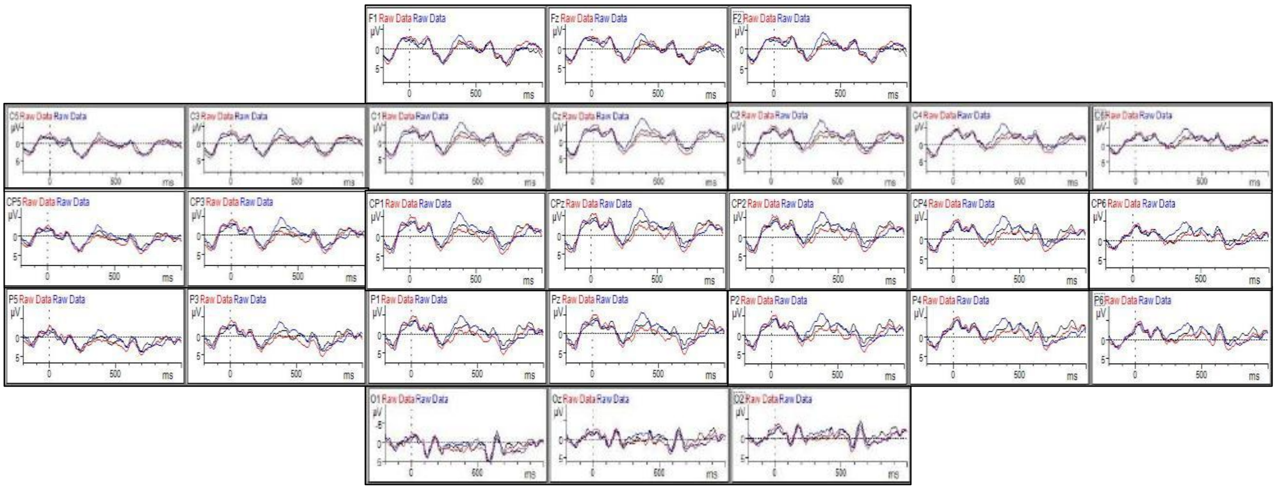
6.6 Results

6.7 Acceptability judgments

Participants judged the stimuli to be acceptable at the following rates: Role Reversed condition, 3%; Incongruous, 6%; syntactically or semantically anomalous fillers, 5%; and well-formed, plausible stimuli (Passive Control or fillers), 97%. For all of the stimuli together, participants agreed with the intended acceptability judgments at a mean rate of 96%, with individual participants ranging from 83 to 99%.

6.8 ERPs

The grand average, Figure 16, shows ERPs to Passive Control condition (2a), Passive Role Reversed condition (2b) and Passive Incongruous condition (2c). Sentence verbs in all conditions elicited the pattern characteristic of ERPs to visual stimuli, such as an initial positivity (P1) peaking at about 80ms, followed by a negativity (N1) at 170ms. These responses were followed by a centro-posterior negativity between about 300ms and 500ms (N400). After the 400ms, the ERPs in all conditions became more positive again (P600).



***The hiker* was attacked** by the bear on the trail.

***The angry bear* was attacked** by the audacious hiker on the trail.

***The large battery* was attacked** by the bear on the trail.

Figure 29: Grand-average ERPs recorded at five midline sites and five medial–lateral sites to Passive Control DPs (solid black line), Passive Role Reversed DPs (red line) and Passive Incongruous DPs (blue line). Onset of the critical DPs is indicated by the vertical bar. Each has mark represents 100ms of activity. Positive voltage is plotted down.

As we can see in Figure 29, the Passive Incongruous condition (blue line) was dominated by N400 responses. The comparison between the Passive Control condition (black line) and Role Reversed one (red line) didn't behave the same way in the overall channels. In the P600 time-window, the comparison between the Control condition (black line) and the Role Reversed condition (red line) was more positive in the posterior sites, than the comparison between Control and Incongruous condition (blue line).

Topographic maps are shown in Fig. 30 and 31. Fig. 30 shows the difference between Passive Control condition and the Passive Role Reversed condition in the N400 and P600 time-windows. Fig. 31 shows the difference between Passive Control condition and the Passive Incongruous condition also in the N400 and P600 time-windows.

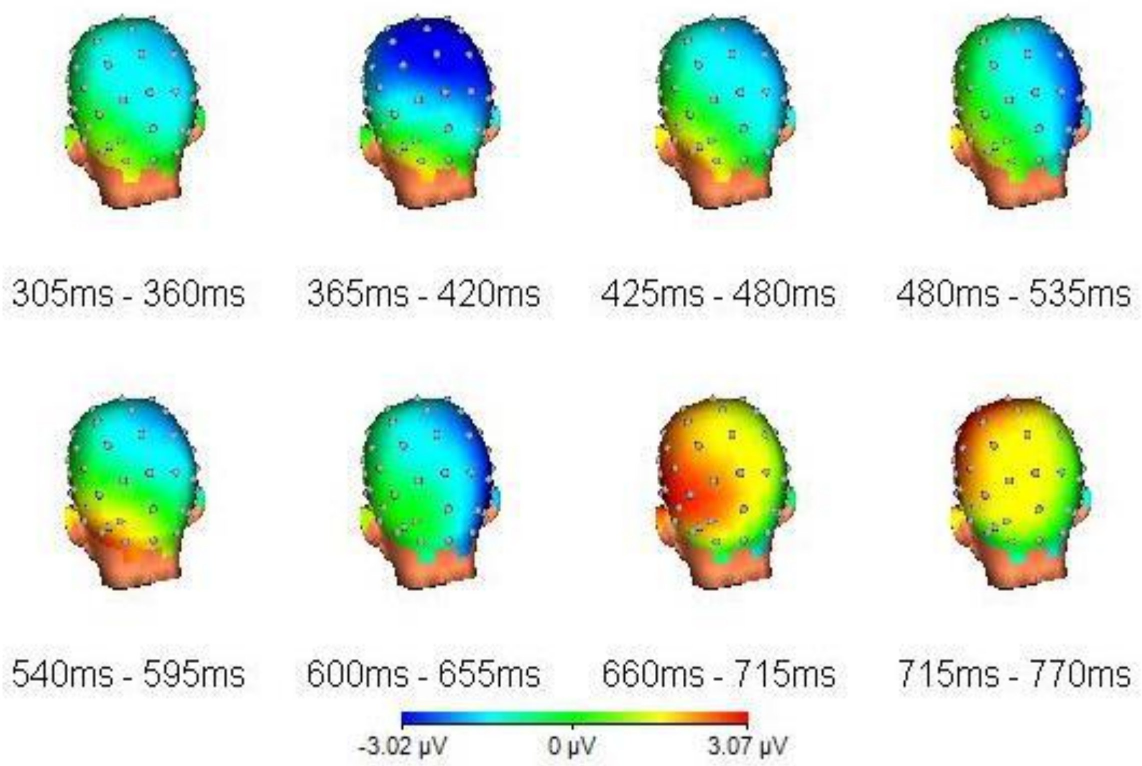


Figure 30: Topographic maps of the differences between the ERP response to the Passive Control condition and Passive Role Reversed condition.

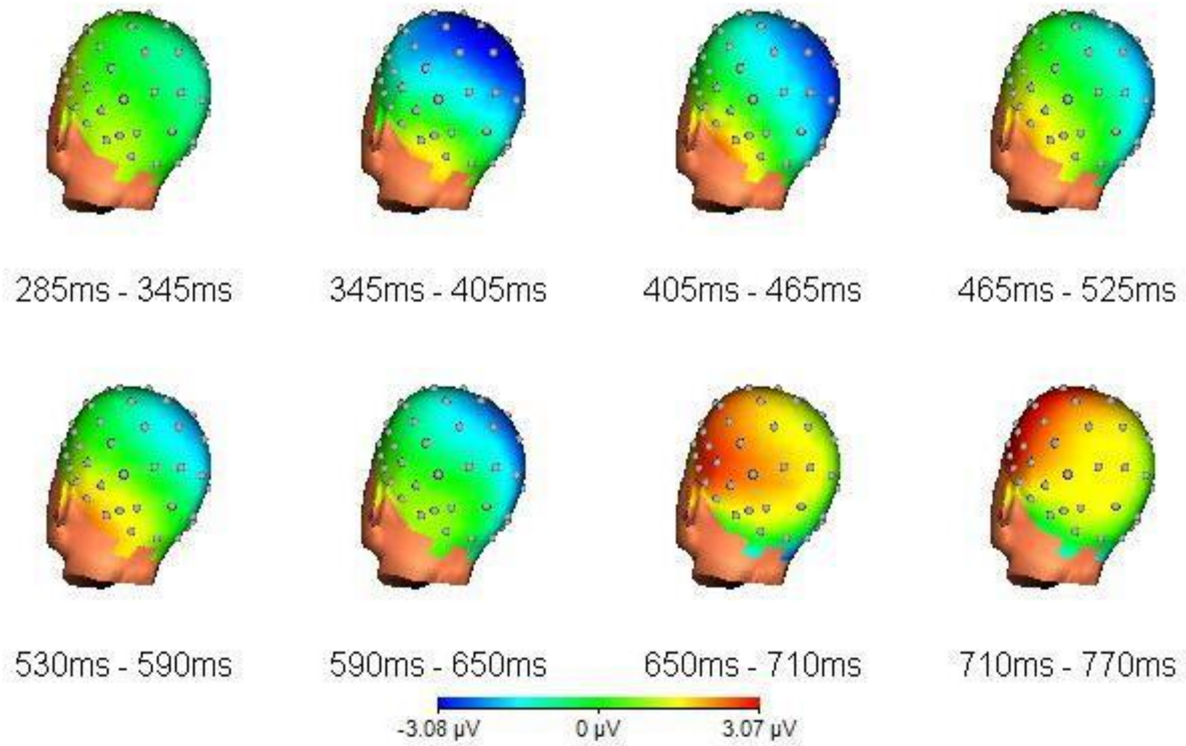


Figure 31: Topographic maps of the differences between the ERP response to the Passive Control condition and Passive Incongruous for the N400 – P600 time-window. Blue areas indicate negative voltages and red areas indicate positive voltages.

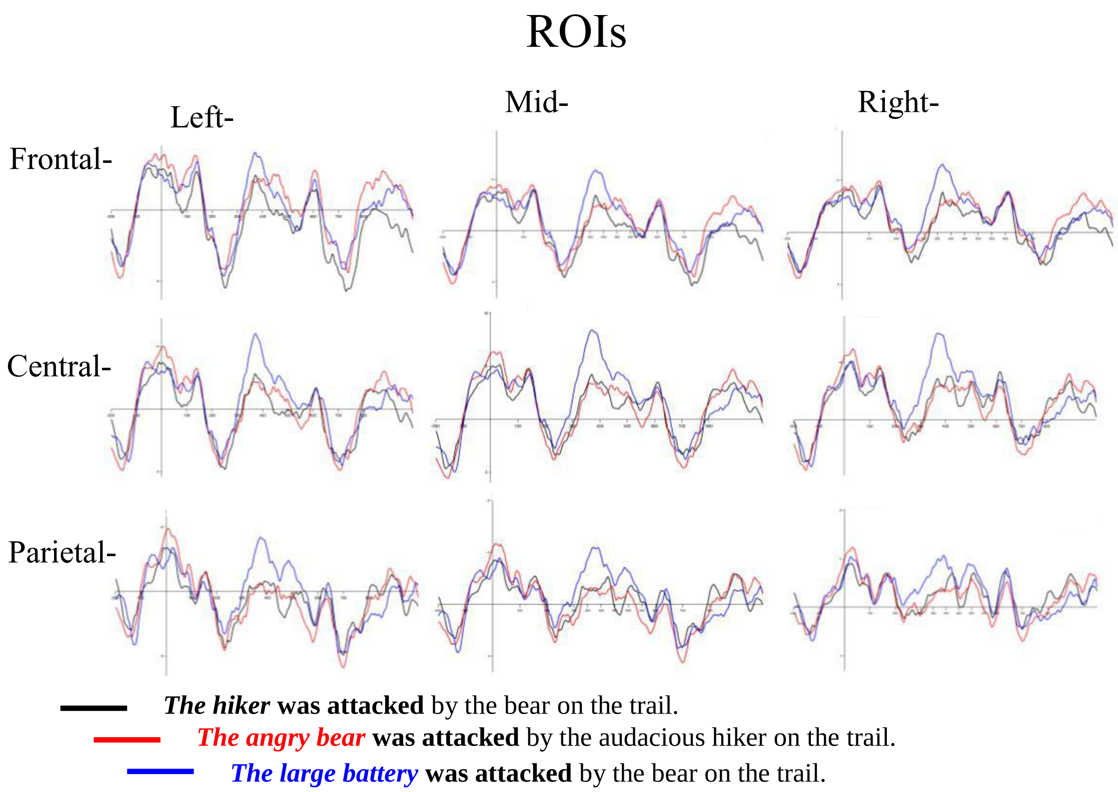


Figure 32: Grand-average ERPs at 36 selected channel locations (6 ROIs) for Passive Control verb (solid black line), Passive Role Reversed verb (red line) and Passive Incongruous verb (blue line). Onset of the critical verb is indicated by the vertical bar. Each has mark represents 100ms of activity. Positive voltage is plotted down.

In order to summarize our findings, 3 comparisons were made in both the N400 and the P600 time-window – (1) Passive Control condition versus Passive Incongruous condition; (2) Passive Role Reversed condition versus Passive Incongruous condition; (3) Passive Control condition versus Passive Role Reversed condition.

Comparison 1 - Passive Control condition versus Passive Incongruous condition

2a **The audacious hiker was attacked** by the bear…
2c **The large battery** **was attacked** by the bear…

N400

In the 350 – 550ms window, ANOVAs revealed a statistically meaningful effect of stimulus type, voltages in the Passive Incongruous condition (2c) were more negative than those of the Passive control (2a), reflected in almost all channels in central and parietal sites: [CZ: $F(2, 13) = p^{*}= .000$; C1: $F(2, 13) = p^{*}= 0.003$; C2: $F(2, 13) = p^{*}= 0.011$; C3: $F(2, 13) = p^{*}= 0.013$; C4: $F(2, 13) = p^{*}= 0.010$; C5: $F(2, 13) = p^{*}= 0.048$; CPZ: $F(2, 13) = p^{*}= 0.002$; CP1: $F(2, 13) = p^{*}= 0.003$; CP2: $F(2, 13) = p^{*}= 0.001$; CP3: $F(2, 13) = p^{*}= 0.004$; CP4: $F(2, 13) = p^{*}= 0.006$; PZ: $F(2, 13) = p^{*}= 0.005$; P1: $F(2, 13) = p^{*}= 0.008$; P1: $F(2, 13) = p^{*}= 0.008$; P3: $F(2, 13) = p^{*}= 0.003$; P4: $F(2, 13) = p^{*}= 0.037$; POZ: $F(2, 13) = p^{*}= 0.008$; PO5: $F(2, 13) = p^{*}= 0.005$; PO6: $F(2, 13) = p^{*}= 0.043$].

Simple effect analysis at midline sites also showed that ERPs to the Passive Incongruous were more negative than those to the Passive Controls [$F(1, 7) = p^{*}= .011$].

Still in the N400 window, Pairwise comparisons showed that the Passive Incongruous condition (2c) was more negative than the Passive control (2a), in both central- and parietal channel groups [central-left: $F(1, 7) = p^{*}= .002$; central-mid: $F(1, 7) = p^{*}= .000$; central-right: $F(1, 7) = p^{*}= .001$; [parietal-left: $F(1, 7) = p= .001$; parietal-mid: $F(1, 7) = p^{*}= .001$; parietal-right: $F(1, 7) = p^{*}= .016$]. This effect was left-lateralized, reflected in an interaction between hemispheres (left-right) and sentence-type at the lateral channel groups [$F(1, 7) = p^*= .011$].

The results in this comparison were already expected, because (2c) is the perfect set up for the large amplitude N400 and (2a) is the control condition that usually yields a small amplitude wave. Thus comparing the two showed the possibility to eliminate the null hypothesis, that is an N400 for (2c). This is exactly the same result as we got for Comparison 1 of the active voice, despite the fact that there is some difference in the shape of the ERPs. According to the account we propose, what will be stored is *the battery.* It will be accessed, via ventral stream, as a loose word and it kept as such. The reason for this is that its standing in the sentence still depends upon the verb. When the verb comes, and with it the morphology of the passive, then integration has to be performed immediately. In fact, the shape of the ERP in the passive shows that the processing of the incongruous word vis-à-vis the verb is done at once. In the active voice the internal argument comes next. In the passive, the internal argument was already presented when the verb calls for it. The ERP in the passive has a protruding peak in contrast with the plateau of the active voice. Now the agent of the passive will come in the next window from 550 – 800ms.

P600

In the 550 – 800ms window, ANOVAs revealed no statistically meaningful effect of stimulus type neither in one electrodes sites [CPZ: $F(2, 13) = p= .93$; PZ: $F(2, 13) = p= 0.83$; POZ: $F(2, 13) = p= 0.76$] nor in channel-groups of interest [parietal-left: [$F(1, 7) = p= .952$]; parietal-mid: [$F(1, 7) = p= .764$]; parietal-right: [$F(1, 7) = p= .633$].

This result was predictable. As for the P600 time-window, since there's no syntactic violation within this condition, these stimuli are syntactically well-formed, no P600 was expected.

In (2c) there is no attempt to integrate *by the bear* because *the battery was attacked* is irreconcilable. So, efforts are dropped after the N400 potential. This does not mean that there won't be extemporaneous integration, between the agent of the passive and the verb-argument complex, but that would be out of the studied windows. Nevertheless, again it is important to pursue further insight on a few lingering cases. What would be the N400-P600 effect relative to a sentence such as *the dirty tabletops were devoured by the termites*? In this sentence we would have the N400 effect for the incongruous VP (*the dirty tabletops were devoured),* but it should be possible to save the sentence within the P600 window still in the syntax processing of the sentence, with the integration of the PP: *by the termites.* After all, we readily understand the sentence *The dirty tabletops were devoured by the termites.* How is this possible, then? For the sake of speculation, that should be seriously pursued in further studies, the dorsal stream is probably less likely to be affected by frequency effects than the ventral stream. Thus, the low frequency and the kind of animacy modulation (animacy of a collective word) of *termites* would probably make the P600 less salient than that of the corresponding active sentence.

Comparison 2 - Passive Role Reversed condition versus Passive Incongruous condition

2b **The angry bear** **was attacked** by the audacious hiker…
2c **The large battery** **was attacked** by the bear…

N400

This comparison revealed a statistically meaningful effect of stimulus type, voltages in the Passive Incongruous condition (2c) were more negative than those of the Passive Role Reversed condition (2b), reflected in almost all channels in central and parietal sites: [CZ: $F(2, 13) = p^{*}= .007$; C1: $F(2, 13) = p^{*}= 0.023$; C2: $F(2, 13) = p^{*}= 0.056$; C4: $F(2, 13) = p^{*}= 0.040$; CPZ: $F(2, 13) = p^{*}= 0.007$; CP1: $F(2, 13) = p^{*}= 0.010$; CP2: $F(2, 13) =$

p*= 0.003; CP3: $F(2, 13)$ = p*= 0.029; CP4: $F(2, 13)$ = p*= 0.008; CP5: $F(2, 13)$ = p*= 0.023; CP6: $F(2, 13)$ = p*= 0.026; PZ: $F(2, 13)$ = p*= 0.006; P1: $F(2, 13)$ = p*= 0.005; P2: $F(2, 13)$ = p*= 0.004; P3: $F(2, 13)$ = p*= 0.007; P4: $F(2, 13)$ = p*= 0.030; P5: $F(2, 13)$ = p*= 0.017; POZ: $F(2, 13)$ = p*= 0.001; PO3: $F(2, 13)$ = p*= 0.004; PO4: $F(2, 13)$ = p*= 0.009; PO5: $F(2, 13)$ = p*= 0.010; PO6: $F(2, 13)$ = p*= 0.002].

Simple effect analysis at midline sites also showed that ERPs to the Passive Incongruous were more negative than those to the Passive Role Reversed [$F(1, 7)$ = p*= .011].

Still in the N400 window, Pairwise comparisons showed that the Passive Incongruous condition (2c) was more negative than the Passive Role Reversed (2b), in both central- and parietal channel groups [central-left: $F(1, 7)$ = p*= .062; central-mid: $F(1, 7)$ = p*= .020; central-right: $F(1, 7)$ = p*= .024; [parietal-left: $F(1, 7)$ = p= .014; parietal-mid: $F(1, 7)$ = p*= .007; parietal-right: $F(1, 7)$ = p*= .021].

This comparison was the main concern of this experiment. On one hand, (2c) is the perfect set up for the large amplitude N400. On the other, (2b) could be either more similar to (2a) or to (2c), in other words could be felt as congruous or incongruous. The experiment results indicate that (2b) is statistically different from (2c), meaning that stimuli in (2b) were not perceived as semantically incongruous. This result is consistent with our account, in which larger amplitude N400 is associated with semantically anomalous stimuli selected by the verb.

P600

Differently from the active condition, this comparison revealed only a marginal statistically meaningful effect of stimulus type [P8: $F(2, 13)$ = p= .10; PO4: $F(2, 13)$ = p= .10].

This was probably our most expressive result, because it means that the exactly same word is sensed differently when it comes wrapped in the passive structure. The agent of the passive in this case is introduced by a PP at the end of the sentence and it yields a much weaker P600, but it is still present is some derivations, as it can be seen in the Figure below:

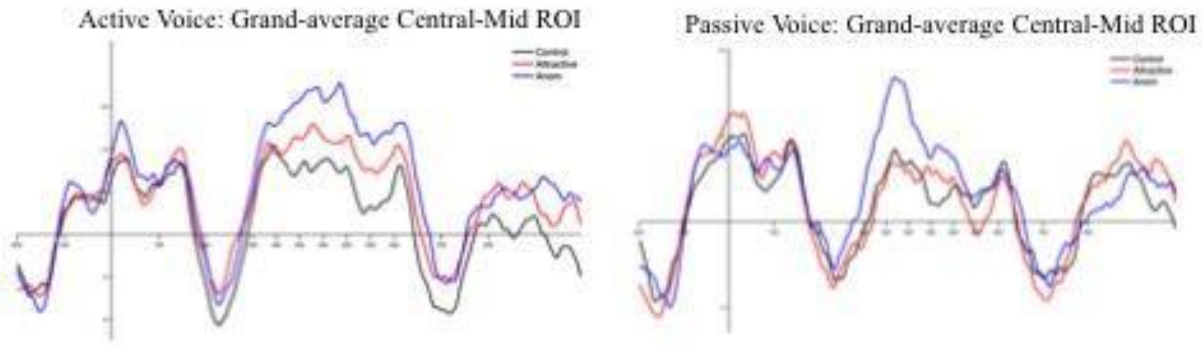


Figure 33: Grand-average ERPs comparing the Active conditions and the Passive conditions in a window from -200ms to 1000ms. Onset of the critical word is indicated by the vertical bar. Each has mark represents 100ms of activity. Positive voltage is plotted down.

Comparison 3 - Passive Control condition versus Passive Role Reversed condition

2a **The audacious hiker was attacked** by the bear…
2b **The angry bear was attacked** by the audacious hiker…

N400

Another way to check how (2b) would fare in comparison with the congruous condition would be if the comparison between them both resulted in an ERP, that has a low amplitude, meaning that there is no difference between them. In fact, that was exactly what we found. No statistically reliable differences were observed in the N400 time-window in this comparison, neither in one electrode [CZ: $F(2, 13) = p^{*}= .92$; CPZ: $F(2, 13) = p^{*}= .90$; PZ: $F(2, 13) = p^{*}= .80$; POZ $F(2, 13) = p^{*}= .72$], nor in channel-groups of interest [central-left: [$F(1, 7) = p= .619$; central-mid: [$F(1, 7) = p= .953$]; central-right: [$F(1, 7) =$

p= .890]. Thus, (2b) was sensed as a congruous sentence like its active counterpart. This result suggests that the N400 amplitudes are not sensitive to reversed thematic role.

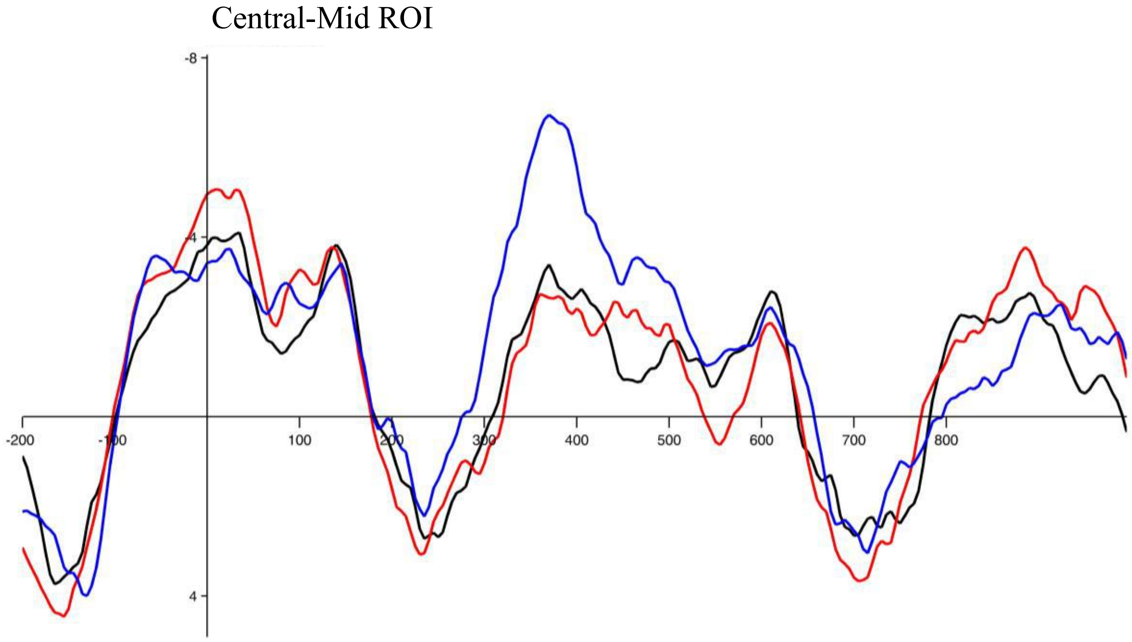
P600

In the P600 time-window, ANOVAs revealed a statistically meaningful effect of stimulus type [P4: $F(2, 13)$ = p*= .030; PO4: $F(2, 13)$ = p*= 0.030; P06: $F(2, 13)$ = p*= 0.045]. As said before, (2b) could be felt as more similar to (2a) or to (2c), as for this result the Role Reversed condition (2b) was not felt as congruous (control), but instead there is a statistical difference in the amplitude P600. Thus comparing the two showed the possibility to verify the sensitivity of the P600 to thematic role reversed sentences.

Looked in the perspective of the N400 findings, in which (2b) and (2c) were different, that is, (2b) was considered congruous at 400ms, this P600 finding means that (2b) turned worse after the VP when the agent of the passive was computed and integrated. Then, in terms of the P600, (2b) – the role reversed condition - is in the middle of the way between the congruous and the incongruous. So the effect should be also viewed as an N400-P600 compound marking the unsettling overall meaning of having a man attack a bear.

Our results suggest that, in the perspective of the N400, stimuli in (2b) are not sensed as semantically incongruous sentences, neither were they perceived as syntactically congruous, as there was statistically meaningful difference between stimuli in (2b) and those in the Control condition, (2a) in the perspective of the P600 effect (see Comparison *vi*). Thus, the Role Reversed stimuli were perceived to be in the middle between a semantic incongruous stimuli and a syntactically well-formed one. Here again the agent of the passive in this case introduced by a PP at the end of the sentence yields a weaker P600 in less derivations than in the active, but it is still present is some derivations.

These three comparisons can be visually inspected in the figure below:



***The hiker* was attacked** by the bear on the trail.

***The angry bear* was attacked** by the audacious hiker on the trail.

***The large battery* was attacked** by the bear on the trail.

Figure 34: Central-Mid ROI comparing Passive Control condition (black line), Passive Role Reversed condition (red line) and Passive Anomalous condition (blue line). Each has mark represents 100ms of activity. Positive voltage is plotted down.

7. CONCLUSION AND FUTURE PERSPECTIVES

This work revolved around some of the most debated topics in Linguistics and Psycholinguistics. It is essential to crack the code of sentence processing as a way to tap into how the human species thinks, speaks and perceives language.

The many years of deduction and introspective Linguistics showed some interesting theoretical possibilities that were discussed in this thesis. The fact that the surface linguistic data always prove to be unsatisfactory to explain all that can be transmitted and analyzed as linguistic discrete categories or primitives, imposes the need for experimental work to capture different aspects of linguistic behavior and physiology.

Most models agree that there is some kind of surface reading boot-strapping sentence processing, namely the Good Enough Theory, Read twice to understand once, Attraction Models, Semantic Illusion and Monitoring Models.

The majority of the tests that such models use explore role-reversed sentences in the passive voice, and often use animacy as a dependent variable. Contrary to this, we prepared stimuli in both active and passive voices, using role-reversed and canonical role sentences. We eliminated animacy as a condition to avoid this confound.

This thesis stated as its general objective that of testing the harder version of the syntax-first account to contribute with cognitive facts in the search for the most suitable language architecture for sentence processing, in view of neuroscience of language alternatives that were presented in Chapter 2. Its specific objective was to put together two experiments using role-reversed stimuli whose results could be clearly compared with those of the competing theories, adding some light to a rather obtrusive literature.

When compared to the Good Enough explanations to the Semantic Illusion sentences, the approach followed here seems more plausible because of the reliance of the Good Enough solely on the attraction properties. This would not explain the different processing between active and passive sentences, such as “the hiker attacked the bear” or “the bear was attacked by the hiker”, since the semantics of both displays borderline possibilities for the agent to be the theme and vice-versa. Our theory, that does not rely on attraction, found different neurophysiological responses to sentences in the passive and in the active.

As to the monitoring theories, the belief is that whenever the participant encounters an unexpected linguistic event, the brain re-attends the unexpected unit to check upon its veridicality. In their model, the algorithmic stream arrives at a sentence interpretation that is always in line with its syntactic structure, step by step, top-down, bottom-up. Thus, the *Monitoring Theory* encompasses syntactic theoretical engines that combine instances of top-down monitoring with bottom-up algorithms interspersed (VISSERS; CHWILLA; KOLK, 2007; YE; ZHOU, 2009). Following their predictions, in the sentence “the hiker attacked the bear”, because the subject for this theory is integrated semantically at the spot, it would not be possible to reach the end of the computation without an N400 indicating the difficulty in semantic integration. Nevertheless, contrary to the Monitoring predictions, the present study only found a P600 in relation to that sentence, and we can provide an explanation based on the fact that there is no immediate integration of the subject. The difficulty in integrating the subject happens towards the end of the sentence, in the P600 time window.

Another theory that investigated Semantic Illusion sentences was proposed by Kuperberg and colleagues. With sentences like “for breakfast, the eggs would eat toast and jam”, these authors purport a P600 effect attributed to sentences with animacy violation in which the verb assigns the wrong thematic role to their arguments: “eggs” as the agent of “eat”. They believe that the P600 has to do with the wrong theta role assignment. Nevertheless, this study has a confound since the animacy violation overlaps with the wrong theta assignment. Therefore testing sentences without animacy violations, the present study could isolate the variables and verify that the P600 was disconnected with the animacy violation and was in fact due to the integration of the subject.

Following another reasoning that relies heavily on the attraction approach, Kim & Osterhout presented a work that is the one that bears the closest connection with the present thesis. Nevertheless, their sentences were in the middle of the way, were ambiguous between being passive or active (the hearty meal was devouring). A possible criticism is that the effect cannot be readily attributed to a perception of the passive or of the active, since the sentence's illusion could make the interpreter fall to either sides. In this thesis, two groups of sentences were tested in isolation: one passive and one active and the results do not favor the attraction model. Another difference between this current study and that of Kim, Osterhout (2005) was the stimulus onset asynchrony (SOA). In our study we worked with a tight SOA so that we could capture the most automatic effect. We also controlled for the animacy variables.

Having established the differences between the present study and those of the literature, to conclude it is necessary to review the study presented in this present work. We set off by trying to reestablish a direct correspondence between syntax-first models and the actual sentence processing. This attempt had already been pursued in the linguistic tradition purported by the DTC (derivational theory of complexity), presented in Chapter 2, typical of the early psycholinguistic studies. DTC sought to determine a correlation between the psychological complexity of sentences and their required computational steps. This attempt was set aside after some investigations of DTC have proven equivocal. Nevertheless, some linguistic theories were advanced in the same spirit of DTC's general methodology. For instance, the Distributed Morphology Model, whose main author, Alec Marantz affirms that "linguists really have no choice but to embrace the derivational theory of complexity, since it's essentially just a name for standard methodology in cognitive science and cognitive neuroscience. All other things being equal, the more complex a representation – the longer and more complex the linguistic computations necessary to generate the representation – the longer it should take for a subject to perform any task involving the representation and the more activity should be observed in the subject's brain in areas associated with creating or accessing the representation and with performing the task (MARANTZ, 2005:17)."

As presented in Chapter 2, the Distributed Morphology advances a series of short syntactic phases that provide an intimate relationship between the computational algorithm and the interfaces. We believe that this is an elegant solution to account for the efficiency of sentence processing, specially for the ones required in tricky language processing such as in the semantic illusion paradigm.

Moreover, we sought for other intimate correlations between linguistic theory and processing by reviewing, also in Chapter 2, new brain image findings, using fMRI-DTI (Diffuse Tensor Imaging). This is a new technique that was able to depict two processing routes – a ventral and a dorsal – respectively for loose words and coordination, and another for hierarchical structures.

Drawing from a theoretical basis on Distributed Morphology, specially in its short phases, pairing minute syntactically formed structures with their semantic readings, and also, bearing from the newly unveiled physiology of the Broca's area, we propose the following processing steps:

Granted a sentence such as "the bear attacked the hiker", the first DP, be it in the active or passive voice, would always take a ventral route and be kept in the memory until the verb is processed dorsally, with its internal argument. Our EEG-ERP testes showed infelicitous integration within the VP, yielded an N400. Then, integration between the VP and its external argument follows. Efforts to perform this operation yields a P600. As explained in details in Chapters 3 and 4, all the small steps will be computational and preprogrammed: “Syntax all the way down” (MARANTZ, 1997).

We believe that the sequence of ERPs we found coupled to the streamlined stimuli were able to provide a better explanatory adequacy to the sentences we tested.

Finally, among the infinite number of follow-ups for this thesis, four seem more urgent:

(i) Testing sentences whose special subjects may save their ill-formed VP semantics, versus sentences, whose subjects condemn them (Cf. p88: *The termites devoured the dirty tabletop versus the lion devoured the dirty tabletop*);

(ii) Testing sentences like that in (i), but looking for an earlier time-window for LAN which might be related to lexical exceptions. Such exceptions, on their turn, might be able to make stored items into more conscious items (more frontal), in a way that they might carry some pre-merge influence onto the verb, even before it merges with the internal argument;

(iii) Testing congruous sentences with intransitive verbs, whose first merge operation will be done with the subject, vs incongruous sentences with intransitives. This might show how our hypotheses fair only with an external argument;

(iv) Testing this new approach on an fMRI_DTI to reconstruct the pathways in view of the different linguistic conditions we have been analyzing.

These are exciting perspectives that will make me busy for the near future, and I hope will help establish a better understanding to new linguistic puzzles.

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Appendix 1: SPSS – ACTIVE – ROI – N400 WINDOW

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

CONDICAO	Dependent Variable
1	Control
2	Attraction
3	Anom

Multivariate Tests[a]

chlabel			Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[c]
ROI_Center_ Left	CONDICAO	Pillai's Trace	.540	5,868[b]	2.000	10.000	.021	11.736	.749
		Wilks' Lambda	.460	5,868[b]	2.000	10.000	.021	11.736	.749
		Hotelling's Trace	1.174	5,868[b]	2.000	10.000	.021	11.736	.749
		Roy's Largest Root	1.174	5,868[b]	2.000	10.000	.021	11.736	.749
ROI_Center_ Mid	CONDICAO	Pillai's Trace	.557	6,276[b]	2.000	10.000	.017	12.552	.779
		Wilks' Lambda	.443	6,276[b]	2.000	10.000	.017	12.552	.779
		Hotelling's Trace	1.255	6,276[b]	2.000	10.000	.017	12.552	.779
		Roy's Largest Root	1.255	6,276[b]	2.000	10.000	.017	12.552	.779
ROI_Center_ Right	CONDICAO	Pillai's Trace	.582	6,955[b]	2.000	10.000	.013	13.910	.821
		Wilks' Lambda	.418	6,955[b]	2.000	10.000	.013	13.910	.821
		Hotelling's Trace	1.391	6,955[b]	2.000	10.000	.013	13.910	.821
		Roy's Largest Root	1.391	6,955[b]	2.000	10.000	.013	13.910	.821
ROI_Frontal	CONDICAO	Pillai's Trace	.656	9,534[b]	2.000	10.000	.005	19.067	.925

_Left		Wilks' Lambda	.344	9,534[b]	2.000	10.000	.005	19.067	.925
		Hotelling's Trace	1.907	9,534[b]	2.000	10.000	.005	19.067	.925
		Roy's Largest Root	1.907	9,534[b]	2.000	10.000	.005	19.067	.925
ROI_Frontal_Mid	CONDICAO	Pillai's Trace	.690	11,132[b]	2.000	10.000	.003	22.263	.957
		Wilks' Lambda	.310	11,132[b]	2.000	10.000	.003	22.263	.957
		Hotelling's Trace	2.226	11,132[b]	2.000	10.000	.003	22.263	.957
		Roy's Largest Root	2.226	11,132[b]	2.000	10.000	.003	22.263	.957
ROI_Frontal_Right	CONDICAO	Pillai's Trace	.573	6,717[b]	2.000	10.000	.014	13.433	.807
		Wilks' Lambda	.427	6,717[b]	2.000	10.000	.014	13.433	.807
		Hotelling's Trace	1.343	6,717[b]	2.000	10.000	.014	13.433	.807
		Roy's Largest Root	1.343	6,717[b]	2.000	10.000	.014	13.433	.807
ROI_Parietal_Left350550	CONDICAO	Pillai's Trace	.397	3,295[b]	2.000	10.000	.080	6.591	.492
		Wilks' Lambda	.603	3,295[b]	2.000	10.000	.080	6.591	.492
		Hotelling's Trace	.659	3,295[b]	2.000	10.000	.080	6.591	.492
		Roy's Largest Root	.659	3,295[b]	2.000	10.000	.080	6.591	.492
ROI_Parietal_Mid	CONDICAO	Pillai's Trace	.518	5,382[b]	2.000	10.000	.026	10.764	.711
		Wilks' Lambda	.482	5,382[b]	2.000	10.000	.026	10.764	.711
		Hotelling's Trace	1.076	5,382[b]	2.000	10.000	.026	10.764	.711
		Roy's Largest Root	1.076	5,382[b]	2.000	10.000	.026	10.764	.711
ROI_Parietal_Right	CONDICAO	Pillai's Trace	.531	5,670[b]	2.000	10.000	.023	11.339	.734
		Wilks' Lambda	.469	5,670[b]	2.000	10.000	.023	11.339	.734
		Hotelling's Trace	1.134	5,670[b]	2.000	10.000	.023	11.339	.734

	Roy's Largest Root	1.134	5,670[b]	2.000	10.000	.023	11.339	.734

a. Design: Intercept
Within Subjects Design: CONDICAO

b. Exact statistic

c. Computed using alpha = ,05

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

chlabel		Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
						Greenhouse-Geisser	Huynh-Feldt	Lower-bound
ROI_Center_Left	CONDICAO	.988	.116	2	.944	.989	1.000	.500
ROI_Center_Mid	CONDICAO	.840	1.745	2	.418	.862	1.000	.500
ROI_Center_Right	CONDICAO	.813	2.069	2	.355	.843	.978	.500
ROI_Frontal_Left	CONDICAO	.958	.424	2	.809	.960	1.000	.500
ROI_Frontal_Mid	CONDICAO	.972	.282	2	.868	.973	1.000	.500
ROI_Frontal_Right	CONDICAO	.994	.059	2	.971	.994	1.000	.500
ROI_Parietal_Left 350550	CONDICAO	.930	.726	2	.695	.935	1.000	.500
ROI_Parietal_Mid	CONDICAO	.796	2.280	2	.320	.831	.960	.500
ROI_Parietal_Right	CONDICAO	.589	5.285	2	.071	.709	.783	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: CONDICAO

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Sphericity Assumed	41.444	2	20.722	7.118	.004	14.235	.893

		Greenhouse-Geisser	41.444	1.977	20.960	7.118	.004	14.073	.890
		Huynh-Feldt	41.444	2.000	20.722	7.118	.004	14.235	.893
		Lower-bound	41.444	1.000	41.444	7.118	.022	7.118	.681
	Error(CONDICAO)	Sphericity Assumed	64.050	22	2.911				
		Greenhouse-Geisser	64.050	21.750	2.945				
		Huynh-Feldt	64.050	22.000	2.911				
		Lower-bound	64.050	11.000	5.823				
ROI_Center_Mid	CONDICAO	Sphericity Assumed	59.696	2	29.848	7.749	.003	15.499	.918
		Greenhouse-Geisser	59.696	1.724	34.628	7.749	.005	13.359	.883
		Huynh-Feldt	59.696	2.000	29.848	7.749	.003	15.499	.918
		Lower-bound	59.696	1.000	59.696	7.749	.018	7.749	.717
	Error(CONDICAO)	Sphericity Assumed	84.738	22	3.852				
		Greenhouse-Geisser	84.738	18.963	4.469				
		Huynh-Feldt	84.738	22.000	3.852				
		Lower-bound	84.738	11.000	7.703				
ROI_Center_Right	CONDICAO	Sphericity Assumed	37.571	2	18.785	4.414	.024	8.829	.699
		Greenhouse-Geisser	37.571	1.685	22.296	4.414	.032	7.438	.641
		Huynh-Feldt	37.571	1.956	19.207	4.414	.025	8.635	.692
		Lower-bound	37.571	1.000	37.571	4.414	.059	4.414	.483
	Error(CONDICAO)	Sphericity Assumed	93.623	22	4.256				
		Greenhouse-Geisser	93.623	18.536	5.051				
		Huynh-Feldt	93.623	21.517	4.351				
		Lower-bound	93.623	11.000	8.511				
ROI_Frontal_Left	CONDICAO	Sphericity Assumed	34.956	2	17.478	8.356	.002	16.712	.937
		Greenhouse-	34.956	1.920	18.204	8.356	.002	16.045	.929

		Geisser							
		Huynh-Feldt	34.956	2.000	17.478	8.356	.002	16.712	.937
		Lower-bound	34.956	1.000	34.956	8.356	.015	8.356	.749
	Error(CONDICAO)	Sphericity Assumed	46.017	22	2.092				
		Greenhouse-Geisser	46.017	21.122	2.179				
		Huynh-Feldt	46.017	22.000	2.092				
		Lower-bound	46.017	11.000	4.183				
ROI_Frontal_Mid	CONDICAO	Sphericity Assumed	46.057	2	23.029	10.314	.001	20.628	.974
		Greenhouse-Geisser	46.057	1.946	23.670	10.314	.001	20.069	.971
		Huynh-Feldt	46.057	2.000	23.029	10.314	.001	20.628	.974
		Lower-bound	46.057	1.000	46.057	10.314	.008	10.314	.832
	Error(CONDICAO)	Sphericity Assumed	49.121	22	2.233				
		Greenhouse-Geisser	49.121	21.404	2.295				
		Huynh-Feldt	49.121	22.000	2.233				
		Lower-bound	49.121	11.000	4.466				
ROI_Frontal_Right	CONDICAO	Sphericity Assumed	44.460	2	22.230	7.919	.003	15.839	.924
		Greenhouse-Geisser	44.460	1.988	22.360	7.919	.003	15.747	.922
		Huynh-Feldt	44.460	2.000	22.230	7.919	.003	15.839	.924
		Lower-bound	44.460	1.000	44.460	7.919	.017	7.919	.727
	Error(CONDICAO)	Sphericity Assumed	61.755	22	2.807				
		Greenhouse-Geisser	61.755	21.872	2.823				
		Huynh-Feldt	61.755	22.000	2.807				
		Lower-bound	61.755	11.000	5.614				
ROI_Parietal_Left350550	CONDICAO	Sphericity Assumed	25.416	2	12.708	3.298	.056	6.596	.565
		Greenhouse-Geisser	25.416	1.869	13.598	3.298	.060	6.164	.544

		Huynh-Feldt	25.416	2.000	12.708	3.298	.056	6.596	.565
		Lower-bound	25.416	1.000	25.416	3.298	.097	3.298	.381
	Error(CONDICAO)	Sphericity Assumed	84.775	22	3.853				
		Greenhouse-Geisser	84.775	20.559	4.123				
		Huynh-Feldt	84.775	22.000	3.853				
		Lower-bound	84.775	11.000	7.707				
ROI_Parietal_Mid	CONDICAO	Sphericity Assumed	29.129	2	14.564	3.590	.045	7.180	.603
		Greenhouse-Geisser	29.129	1.661	17.533	3.590	.056	5.964	.544
		Huynh-Feldt	29.129	1.921	15.166	3.590	.047	6.895	.590
		Lower-bound	29.129	1.000	29.129	3.590	.085	3.590	.409
	Error(CONDICAO)	Sphericity Assumed	89.256	22	4.057				
		Greenhouse-Geisser	89.256	18.275	4.884				
		Huynh-Feldt	89.256	21.127	4.225				
		Lower-bound	89.256	11.000	8.114				
ROI_Parietal_Right	CONDICAO	Sphericity Assumed	27.338	2	13.669	2.263	.128	4.526	.411
		Greenhouse-Geisser	27.338	1.418	19.281	2.263	.147	3.209	.337
		Huynh-Feldt	27.338	1.567	17.447	2.263	.142	3.546	.357
		Lower-bound	27.338	1.000	27.338	2.263	.161	2.263	.280
	Error(CONDICAO)	Sphericity Assumed	132.891	22	6.041				
		Greenhouse-Geisser	132.891	15.597	8.520				
		Huynh-Feldt	132.891	17.237	7.710				
		Lower-bound	132.891	11.000	12.081				

a. Computed using alpha = ,05

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_ Left	CONDICAO	Linear	41.069	1	41.069	12.743	.004	12.743	.901
		Quadratic	.375	1	.375	.144	.711	.144	.064
	Error(CONDI CAO)	Linear	35.452	11	3.223				
		Quadratic	28.598	11	2.600				
ROI_Center_ Mid	CONDICAO	Linear	59.340	1	59.340	11.881	.005	11.881	.880
		Quadratic	.356	1	.356	.131	.724	.131	.063
	Error(CONDI CAO)	Linear	54.940	11	4.995				
		Quadratic	29.797	11	2.709				
ROI_Center_ Right	CONDICAO	Linear	30.177	1	30.177	11.063	.007	11.063	.857
		Quadratic	7.393	1	7.393	1.278	.282	1.278	.179
	Error(CONDI CAO)	Linear	30.006	11	2.728				
		Quadratic	63.617	11	5.783				
ROI_Frontal _Left	CONDICAO	Linear	34.375	1	34.375	20.571	.001	20.571	.984
		Quadratic	.580	1	.580	.231	.640	.231	.072
	Error(CONDI CAO)	Linear	18.382	11	1.671				
		Quadratic	27.635	11	2.512				
ROI_Frontal _Mid	CONDICAO	Linear	44.141	1	44.141	22.358	.001	22.358	.990
		Quadratic	1.917	1	1.917	.769	.399	.769	.126
	Error(CONDI CAO)	Linear	21.717	11	1.974				
		Quadratic	27.404	11	2.491				
ROI_Frontal _Right	CONDICAO	Linear	41.226	1	41.226	13.669	.004	13.669	.919
		Quadratic	3.234	1	3.234	1.245	.288	1.245	.175
	Error(CONDI CAO)	Linear	33.177	11	3.016				
		Quadratic	28.578	11	2.598				
ROI_Parietal _Left350550	CONDICAO	Linear	25.123	1	25.123	7.071	.022	7.071	.678
		Quadratic	.293	1	.293	.071	.795	.071	.057
	Error(CONDI CAO)	Linear	39.081	11	3.553				
		Quadratic	45.694	11	4.154				
ROI_Parietal	CONDICAO	Linear	28.862	1	28.862	9.426	.011	9.426	.798

_Mid		Quadratic	.267	1	.267	.053	.822	.053	.055
	Error(CONDICAO)	Linear	33.681	11	3.062				
		Quadratic	55.575	11	5.052				
ROI_Parietal_Right	CONDICAO	Linear	22.794	1	22.794	7.918	.017	7.918	.727
		Quadratic	4.545	1	4.545	.494	.497	.494	.099
	Error(CONDICAO)	Linear	31.667	11	2.879				
		Quadratic	101.224	11	9.202				

a. Computed using alpha = ,05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

chlabel		Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	Intercept	374.429	1	374.429	44.900	.000	44.900	1.000
	Error	91.730	11	8.339				
ROI_Center_Mid	Intercept	683.639	1	683.639	64.383	.000	64.383	1.000
	Error	116.801	11	10.618				
ROI_Center_Right	Intercept	500.633	1	500.633	39.898	.000	39.898	1.000
	Error	138.028	11	12.548				
ROI_Frontal_Left	Intercept	109.656	1	109.656	6.612	.026	6.612	.649
	Error	182.440	11	16.585				
ROI_Frontal_Mid	Intercept	210.613	1	210.613	9.460	.011	9.460	.799
	Error	244.902	11	22.264				
ROI_Frontal_Right	Intercept	170.150	1	170.150	7.475	.019	7.475	.702
	Error	250.388	11	22.763				
ROI_Parietal_Left350550	Intercept	449.080	1	449.080	64.159	.000	64.159	1.000
	Error	76.994	11	6.999				
ROI_Parietal_Mid	Intercept	699.708	1	699.708	88.903	.000	88.903	1.000
	Error	86.575	11	7.870				
ROI_Parietal_Right	Intercept	616.943	1	616.943	73.224	.000	73.224	1.000
	Error	92.680	11	8.425				

a. Computed using alpha = ,05

Estimated Marginal Means

CONDICAO

Estimates

Measure: MEASURE_1

chlabel					
Measure: MEASURE_1					
ROI_Center_Left		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
ROI_Center_Left	1	-1.989	.685	-3.496	-.482
ROI_Center_Mid	2	-3.081	.734	-4.696	-1.465
	3	-4.605	.416	-5.520	-3.691
ROI_Center_Mid	1	-2.856	.882	-4.798	-.913
ROI_Center_Right	2	-4.217	.706	-5.772	-2.663
	3	-6.001	.499	-7.099	-4.902
ROI_Center_Right	1	-2.928	.624	-4.302	-1.554
ROI_Frontal_Left	2	-3.088	1.032	-5.359	-.817
	3	-5.171	.548	-6.377	-3.965
ROI_Frontal_Left	1	-.638	.741	-2.269	.992

ROI_Frontal_Mid	2	-1.566	.942	-3.640	.509
	3	-3.032	.542	-4.225	-1.839
	1	-1.226	.810	-3.008	.557
ROI_Frontal_Mid ROI_Frontal_Right	2	-2.092	1.013	-4.322	.137
	3	-3.938	.739	-5.564	-2.312
ROI_Frontal_Right	1	-1.075	.788	-2.809	.659
ROI_Parietal_Left350550	2	-1.750	1.099	-4.169	.669
	3	-3.697	.732	-5.308	-2.085
ROI_Parietal_Left350550	1	-2.445	.666	-3.911	-.979
	2	-3.660	.715	-5.234	-2.085
ROI_Parietal_Mid	3	-4.491	.520	-5.635	-3.348
	1	-3.373	.647	-4.796	-1.950
ROI_Parietal_Mid ROI_Parietal_Right	2	-4.287	.824	-6.102	-2.472
	3	-5.566	.484	-6.631	-4.501
ROI_Parietal_Right	1	-3.416	.645	-4.837	-1.996
	2	-3.637	1.040	-5.926	-1.349
	3	-5.366	.460	-6.378	-4.353

Pairwise Comparisons

Measure: MEASURE_1

chlabel				
Measure: MEASURE_1				
ROI_Center_Left	Mean Difference	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]

			(I-J)			Lower Bound	Upper Bound
	1	2	1.092	.680	.137	-.405	2.589
		3	2,616*	.733	.004	1.003	4.229
ROI_Center_Left	2	1	-1.092	.680	.137	-2.589	.405
ROI_Center_Mid		3	1,525*	.675	.045	.038	3.011
	3	1	-2,616*	.733	.004	-4.229	-1.003
		2	-1,525*	.675	.045	-3.011	-.038
	1	2	1.361	.834	.131	-.475	3.198
		3	3,145*	.912	.005	1.137	5.153
ROI_Center_Mid	2	1	-1.361	.834	.131	-3.198	.475
ROI_Center_Right		3	1,783*	.630	.016	.396	3.171
	3	1	-3,145*	.912	.005	-5.153	-1.137
		2	-1,783*	.630	.016	-3.171	-.396
	1	2	.160	.992	.875	-2.024	2.344
		3	2,243*	.674	.007	.759	3.727
ROI_Center_Right	2	1	-.160	.992	.875	-2.344	2.024
ROI_Frontal_Left		3	2,083*	.830	.029	.256	3.909
	3	1	-2,243*	.674	.007	-3.727	-.759
		2	-2,083*	.830	.029	-3.909	-.256
	1	2	.928	.627	.167	-.454	2.309
		3	2,394*	.528	.001	1.232	3.555
ROI_Frontal_Left	2	1	-.928	.627	.167	-2.309	.454
ROI_Frontal_Mid		3	1,466*	.611	.035	.121	2.811
	3	1	-2,394*	.528	.001	-3.555	-1.232
		2	-1,466*	.611	.035	-2.811	-.121
	1	2	.867	.658	.214	-.581	2.314
		3	2,712*	.574	.001	1.450	3.975
ROI_Frontal_Mid	2	1	-.867	.658	.214	-2.314	.581
ROI_Frontal_Right		3	1,846*	.596	.010	.534	3.157
	3	1	-2,712*	.574	.001	-3.975	-1.450
		2	-1,846*	.596	.010	-3.157	-.534

	1	2	.675	.666	.333	-.791	2.141
		3	2,621*	.709	.004	1.061	4.182
ROI_Frontal_Right	2	1	-.675	.666	.333	-2.141	.791
ROI_Parietal_Left350550		3	1,946*	.676	.015	.458	3.435
	3	1	-2,621*	.709	.004	-4.182	-1.061
		2	-1,946*	.676	.015	-3.435	-.458
	1	2	1.215	.899	.204	-.764	3.193
		3	2,046*	.770	.022	.353	3.740
ROI_Parietal_Left350550	2	1	-1.215	.899	.204	-3.193	.764
ROI_Parietal_Mid		3	.832	.726	.276	-.765	2.429
	3	1	-2,046*	.770	.022	-3.740	-.353
		2	-.832	.726	.276	-2.429	.765
	1	2	.914	.990	.376	-1.266	3.094
		3	2,193*	.714	.011	.621	3.766
ROI_Parietal_Mid	2	1	-.914	.990	.376	-3.094	1.266
ROI_Parietal_Right		3	1.279	.733	.109	-.334	2.892
	3	1	-2,193*	.714	.011	-3.766	-.621
		2	-1.279	.733	.109	-2.892	.334
	1	2	.221	1.262	.864	-2.557	2.998
ROI_Parietal_Right		3	1,949*	.693	.017	.425	3.474
Based on estimated marginal means	2	1	-.221	1.262	.864	-2.998	2.557
		3	1.728	.974	.104	-.415	3.871
*. The mean difference is significant at the ,05 level.	3	1	-1,949*	.693	.017	-3.474	-.425
		2	-1.728	.974	.104	-3.871	.415

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

chlabel	ROI_Center_Left						
chlabel	Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[b]

	Pillai's trace	.540	5,868[a]	2.000	10.000	.021	11.736	.749
ROI_Center_Left	Wilks' lambda	.460	5,868[a]	2.000	10.000	.021	11.736	.749
ROI_Center_Mid	Hotelling's trace	1.174	5,868[a]	2.000	10.000	.021	11.736	.749
	Roy's largest root	1.174	5,868[a]	2.000	10.000	.021	11.736	.749
	Pillai's trace	.557	6,276[a]	2.000	10.000	.017	12.552	.779
ROI_Center_Mid	Wilks' lambda	.443	6,276[a]	2.000	10.000	.017	12.552	.779
ROI_Center_Right	Hotelling's trace	1.255	6,276[a]	2.000	10.000	.017	12.552	.779
	Roy's largest root	1.255	6,276[a]	2.000	10.000	.017	12.552	.779
	Pillai's trace	.582	6,955[a]	2.000	10.000	.013	13.910	.821
ROI_Center_Right	Wilks' lambda	.418	6,955[a]	2.000	10.000	.013	13.910	.821
ROI_Frontal_Left	Hotelling's trace	1.391	6,955[a]	2.000	10.000	.013	13.910	.821
	Roy's largest root	1.391	6,955[a]	2.000	10.000	.013	13.910	.821
	Pillai's trace	.656	9,534[a]	2.000	10.000	.005	19.067	.925
ROI_Frontal_Left	Wilks' lambda	.344	9,534[a]	2.000	10.000	.005	19.067	.925
ROI_Frontal_Mid	Hotelling's trace	1.907	9,534[a]	2.000	10.000	.005	19.067	.925
	Roy's largest root	1.907	9,534[a]	2.000	10.000	.005	19.067	.925
	Pillai's trace	.690	11,132[a]	2.000	10.000	.003	22.263	.957
ROI_Frontal_Mid	Wilks' lambda	.310	11,132[a]	2.000	10.000	.003	22.263	.957
ROI_Frontal_Right	Hotelling's trace	2.226	11,132[a]	2.000	10.000	.003	22.263	.957
	Roy's largest root	2.226	11,132[a]	2.000	10.000	.003	22.263	.957
	Pillai's trace	.573	6,717[a]	2.000	10.000	.014	13.433	.807
ROI_Frontal_Right	Wilks' lambda	.427	6,717[a]	2.000	10.000	.014	13.433	.807
ROI_Parietal_Left350550	Hotelling's trace	1.343	6,717[a]	2.000	10.000	.014	13.433	.807
	Roy's largest root	1.343	6,717[a]	2.000	10.000	.014	13.433	.807
	Pillai's trace	.397	3,295[a]	2.000	10.000	.080	6.591	.492
ROI_Parietal_Left350550	Wilks' lambda	.603	3,295[a]	2.000	10.000	.080	6.591	.492
ROI_Parietal_Mid	Hotelling's trace	.659	3,295[a]	2.000	10.000	.080	6.591	.492
	Roy's largest root	.659	3,295[a]	2.000	10.000	.080	6.591	.492
	Pillai's trace	.518	5,382[a]	2.000	10.000	.026	10.764	.711
ROI_Parietal_Mid	Wilks' lambda	.482	5,382[a]	2.000	10.000	.026	10.764	.711
ROI_Parietal_Right	Hotelling's trace	1.076	5,382[a]	2.000	10.000	.026	10.764	.711

	Roy's largest root	1.076	5,382[a]	2.000	10.000	.026	10.764	.711
ROI_Parietal_Right	Pillai's trace	.531	5,670[a]	2.000	10.000	.023	11.339	.734
	Wilks' lambda	.469	5,670[a]	2.000	10.000	.023	11.339	.734
	Hotelling's trace	1.134	5,670[a]	2.000	10.000	.023	11.339	.734
	Roy's largest root	1.134	5,670[a]	2.000	10.000	.023	11.339	.734

Each F tests the multivariate effect of

a. Exact statistic

b. Computed using alpha = ,05

Appendix 2: SPSS – ACTIVE – ROI – P600 WINDOW

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

CONDICAO	Dependent Variable
1	Control
2	Attraction
3	Anom

Multivariate Tests[a]

chlabel			Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[c]
ROI_Center _Left	CONDI CAO	Pillai's Trace	.397	3,299[b]	2.000	10.000	.079	6.597	.492
		Wilks' Lambda	.603	3,299[b]	2.000	10.000	.079	6.597	.492
		Hotelling 's Trace	.660	3,299[b]	2.000	10.000	.079	6.597	.492
		Roy's Largest Root	.660	3,299[b]	2.000	10.000	.079	6.597	.492
ROI_Center _Mid	CONDI CAO	Pillai's Trace	.399	3,324[b]	2.000	10.000	.078	6.648	.495
		Wilks' Lambda	.601	3,324[b]	2.000	10.000	.078	6.648	.495
		Hotelling 's Trace	.665	3,324[b]	2.000	10.000	.078	6.648	.495
		Roy's Largest Root	.665	3,324[b]	2.000	10.000	.078	6.648	.495
ROI_Center _Right	CONDI CAO	Pillai's Trace	.384	3,116[b]	2.000	10.000	.089	6.231	.469
		Wilks' Lambda	.616	3,116[b]	2.000	10.000	.089	6.231	.469

		Hotelling's Trace	.623	3,116b	2.000	10.000	.089	6.231	.469
		Roy's Largest Root	.623	3,116b	2.000	10.000	.089	6.231	.469
ROI_Frontal_Left	CONDICAO	Pillai's Trace	.655	9,485b	2.000	10.000	.005	18.969	.923
		Wilks' Lambda	.345	9,485b	2.000	10.000	.005	18.969	.923
		Hotelling's Trace	1.897	9,485b	2.000	10.000	.005	18.969	.923
		Roy's Largest Root	1.897	9,485b	2.000	10.000	.005	18.969	.923
ROI_Frontal_Mid	CONDICAO	Pillai's Trace	.668	10,058b	2.000	10.000	.004	20.116	.937
		Wilks' Lambda	.332	10,058b	2.000	10.000	.004	20.116	.937
		Hotelling's Trace	2.012	10,058b	2.000	10.000	.004	20.116	.937
		Roy's Largest Root	2.012	10,058b	2.000	10.000	.004	20.116	.937
ROI_Frontal_Right	CONDICAO	Pillai's Trace	.610	7,836b	2.000	10.000	.009	15.673	.865
		Wilks' Lambda	.390	7,836b	2.000	10.000	.009	15.673	.865
		Hotelling's Trace	1.567	7,836b	2.000	10.000	.009	15.673	.865
		Roy's Largest Root	1.567	7,836b	2.000	10.000	.009	15.673	.865
ROI_Parietal_Left500800	CONDICAO	Pillai's Trace	.177	1,073b	2.000	10.000	.378	2.146	.188
		Wilks' Lambda	.823	1,073b	2.000	10.000	.378	2.146	.188
		Hotelling's Trace	.215	1,073b	2.000	10.000	.378	2.146	.188
		Roy's Largest Root	.215	1,073b	2.000	10.000	.378	2.146	.188
ROI_Pariet	CONDI	Pillai's	.188	1,159b	2.000	10.000	.353	2.318	.200

al_Mid	CAO	Trace							
		Wilks' Lambda	.812	1,159[b]	2.000	10.000	.353	2.318	.200
		Hotelling's Trace	.232	1,159[b]	2.000	10.000	.353	2.318	.200
		Roy's Largest Root	.232	1,159[b]	2.000	10.000	.353	2.318	.200
ROI_Parietal_Right	CONDICAO	Pillai's Trace	.244	1,615[b]	2.000	10.000	.247	3.230	.264
		Wilks' Lambda	.756	1,615[b]	2.000	10.000	.247	3.230	.264
		Hotelling's Trace	.323	1,615[b]	2.000	10.000	.247	3.230	.264
		Roy's Largest Root	.323	1,615[b]	2.000	10.000	.247	3.230	.264

a. Design: Intercept
Within Subjects Design: CONDICAO

b. Exact statistic

c. Computed using alpha = ,05

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

chlabel		Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
						Greenhouse-Geisser	Huynh-Feldt	Lower-bound
ROI_Center_Left	CONDICAO	.943	.589	2	.745	.946	1.000	.500
ROI_Center_Mid	CONDICAO	.743	2.971	2	.226	.796	.908	.500
ROI_Center_Right	CONDICAO	.679	3.865	2	.145	.757	.853	.500
ROI_Frontal_Left	CONDICAO	.845	1.690	2	.430	.865	1.000	.500
ROI_Frontal_Mid	CONDICAO	.756	2.797	2	.247	.804	.921	.500

ROI_Frontal_Right	CONDICAO	.919	.840	2	.657	.925	1.000	.500
ROI_Parietal_Left500800	CONDICAO	.794	2.311	2	.315	.829	.958	.500
ROI_Parietal_Mid	CONDICAO	.600	5.116	2	.077	.714	.791	.500
ROI_Parietal_Right	CONDICAO	.593	5.233	2	.073	.711	.786	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: CONDICAO

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Sphericity Assumed	31.897	2	15.948	4.448	.024	8.896	.703
		Greenhouse-Geisser	31.897	1.892	16.861	4.448	.026	8.415	.684
		Huynh-Feldt	31.897	2.000	15.948	4.448	.024	8.896	.703
		Lower-bound	31.897	1.000	31.897	4.448	.059	4.448	.486
	Error(CONDICAO)	Sphericity Assumed	78.880	22	3.585				
		Greenhouse-Geisser	78.880	20.809	3.791				
		Huynh-Feldt	78.880	22.000	3.585				

		Lower-bound	78.880	11.000	7.171				
ROI_Center_Mid	CONDICAO	Sphericity Assumed	33.241	2	16.620	4.087	.031	8.173	.663
		Greenhouse-Geisser	33.241	1.591	20.893	4.087	.043	6.502	.588
		Huynh-Feldt	33.241	1.817	18.299	4.087	.036	7.424	.631
		Lower-bound	33.241	1.000	33.241	4.087	.068	4.087	.454
	Error(CONDICAO)	Sphericity Assumed	89.474	22	4.067				
		Greenhouse-Geisser	89.474	17.501	5.112				
		Huynh-Feldt	89.474	19.982	4.478				
		Lower-bound	89.474	11.000	8.134				
ROI_Center_Right	CONDICAO	Sphericity Assumed	21.283	2	10.641	1.610	.222	3.221	.303
		Greenhouse-Geisser	21.283	1.514	14.053	1.610	.229	2.439	.261
		Huynh-Feldt	21.283	1.705	12.482	1.610	.227	2.746	.278
		Lower-bound	21.283	1.000	21.283	1.610	.231	1.610	.213
	Error(CONDICAO)	Sphericity Assumed	145.375	22	6.608				
		Greenhouse-Geisser	145.375	16.659	8.726				
		Huynh-Feldt	145.375	18.756	7.751				

		Lower-bound	145.375	11.000	13.216				
ROI_Frontal_Left	CONDICAO	Sphericity Assumed	29.412	2	14.706	6.987	.004	13.974	.887
		Greenhouse-Geisser	29.412	1.731	16.992	6.987	.007	12.094	.848
		Huynh-Feldt	29.412	2.000	14.706	6.987	.004	13.974	.887
		Lower-bound	29.412	1.000	29.412	6.987	.023	6.987	.673
	Error(CONDICAO)	Sphericity Assumed	46.305	22	2.105				
		Greenhouse-Geisser	46.305	19.040	2.432				
		Huynh-Feldt	46.305	22.000	2.105				
		Lower-bound	46.305	11.000	4.210				
ROI_Frontal_Mid	CONDICAO	Sphericity Assumed	31.038	2	15.519	5.993	.008	11.987	.832
		Greenhouse-Geisser	31.038	1.608	19.306	5.993	.014	9.636	.763
		Huynh-Feldt	31.038	1.841	16.858	5.993	.010	11.035	.807
		Lower-bound	31.038	1.000	31.038	5.993	.032	5.993	.607
	Error(CONDICAO)	Sphericity Assumed	56.966	22	2.589				
		Greenhouse-Geisser	56.966	17.685	3.221				
		Huynh-Feldt	56.966	20.253	2.813				

		Lower-bound	56.966	11.000	5.179				
ROI_Frontal_Right	CONDICAO	Sphericity Assumed	38.905	2	19.452	6.364	.007	12.729	.855
		Greenhouse-Geisser	38.905	1.851	21.020	6.364	.008	11.780	.832
		Huynh-Feldt	38.905	2.000	19.452	6.364	.007	12.729	.855
		Lower-bound	38.905	1.000	38.905	6.364	.028	6.364	.633
	Error(CONDICAO)	Sphericity Assumed	67.241	22	3.056				
		Greenhouse-Geisser	67.241	20.360	3.303				
		Huynh-Feldt	67.241	22.000	3.056				
		Lower-bound	67.241	11.000	6.113				
ROI_Parietal_Left500800	CONDICAO	Sphericity Assumed	10.702	2	5.351	1.141	.338	2.282	.225
		Greenhouse-Geisser	10.702	1.658	6.455	1.141	.331	1.892	.205
		Huynh-Feldt	10.702	1.916	5.587	1.141	.336	2.185	.220
		Lower-bound	10.702	1.000	10.702	1.141	.308	1.141	.164
	Error(CONDICAO)	Sphericity Assumed	103.185	22	4.690				
		Greenhouse-Geisser	103.185	18.237	5.658				
		Huynh-Feldt	103.185	21.071	4.897				

		Lower-bound	103.185	11.000	9.380				
ROI_Parietal_Mid	CONDICAO	Sphericity Assumed	10.708	2	5.354	1.158	.332	2.317	.228
		Greenhouse-Geisser	10.708	1.428	7.498	1.158	.321	1.654	.194
		Huynh-Feldt	10.708	1.581	6.771	1.158	.325	1.832	.203
		Lower-bound	10.708	1.000	10.708	1.158	.305	1.158	.166
	Error(CONDICAO)	Sphericity Assumed	101.674	22	4.622				
		Greenhouse-Geisser	101.674	15.709	6.472				
		Huynh-Feldt	101.674	17.396	5.845				
		Lower-bound	101.674	11.000	9.243				
ROI_Parietal_Right	CONDICAO	Sphericity Assumed	10.708	2	5.354	.644	.535	1.289	.144
		Greenhouse-Geisser	10.708	1.421	7.535	.644	.487	.916	.127
		Huynh-Feldt	10.708	1.571	6.814	.644	.501	1.012	.132
		Lower-bound	10.708	1.000	10.708	.644	.439	.644	.114
	Error(CONDICAO)	Sphericity Assumed	182.801	22	8.309				
		Greenhouse-Geisser	182.801	15.631	11.695				
		Huynh-Feldt	182.801	17.285	10.576				

		Lower-bound	182.801	11.000	16.618				

a. Computed using alpha = ,05

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Linear	31.763	1	31.763	7.256	.021	7.256	.689
		Quadratic	.134	1	.134	.048	.831	.048	.055
	Error(CONDICAO)	Linear	48.155	11	4.378				
		Quadratic	30.725	11	2.793				
ROI_Center_Mid	CONDICAO	Linear	32.723	1	32.723	6.538	.027	6.538	.644
		Quadratic	.518	1	.518	.166	.692	.166	.066
	Error(CONDICAO)	Linear	55.054	11	5.005				
		Quadratic	34.420	11	3.129				
ROI_Center_Right	CONDICAO	Linear	15.601	1	15.601	4.883	.049	4.883	.522
		Quadratic	5.682	1	5.682	.567	.467	.567	.106
	Error(CONDICAO)	Linear	35.143	11	3.195				
		Quadratic	110.233	11	10.021				
ROI_Frontal_Left	CONDICAO	Linear	29.055	1	29.055	17.044	.002	17.044	.963
		Quadratic	.357	1	.357	.142	.713	.142	.064
	Error(C	Linear	18.75	11	1.705				

	ONDICAO)		2						
		Quadratic	27.553	11	2.505				
ROI_Frontal_Mid	CONDICAO	Linear	29.389	1	29.389	14.565	.003	14.565	.934
		Quadratic	1.650	1	1.650	.522	.485	.522	.101
	Error(CONDICAO)	Linear	22.195	11	2.018				
		Quadratic	34.771	11	3.161				
ROI_Frontal_Right	CONDICAO	Linear	32.334	1	32.334	14.482	.003	14.482	.933
		Quadratic	6.571	1	6.571	1.693	.220	1.693	.221
	Error(CONDICAO)	Linear	24.560	11	2.233				
		Quadratic	42.681	11	3.880				
ROI_Parietal_Left500800	CONDICAO	Linear	9.140	1	9.140	2.342	.154	2.342	.288
		Quadratic	1.562	1	1.562	.285	.604	.285	.078
	Error(CONDICAO)	Linear	42.927	11	3.902				
		Quadratic	60.258	11	5.478				
ROI_Parietal_Mid	CONDICAO	Linear	9.405	1	9.405	2.240	.163	2.240	.277
		Quadratic	1.302	1	1.302	.258	.621	.258	.075
	Error(CONDICAO)	Linear	46.194	11	4.199				
		Quadratic	55.480	11	5.044				
ROI_Parietal_Right	CONDICAO	Linear	9.546	1	9.546	2.522	.141	2.522	.306
		Quadratic	1.162	1	1.162	.091	.769	.091	.059
	Error(CONDICAO)	Linear	41.628	11	3.784				
		Quadrati	141.1	11	12.834				

c	73						

a. Computed using alpha = ,05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

chlabel		Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	Intercept	2.463	1	2.463	.303	.593	.303	.080
	Error	89.350	11	8.123				
ROI_Center_Mid	Intercept	47.976	1	47.976	4.002	.071	4.002	.447
	Error	131.853	11	11.987				
ROI_Center_Right	Intercept	90.412	1	90.412	12.478	.005	12.478	.895
	Error	79.701	11	7.246				
ROI_Frontal_Left	Intercept	4.705	1	4.705	.258	.622	.258	.075
	Error	200.607	11	18.237				
ROI_Frontal_Mid	Intercept	.523	1	.523	.020	.890	.020	.052
	Error	288.566	11	26.233				
ROI_Frontal_Right	Intercept	17.478	1	17.478	.855	.375	.855	.135
	Error	224.970	11	20.452				
ROI_Parietal_Left500800	Intercept	15.721	1	15.721	6.410	.028	6.410	.636
	Error	26.980	11	2.453				
ROI_Parietal_Mid	Intercept	63.433	1	63.433	14.808	.003	14.808	.938
	Error	47.121	11	4.284				
ROI_Parietal_Right	Intercept	182.003	1	182.003	67.193	.000	67.193	1.000
	Error	29.795	11	2.709				

Estimated Marginal Means

CONDICAO

Estimates

Measure: MEASURE_1

chlabel		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
ROI_Center_Left	1	.932	.684	-.574	2.438
	2	-.348	.744	-1.986	1.290
	3	-1.369	.503	-2.475	-.263
ROI_Center_Mid	1	.098	.895	-1.873	2.069
	2	-1.324	.689	-2.842	.193
	3	-2.237	.632	-3.629	-.846
ROI_Center_Right	1	-1.059	.589	-2.355	.236
	2	-1.023	1.043	-3.318	1.272
	3	-2.672	.521	-3.819	-1.525
ROI_Frontal_Left	1	1.391	.808	-.387	3.170
	2	.502	.912	-1.505	2.509
	3	-.809	.621	-2.177	.559
ROI_Frontal_Mid	1	.835	.935	-1.224	2.893
	2	.182	.991	-2.000	2.364
	3	-1.379	.872	-3.297	.540
ROI_Frontal_Right	1	.162	.856	-1.721	2.045
	2	-.093	1.038	-2.378	2.193
	3	-2.160	.635	-3.557	-.762
ROI_Parietal_Left500800	1	.104	.594	-1.204	1.411
	2	-.955	.704	-2.505	.594
	3	-1.131	.371	-1.947	-.314
ROI_Parietal_Mid	1	-.567	.596	-1.878	.744
	2	-1.596	.755	-3.258	.065
	3	-1.819	.450	-2.809	-.829
ROI_Pariet	1	-1.745	.657	-3.192	-.298

al_Right	2		-1.994	1.003	-4.201	.212
	3		-3.006	.416	-3.922	-2.090

Pairwise Comparisons

Measure: MEASURE_1

chlabel			Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
ROI_Center_Left	1	2	1.280	.761	.121	-.395	2.955
		3	2,301*	.854	.021	.421	4.181
	2	1	-1.280	.761	.121	-2.955	.395
		3	1.021	.696	.170	-.510	2.552
	3	1	-2,301*	.854	.021	-4.181	-.421
		2	-1.021	.696	.170	-2.552	.510
ROI_Center_Mid	1	2	1.422	.930	.154	-.625	3.469
		3	2,335*	.913	.027	.325	4.346
	2	1	-1.422	.930	.154	-3.469	.625
		3	.913	.578	.143	-.360	2.186
	3	1	-2,335*	.913	.027	-4.346	-.325
		2	-.913	.578	.143	-2.186	.360
ROI_Center_Right	1	2	-.036	1.268	.978	-2.827	2.754
		3	1,613*	.730	.049	.006	3.219
	2	1	.036	1.268	.978	-2.754	2.827
		3	1.649	1.079	.155	-.726	4.024
	3	1	-1,613*	.730	.049	-3.219	-.006
		2	-1.649	1.079	.155	-4.024	.726
ROI_Frontal_Left	1	2	.889	.699	.230	-.650	2.428
		3	2,201*	.533	.002	1.027	3.374

	2	1	-.889	.699	.230	-2.428	.650
		3	1,311*	.528	.030	.148	2.474
	3	1	-2,201*	.533	.002	-3.374	-1.027
		2	-1,311*	.528	.030	-2.474	-.148
ROI_Frontal_Mid	1	2	.653	.803	.434	-1.114	2.419
		3	2,213*	.580	.003	.937	3.490
	2	1	-.653	.803	.434	-2.419	1.114
		3	1,561*	.560	.018	.327	2.794
	3	1	-2,213*	.580	.003	-3.490	-.937
		2	-1,561*	.560	.018	-2.794	-.327
ROI_Frontal_Right	1	2	.254	.786	.752	-1.475	1.984
		3	2,321*	.610	.003	.979	3.664
	2	1	-.254	.786	.752	-1.984	1.475
		3	2,067*	.734	.017	.452	3.682
	3	1	-2,321*	.610	.003	-3.664	-.979
		2	-2,067*	.734	.017	-3.682	-.452
ROI_Parietal_Left500800	1	2	1.059	1.064	.341	-1.284	3.402
		3	1.234	.806	.154	-.541	3.009
	2	1	-1.059	1.064	.341	-3.402	1.284
		3	.175	.749	.819	-1.474	1.825
	3	1	-1.234	.806	.154	-3.009	.541
		2	-.175	.749	.819	-1.825	1.474
ROI_Parietal_Mid	1	2	1.030	1.106	.372	-1.405	3.464
		3	1.252	.837	.163	-.589	3.093
	2	1	-1.030	1.106	.372	-3.464	1.405
		3	.223	.623	.728	-1.148	1.593
	3	1	-1.252	.837	.163	-3.093	.589
		2	-.223	.623	.728	-1.593	1.148
ROI_Parietal_Right	1	2	.250	1.470	.868	-2.986	3.485
		3	1.261	.794	.141	-.487	3.009
	2	1	-.250	1.470	.868	-3.485	2.986

	3	1.012	1.167	.405	-1.557	3.581
3	1	-1.261	.794	.141	-3.009	.487
	2	-1.012	1.167	.405	-3.581	1.557

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

chlabel		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[b]
ROI_Center_Left	Pillai's trace	.397	3,299[a]	2.000	10.000	.079	6.597	.492
	Wilks' lambda	.603	3,299[a]	2.000	10.000	.079	6.597	.492
	Hotelling's trace	.660	3,299[a]	2.000	10.000	.079	6.597	.492
	Roy's largest root	.660	3,299[a]	2.000	10.000	.079	6.597	.492
ROI_Center_Mid	Pillai's trace	.399	3,324[a]	2.000	10.000	.078	6.648	.495
	Wilks' lambda	.601	3,324[a]	2.000	10.000	.078	6.648	.495
	Hotelling's trace	.665	3,324[a]	2.000	10.000	.078	6.648	.495
	Roy's largest root	.665	3,324[a]	2.000	10.000	.078	6.648	.495
ROI_Center_Right	Pillai's trace	.384	3,116[a]	2.000	10.000	.089	6.231	.469
	Wilks' lambda	.616	3,116[a]	2.000	10.000	.089	6.231	.469
	Hotelling's trace	.623	3,116[a]	2.000	10.000	.089	6.231	.469
	Roy's largest root	.623	3,116[a]	2.000	10.000	.089	6.231	.469
ROI_Frontal_Left	Pillai's trace	.655	9,485[a]	2.000	10.000	.005	18.969	.923
	Wilks'	.345	9,485[a]	2.000	10.000	.00	18.969	.923

	lambda					5		
	Hotelling's trace	1.897	9,485[a]	2.000	10.000	.005	18.969	.923
	Roy's largest root	1.897	9,485[a]	2.000	10.000	.005	18.969	.923
ROI_Frontal_Mid	Pillai's trace	.668	10,058[a]	2.000	10.000	.004	20.116	.937
	Wilks' lambda	.332	10,058[a]	2.000	10.000	.004	20.116	.937
	Hotelling's trace	2.012	10,058[a]	2.000	10.000	.004	20.116	.937
	Roy's largest root	2.012	10,058[a]	2.000	10.000	.004	20.116	.937
ROI_Frontal_Right	Pillai's trace	.610	7,836[a]	2.000	10.000	.009	15.673	.865
	Wilks' lambda	.390	7,836[a]	2.000	10.000	.009	15.673	.865
	Hotelling's trace	1.567	7,836[a]	2.000	10.000	.009	15.673	.865
	Roy's largest root	1.567	7,836[a]	2.000	10.000	.009	15.673	.865
ROI_Parietal_Left500800	Pillai's trace	.177	1,073[a]	2.000	10.000	.378	2.146	.188
	Wilks' lambda	.823	1,073[a]	2.000	10.000	.378	2.146	.188
	Hotelling's trace	.215	1,073[a]	2.000	10.000	.378	2.146	.188
	Roy's largest root	.215	1,073[a]	2.000	10.000	.378	2.146	.188
ROI_Parietal_Mid	Pillai's trace	.188	1,159[a]	2.000	10.000	.353	2.318	.200
	Wilks' lambda	.812	1,159[a]	2.000	10.000	.353	2.318	.200
	Hotelling's trace	.232	1,159[a]	2.000	10.000	.353	2.318	.200
	Roy's largest root	.232	1,159[a]	2.000	10.000	.353	2.318	.200
ROI_Parietal_Right	Pillai's trace	.244	1,615[a]	2.000	10.000	.247	3.230	.264
	Wilks' lambda	.756	1,615[a]	2.000	10.000	.247	3.230	.264

	Hotelling's trace	.323	1,615[a]	2.000	10.000	.247	3.230	.264
	Roy's largest root	.323	1,615[a]	2.000	10.000	.247	3.230	.264

Each F tests the multivariate effect of CONDICAO. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = ,05

Appendix 3: SPSS – PASSIVE – ROI – N400 WINDOW

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

CONDICAO	Dependent Variable
1	Control
2	Attraction
3	Anom

Multivariate Tests[a]

chlabel			Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[c]
ROI_Center_Left	CONDICAO	Pillai's Trace	.593	7,291[b]	2.000	10.000	.011	14.581	.839
		Wilks' Lambda	.407	7,291[b]	2.000	10.000	.011	14.581	.839
		Hotelling's Trace	1.458	7,291[b]	2.000	10.000	.011	14.581	.839
		Roy's Largest Root	1.458	7,291[b]	2.000	10.000	.011	14.581	.839
ROI_Center_Mid	CONDICAO	Pillai's Trace	.702	11,779[b]	2.000	10.000	.002	23.558	.966
		Wilks' Lambda	.298	11,779[b]	2.000	10.000	.002	23.558	.966
		Hotelling's Trace	2.356	11,779[b]	2.000	10.000	.002	23.558	.966
		Roy's Largest Root	2.356	11,779[b]	2.000	10.000	.002	23.558	.966
ROI_Center_Right	CONDICAO	Pillai's Trace	.629	8,464[b]	2.000	10.000	.007	16.928	.891
		Wilks' Lambda	.371	8,464[b]	2.000	10.000	.007	16.928	.891
		Hotelling's Trace	1.693	8,464[b]	2.000	10.000	.007	16.928	.891

		Roy's Largest Root	1.693	8,464[b]	2.000	10.000	.007	16.928	.891
ROI_Frontal _Left	CONDI CAO	Pillai's Trace	.457	4,207[b]	2.000	10.000	.047	8.414	.598
		Wilks' Lambda	.543	4,207[b]	2.000	10.000	.047	8.414	.598
		Hotelling's Trace	.841	4,207[b]	2.000	10.000	.047	8.414	.598
		Roy's Largest Root	.841	4,207[b]	2.000	10.000	.047	8.414	.598
ROI_Frontal _Mid	CONDI CAO	Pillai's Trace	.418	3,590[b]	2.000	10.000	.067	7.179	.528
		Wilks' Lambda	.582	3,590[b]	2.000	10.000	.067	7.179	.528
		Hotelling's Trace	.718	3,590[b]	2.000	10.000	.067	7.179	.528
		Roy's Largest Root	.718	3,590[b]	2.000	10.000	.067	7.179	.528
ROI_Frontal _Right	CONDI CAO	Pillai's Trace	.414	3,536[b]	2.000	10.000	.069	7.072	.521
		Wilks' Lambda	.586	3,536[b]	2.000	10.000	.069	7.072	.521
		Hotelling's Trace	.707	3,536[b]	2.000	10.000	.069	7.072	.521
		Roy's Largest Root	.707	3,536[b]	2.000	10.000	.069	7.072	.521
ROI_Parietal _Left350550	CONDI CAO	Pillai's Trace	.692	11,248[b]	2.000	10.000	.003	22.497	.959
		Wilks' Lambda	.308	11,248[b]	2.000	10.000	.003	22.497	.959
		Hotelling's Trace	2.250	11,248[b]	2.000	10.000	.003	22.497	.959
		Roy's Largest Root	2.250	11,248[b]	2.000	10.000	.003	22.497	.959
ROI_Parietal _Mid	CONDI CAO	Pillai's Trace	.684	10,839[b]	2.000	10.000	.003	21.677	.953
		Wilks'	.316	10,839	2.000	10.000	.003	21.677	.953

		Lambda		b					
		Hotelling's Trace	2.168	10,839[b]	2.000	10.000	.003	21.677	.953
		Roy's Largest Root	2.168	10,839[b]	2.000	10.000	.003	21.677	.953
ROI_Parietal_Right	CONDICAO	Pillai's Trace	.497	4,931[b]	2.000	10.000	.032	9.862	.671
		Wilks' Lambda	.503	4,931[b]	2.000	10.000	.032	9.862	.671
		Hotelling's Trace	.986	4,931[b]	2.000	10.000	.032	9.862	.671
		Roy's Largest Root	.986	4,931[b]	2.000	10.000	.032	9.862	.671

a. Design: Intercept
Within Subjects Design: CONDICAO

b. Exact statistic

c. Computed using alpha = ,05

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

chlabel		Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
						Greenhouse-Geisser	Huynh-Feldt	Lower-bound
ROI_Center_Left	CONDICAO	.695	3.637	2	.162	.766	.866	.500
ROI_Center_Mid	CONDICAO	.544	6.093	2	.048	.687	.752	.500
ROI_Center_Right	CONDICAO	.615	4.869	2	.088	.722	.802	.500
ROI_Frontal_Left	CONDICAO	.660	4.160	2	.125	.746	.836	.500
ROI_Frontal_Mid	CONDICAO	.699	3.583	2	.167	.769	.869	.500
ROI_Frontal_Right	CONDICAO	.722	3.258	2	.196	.782	.889	.500
ROI_Parietal	CONDI	.701	3.557	2	.169	.770	.870	.500

_Left350550	CAO							
ROI_Parietal_Mid	CONDICAO	.784	2.433	2	.296	.822	.948	.500
ROI_Parietal_Right	CONDICAO	.936	.667	2	.717	.939	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: CONDICAO

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Sphericity Assumed	20.599	2	10.299	5.372	.013	10.744	.787
		Greenhouse-Geisser	20.599	1.533	13.440	5.372	.022	8.233	.699
		Huynh-Feldt	20.599	1.731	11.897	5.372	.017	9.301	.740
		Lower-bound	20.599	1.000	20.599	5.372	.041	5.372	.561
	Error(CONDICAO)	Sphericity Assumed	42.181	22	1.917				
		Greenhouse-Geisser	42.181	16.859	2.502				
		Huynh-Feldt	42.181	19.046	2.215				
		Lower-bound	42.181	11.000	3.835				
ROI_Center_Mid	CONDICAO	Sphericity Assumed	33.219	2	16.609	8.188	.002	16.376	.932
		Greenhouse-se-	33.219	1.373	24.188	8.188	.007	11.245	.840

		Geisser							
		Huynh-Feldt	33.219	1.504	22.084	8.188	.006	12.316	.865
		Lower-bound	33.219	1.000	33.219	8.188	.015	8.188	.741
	Error(CONDICAO)	Sphericity Assumed	44.628	22	2.029				
		Greenhouse-Geisser	44.628	15.107	2.954				
		Huynh-Feldt	44.628	16.546	2.697				
		Lower-bound	44.628	11.000	4.057				
ROI_Center_Right	CONDICAO	Sphericity Assumed	24.982	2	12.491	6.951	.005	13.903	.885
		Greenhouse-Geisser	24.982	1.444	17.306	6.951	.011	10.035	.791
		Huynh-Feldt	24.982	1.603	15.581	6.951	.009	11.146	.823
		Lower-bound	24.982	1.000	24.982	6.951	.023	6.951	.671
	Error(CONDICAO)	Sphericity Assumed	39.533	22	1.797				
		Greenhouse-Geisser	39.533	15.879	2.490				
		Huynh-Feldt	39.533	17.637	2.241				
		Lower-bound	39.533	11.000	3.594				
ROI_Frontal_Left	CONDICAO	Sphericity Assumed	8.125	2	4.062	1.931	.169	3.863	.357
		Greenhouse-Geisser	8.125	1.492	5.445	1.931	.182	2.882	.303
		Huynh-Feldt	8.125	1.673	4.857	1.931	.177	3.231	.322
		Lower-bound	8.125	1.000	8.125	1.931	.192	1.931	.246
	Error(C	Sphericity	46.27	22	2.103				

	ONDICAO)	Assumed	6						
		Greenhouse-Geisser	46.276	16.414	2.819				
		Huynh-Feldt	46.276	18.402	2.515				
		Lower-bound	46.276	11.000	4.207				
ROI_Frontal_Mid	CONDICAO	Sphericity Assumed	10.129	2	5.065	2.458	.109	4.915	.441
		Greenhouse-Geisser	10.129	1.537	6.590	2.458	.125	3.778	.379
		Huynh-Feldt	10.129	1.738	5.828	2.458	.118	4.271	.407
		Lower-bound	10.129	1.000	10.129	2.458	.145	2.458	.299
	Error(CONDICAO)	Sphericity Assumed	45.338	22	2.061				
		Greenhouse-Geisser	45.338	16.909	2.681				
		Huynh-Feldt	45.338	19.117	2.372				
		Lower-bound	45.338	11.000	4.122				
ROI_Frontal_Right	CONDICAO	Sphericity Assumed	7.763	2	3.881	2.414	.113	4.828	.435
		Greenhouse-Geisser	7.763	1.565	4.961	2.414	.128	3.778	.377
		Huynh-Feldt	7.763	1.778	4.365	2.414	.120	4.293	.406
		Lower-bound	7.763	1.000	7.763	2.414	.149	2.414	.295
	Error(CONDICAO)	Sphericity Assumed	35.372	22	1.608				
		Greenhouse-Geisser	35.372	17.214	2.055				
		Huynh-Feldt	35.372	19.562	1.808				

		Lower-bound	35.372	11.000	3.216				
ROI_Parietal_Left350550	CONDICAO	Sphericity Assumed	29.575	2	14.788	7.114	.004	14.229	.893
		Greenhouse-Geisser	29.575	1.539	19.214	7.114	.009	10.951	.820
		Huynh-Feldt	29.575	1.741	16.988	7.114	.006	12.386	.856
		Lower-bound	29.575	1.000	29.575	7.114	.022	7.114	.681
	Error(CONDICAO)	Sphericity Assumed	45.727	22	2.079				
		Greenhouse-Geisser	45.727	16.932	2.701				
		Huynh-Feldt	45.727	19.151	2.388				
		Lower-bound	45.727	11.000	4.157				
ROI_Parietal_Mid	CONDICAO	Sphericity Assumed	29.816	2	14.908	7.395	.003	14.790	.905
		Greenhouse-Geisser	29.816	1.645	18.128	7.395	.006	12.163	.854
		Huynh-Feldt	29.816	1.896	15.726	7.395	.004	14.021	.892
		Lower-bound	29.816	1.000	29.816	7.395	.020	7.395	.697
	Error(CONDICAO)	Sphericity Assumed	44.352	22	2.016				
		Greenhouse-Geisser	44.352	18.092	2.451				
		Huynh-Feldt	44.352	20.856	2.127				
		Lower-bound	44.352	11.000	4.032				
ROI_Parietal_Right	CONDICAO	Sphericity Assumed	20.153	2	10.076	4.785	.019	9.570	.736
		Greenhouse-Geisser	20.153	1.879	10.726	4.785	.021	8.990	.715

		Geisser							
		Huynh-Feldt	20.153	2.000	10.076	4.785	.019	9.570	.736
		Lower-bound	20.153	1.000	20.153	4.785	.051	4.785	.514
	Error(CONDICAO)	Sphericity Assumed	46.328	22	2.106				
		Greenhouse-Geisser	46.328	20.667	2.242				
		Huynh-Feldt	46.328	22.000	2.106				
		Lower-bound	46.328	11.000	4.212				

a. Computed using alpha = ,05

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Linear	17.811	1	17.811	15.597	.002	15.597	.948
		Quadratic	2.788	1	2.788	1.035	.331	1.035	.154
	Error(CONDICAO)	Linear	12.561	11	1.142				
		Quadratic	29.620	11	2.693				
ROI_Center_Mid	CONDICAO	Linear	25.305	1	25.305	24.461	.000	24.461	.994
		Quadratic	7.914	1	7.914	2.618	.134	2.618	.315
	Error(CONDICAO)	Linear	11.380	11	1.035				
		Quadratic	33.248	11	3.023				
ROI_Center_Right	CONDICAO	Linear	17.959	1	17.959	18.427	.001	18.427	.973

		Quadratic	7.023	1	7.023	2.681	.130	2.681	.322
	Error(CONDICAO)	Linear	10.721	11	.975				
		Quadratic	28.812	11	2.619				
ROI_Frontal_Left	CONDICAO	Linear	5.142	1	5.142	2.715	.128	2.715	.325
		Quadratic	2.983	1	2.983	1.290	.280	1.290	.180
	Error(CONDICAO)	Linear	20.837	11	1.894				
		Quadratic	25.439	11	2.313				
ROI_Frontal_Mid	CONDICAO	Linear	10.115	1	10.115	5.352	.041	5.352	.559
		Quadratic	.014	1	.014	.006	.938	.006	.051
	Error(CONDICAO)	Linear	20.789	11	1.890				
		Quadratic	24.549	11	2.232				
ROI_Frontal_Right	CONDICAO	Linear	7.702	1	7.702	6.379	.028	6.379	.634
		Quadratic	.061	1	.061	.030	.865	.030	.053
	Error(CONDICAO)	Linear	13.282	11	1.207				
		Quadratic	22.089	11	2.008				
ROI_Parietal_Left350550	CONDICAO	Linear	21.554	1	21.554	22.840	.001	22.840	.991
		Quadratic	8.021	1	8.021	2.496	.142	2.496	.303
	Error(CONDICAO)	Linear	10.380	11	.944				
		Quadratic	35.347	11	3.213				
ROI_Parietal_Mid	CONDICAO	Linear	19.736	1	19.736	17.714	.001	17.714	.969
		Quadratic	10.080	1	10.080	3.455	.090	3.455	.396
	Error(CONDICAO)	Linear	12.256	11	1.114				
		Quadratic	32.096	11	2.918				

ROI_Parietal_Right	CONDICAO	Linear	12.711	1	12.711	8.090	.016	8.090	.736
		Quadratic	7.442	1	7.442	2.819	.121	2.819	.335
	Error(CONDICAO)	Linear	17.283	11	1.571				
		Quadratic	29.045	11	2.640				

a. Computed using alpha = ,05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

chlabel		Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	Intercept	48.986	1	48.986	3.662	.082	3.662	.416
	Error	147.161	11	13.378				
ROI_Center_Mid	Intercept	225.686	1	225.686	12.526	.005	12.526	.896
	Error	198.193	11	18.018				
ROI_Center_Right	Intercept	243.246	1	243.246	13.802	.003	13.802	.922
	Error	193.859	11	17.624				
ROI_Frontal_Left	Intercept	19.714	1	19.714	2.113	.174	2.113	.264
	Error	102.630	11	9.330				
ROI_Frontal_Mid	Intercept	78.078	1	78.078	6.098	.031	6.098	.614
	Error	140.834	11	12.803				
ROI_Frontal_Right	Intercept	171.025	1	171.025	11.477	.006	11.477	.869
	Error	163.921	11	14.902				
ROI_Parietal_Left350550	Intercept	5.317	1	5.317	.352	.565	.352	.084
	Error	166.342	11	15.122				

ROI_Parietal_Mid	Intercept	65.286	1	65.286	3.967	.072	3.967	.443
	Error	181.052	11	16.459				
ROI_Parietal_Right	Intercept	137.546	1	137.546	8.762	.013	8.762	.769
	Error	172.677	11	15.698				

a. Computed using alpha = ,05

Estimated Marginal Means

CONDICAO

Estimates

Measure: MEASURE_1

chlabel		Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
ROI_Center_Left	1	-.502	.566	-1.747	.743
	2	-.773	.934	-2.829	1.283
	3	-2.225	.492	-3.307	-1.143
ROI_Center_Mid	1	-1.809	.671	-3.286	-.331
	2	-1.841	1.003	-4.049	.368
	3	-3.862	.618	-5.222	-2.502
ROI_Center_Right	1	-2.047	.601	-3.369	-.725
	2	-1.975	.877	-3.905	-.045
	3	-3.777	.799	-5.535	-2.018
ROI_Frontal_Left	1	-.074	.579	-1.349	1.202
	2	-1.147	.772	-2.846	.552
	3	-.999	.443	-1.975	-.023
ROI_Frontal_Mid	1	-.810	.683	-2.314	.695
	2	-1.501	.842	-3.354	.353
	3	-2.108	.484	-3.173	-1.043

ROI_Frontal _Right	1	-1.642	.664	-3.103	-.182
	2	-2.122	.824	-3.935	-.308
	3	-2.775	.625	-4.150	-1.400
ROI_Parietal _Left350550	1	.230	.517	-.909	1.368
	2	.283	1.018	-1.957	2.523
	3	-1.666	.551	-2.879	-.453
ROI_Parietal _Mid	1	-.814	.488	-1.888	.260
	2	-.598	1.004	-2.808	1.612
	3	-2.628	.679	-4.123	-1.132
ROI_Parietal _Right	1	-1.548	.458	-2.556	-.541
	2	-1.312	.909	-3.313	.690
	3	-3.004	.789	-4.741	-1.267

Pairwise Comparisons

Measure: MEASURE_1

chlabel			Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
ROI_Center _Left	1	2	.271	.529	.619	-.894	1.436
		3	1,723*	.436	.002	.763	2.683
	2	1	-.271	.529	.619	-1.436	.894
		3	1.452	.699	.062	-.086	2.990
	3	1	-1,723*	.436	.002	-2.683	-.763
		2	-1.452	.699	.062	-2.990	.086
ROI_Center _Mid	1	2	.032	.534	.953	-1.142	1.207
		3	2,054*	.415	.000	1.140	2.96

							8
	2	1	-.032	.534	.953	-1.207	1.142
		3	2,021*	.746	.020	.379	3.664
	3	1	-2,054*	.415	.000	-2.968	-1.140
		2	-2,021*	.746	.020	-3.664	-.379
ROI_Center_Right	1	2	-.072	.509	.890	-1.192	1.049
		3	1,730*	.403	.001	.843	2.617
	2	1	.072	.509	.890	-1.049	1.192
		3	1,802*	.691	.024	.282	3.322
	3	1	-1,730*	.403	.001	-2.617	-.843
		2	-1,802*	.691	.024	-3.322	-.282
ROI_Frontal_Left	1	2	1,074*	.440	.033	.105	2.042
		3	.926	.562	.128	-.311	2.162
	2	1	-1,074*	.440	.033	-2.042	-.105
		3	-.148	.737	.845	-1.769	1.473
	3	1	-.926	.562	.128	-2.162	.311
		2	.148	.737	.845	-1.473	1.769
ROI_Frontal_Mid	1	2	.691	.443	.147	-.284	1.666
		3	1,298*	.561	.041	.063	2.534
	2	1	-.691	.443	.147	-1.666	.284
		3	.608	.720	.417	-.978	2.193

	3	1	-1,298*	.561	.041	-2.534	-.063
		2	-.608	.720	.417	-2.193	.978
ROI_Frontal_Right	1	2	.479	.440	.299	-.489	1.447
		3	1,133*	.449	.028	.146	2.120
	2	1	-.479	.440	.299	-1.447	.489
		3	.654	.640	.329	-.754	2.062
	3	1	-1,133*	.449	.028	-2.120	-.146
		2	-.654	.640	.329	-2.062	.754
ROI_Parietal_Left350550	1	2	-.054	.656	.936	-1.498	1.390
		3	1,895*	.397	.001	1.022	2.768
	2	1	.054	.656	.936	-1.390	1.498
		3	1,949*	.672	.014	.470	3.428
	3	1	-1,895*	.397	.001	-2.768	-1.022
		2	-1,949*	.672	.014	-3.428	-.470
ROI_Parietal_Mid	1	2	-.216	.669	.753	-1.689	1.257
		3	1,814*	.431	.001	.865	2.762
	2	1	.216	.669	.753	-1.257	1.689
		3	2,029*	.612	.007	.682	3.376
	3	1	-1,814*	.431	.001	-2.762	-.865
		2	-2,029*	.612	.007	-3.376	-.682
ROI_Parietal_Right	1	2	-.237	.627	.713	-1.618	1.144

		3	1,455*	.512	.016	.329	2.582
	2	1	.237	.627	.713	-1.144	1.618
		3	1,692*	.630	.021	.305	3.080
	3	1	-1,455*	.512	.016	-2.582	-.329
		2	-1,692*	.630	.021	-3.080	-.305

Based on estimated marginal means

*. The mean difference is significant at the ,05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

chlabel		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[b]
ROI_Center_Left	Pillai's trace	.593	7,291[a]	2.000	10.000	.011	14.581	.839
	Wilks' lambda	.407	7,291[a]	2.000	10.000	.011	14.581	.839
	Hotelling's trace	1.458	7,291[a]	2.000	10.000	.011	14.581	.839
	Roy's largest root	1.458	7,291[a]	2.000	10.000	.011	14.581	.839
ROI_Center_Mid	Pillai's trace	.702	11,779[a]	2.000	10.000	.002	23.558	.966
	Wilks' lambda	.298	11,779[a]	2.000	10.000	.002	23.558	.966
	Hotelling's trace	2.356	11,779[a]	2.000	10.000	.002	23.558	.966
	Roy's largest root	2.356	11,779[a]	2.000	10.000	.002	23.558	.966
ROI_Center_Right	Pillai's trace	.629	8,464[a]	2.000	10.000	.007	16.928	.891

	Wilks' lambda	.371	8,464[a]	2.000	10.000	.007	16.928	.891
	Hotelling's trace	1.693	8,464[a]	2.000	10.000	.007	16.928	.891
	Roy's largest root	1.693	8,464[a]	2.000	10.000	.007	16.928	.891
ROI_Frontal_Left	Pillai's trace	.457	4,207[a]	2.000	10.000	.047	8.414	.598
	Wilks' lambda	.543	4,207[a]	2.000	10.000	.047	8.414	.598
	Hotelling's trace	.841	4,207[a]	2.000	10.000	.047	8.414	.598
	Roy's largest root	.841	4,207[a]	2.000	10.000	.047	8.414	.598
ROI_Frontal_Mid	Pillai's trace	.418	3,590[a]	2.000	10.000	.067	7.179	.528
	Wilks' lambda	.582	3,590[a]	2.000	10.000	.067	7.179	.528
	Hotelling's trace	.718	3,590[a]	2.000	10.000	.067	7.179	.528
	Roy's largest root	.718	3,590[a]	2.000	10.000	.067	7.179	.528
ROI_Frontal_Right	Pillai's trace	.414	3,536[a]	2.000	10.000	.069	7.072	.521
	Wilks' lambda	.586	3,536[a]	2.000	10.000	.069	7.072	.521
	Hotelling's trace	.707	3,536[a]	2.000	10.000	.069	7.072	.521
	Roy's largest root	.707	3,536[a]	2.000	10.000	.069	7.072	.521
ROI_Parietal_Left350550	Pillai's trace	.692	11,248[a]	2.000	10.000	.003	22.497	.959
	Wilks' lambda	.308	11,248[a]	2.000	10.000	.003	22.497	.959
	Hotelling's trace	2.250	11,248[a]	2.000	10.000	.003	22.497	.959
	Roy's largest	2.250	11,248[a]	2.000	10.000	.003	22.497	.959

	root							
ROI_Parietal_Mid	Pillai's trace	.684	10,839[a]	2.000	10.000	.003	21.677	.953
	Wilks' lambda	.316	10,839[a]	2.000	10.000	.003	21.677	.953
	Hotelling's trace	2.168	10,839[a]	2.000	10.000	.003	21.677	.953
	Roy's largest root	2.168	10,839[a]	2.000	10.000	.003	21.677	.953
ROI_Parietal_Right	Pillai's trace	.497	4,931[a]	2.000	10.000	.032	9.862	.671
	Wilks' lambda	.503	4,931[a]	2.000	10.000	.032	9.862	.671
	Hotelling's trace	.986	4,931[a]	2.000	10.000	.032	9.862	.671
	Roy's largest root	.986	4,931[a]	2.000	10.000	.032	9.862	.671

Each F tests the multivariate effect of CONDICAO. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = ,05

Appendix 4: SPSS – PASSIVE – ROI – P600 WINDOW

General Linear Model

Notes

Within-Subjects Factors

Measure: MEASURE_1

CONDICAO	Dependent Variable
1	Control
2	Attraction
3	Anom

Multivariate Tests[a]

chlabel			Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[c]
ROI_Center _Left	CONDI CAO	Pillai's Trace	.048	,251[b]	2.000	10.000	.783	.502	.079
		Wilks' Lambda	.952	,251[b]	2.000	10.000	.783	.502	.079
		Hotelling's Trace	.050	,251[b]	2.000	10.000	.783	.502	.079
		Roy's Largest Root	.050	,251[b]	2.000	10.000	.783	.502	.079
ROI_Center _Mid	CONDI CAO	Pillai's Trace	.063	,338[b]	2.000	10.000	.721	.676	.090
		Wilks' Lambda	.937	,338[b]	2.000	10.000	.721	.676	.090
		Hotelling's Trace	.068	,338[b]	2.000	10.000	.721	.676	.090
		Roy's Largest Root	.068	,338[b]	2.000	10.000	.721	.676	.090
ROI_Center _Right	CONDI CAO	Pillai's Trace	.063	,337[b]	2.000	10.000	.722	.675	.090
		Wilks' Lambda	.937	,337[b]	2.000	10.000	.722	.675	.090

		Hotelling's Trace	.067	,337[b]	2.000	10.000	.722	.675	.090
		Roy's Largest Root	.067	,337[b]	2.000	10.000	.722	.675	.090
ROI_Frontal_Left	CONDICAO	Pillai's Trace	.485	4,715[b]	2.000	10.000	.036	9.430	.650
		Wilks' Lambda	.515	4,715[b]	2.000	10.000	.036	9.430	.650
		Hotelling's Trace	.943	4,715[b]	2.000	10.000	.036	9.430	.650
		Roy's Largest Root	.943	4,715[b]	2.000	10.000	.036	9.430	.650
ROI_Frontal_Mid	CONDICAO	Pillai's Trace	.308	2,229[b]	2.000	10.000	.158	4.458	.350
		Wilks' Lambda	.692	2,229[b]	2.000	10.000	.158	4.458	.350
		Hotelling's Trace	.446	2,229[b]	2.000	10.000	.158	4.458	.350
		Roy's Largest Root	.446	2,229[b]	2.000	10.000	.158	4.458	.350
ROI_Frontal_Right	CONDICAO	Pillai's Trace	.232	1,511[b]	2.000	10.000	.267	3.022	.249
		Wilks' Lambda	.768	1,511[b]	2.000	10.000	.267	3.022	.249
		Hotelling's Trace	.302	1,511[b]	2.000	10.000	.267	3.022	.249
		Roy's Largest Root	.302	1,511[b]	2.000	10.000	.267	3.022	.249
ROI_Parietal_Left500800	CONDICAO	Pillai's Trace	.060	,321[b]	2.000	10.000	.733	.642	.088
		Wilks' Lambda	.940	,321[b]	2.000	10.000	.733	.642	.088
		Hotelling's Trace	.064	,321[b]	2.000	10.000	.733	.642	.088
		Roy's Largest Root	.064	,321[b]	2.000	10.000	.733	.642	.088
ROI_Parietal_Mid	CONDICAO	Pillai's Trace	.143	,834[b]	2.000	10.000	.462	1.668	.155
		Wilks' Lambda	.857	,834[b]	2.000	10.000	.462	1.668	.155
		Hotelling's Trace	.167	,834[b]	2.000	10.000	.462	1.668	.155

		Roy's Largest Root	.167	,834[b]	2.000	10.000	.462	1.668	.155
ROI_Pariet al_Right	CONDI CAO	Pillai's Trace	.172	1,041[b]	2.000	10.000	.389	2.081	.183
		Wilks' Lambda	.828	1,041[b]	2.000	10.000	.389	2.081	.183
		Hotelling's Trace	.208	1,041[b]	2.000	10.000	.389	2.081	.183
		Roy's Largest Root	.208	1,041[b]	2.000	10.000	.389	2.081	.183

a. Design: Intercept
Within Subjects Design: CONDICAO

b. Exact statistic

c. Computed using alpha = ,05

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

chlabel		Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
						Greenhouse-Geisser	Huynh-Feldt	Lower-bound
ROI_Center_Left	CONDI CAO	.595	5.184	2	.075	.712	.788	.500
ROI_Center_Mid	CONDI CAO	.688	3.743	2	.154	.762	.860	.500
ROI_Center_Right	CONDI CAO	.478	7.376	2	.025	.657	.711	.500
ROI_Frontal_Left	CONDI CAO	.491	7.122	2	.028	.662	.718	.500
ROI_Frontal_Mid	CONDI CAO	.451	7.972	2	.019	.645	.695	.500
ROI_Frontal_Right	CONDI CAO	.327	11.164	2	.004	.598	.630	.500
ROI_Parietal_Left500800	CONDI CAO	.729	3.155	2	.207	.787	.896	.500
ROI_Parietal_Mid	CONDI CAO	.917	.870	2	.647	.923	1.000	.500
ROI_Pariet	CONDI	.653	4.255	2	.119	.743	.832	.500

al_Right	CAO							

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: CONDICAO

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Sphericity Assumed	1.562	2	.781	.254	.778	.508	.085
		Greenhouse-Geisser	1.562	1.424	1.097	.254	.704	.362	.079
		Huynh-Feldt	1.562	1.576	.991	.254	.726	.400	.081
		Lower-bound	1.562	1.000	1.562	.254	.624	.254	.075
	Error(CONDICAO)	Sphericity Assumed	67.639	22	3.074				
		Greenhouse-Geisser	67.639	15.664	4.318				
		Huynh-Feldt	67.639	17.331	3.903				
		Lower-bound	67.639	11.000	6.149				
ROI_Center_Mid	CONDICAO	Sphericity Assumed	3.247	2	1.623	.580	.568	1.160	.134
		Greenhouse-Geisser	3.247	1.524	2.130	.580	.526	.884	.122
		Huynh-Feldt	3.247	1.719	1.889	.580	.545	.997	.127
		Lower-bound	3.247	1.000	3.247	.580	.462	.580	.107
	Error(CONDICAO)	Sphericity Assumed	61.596	22	2.800				
		Greenhouse-Geisser	61.596	16.765	3.674				

		Huynh-Feldt	61.596	18.909	3.257				
		Lower-bound	61.596	11.000	5.600				
ROI_Center_Right	CONDICAO	Sphericity Assumed	2.890	2	1.445	.629	.542	1.259	.142
		Greenhouse-Geisser	2.890	1.314	2.199	.629	.483	.827	.122
		Huynh-Feldt	2.890	1.422	2.032	.629	.494	.895	.126
		Lower-bound	2.890	1.000	2.890	.629	.444	.629	.112
	Error(CONDICAO)	Sphericity Assumed	50.502	22	2.296				
		Greenhouse-Geisser	50.502	14.457	3.493				
		Huynh-Feldt	50.502	15.640	3.229				
		Lower-bound	50.502	11.000	4.591				
ROI_Frontal_Left	CONDICAO	Sphericity Assumed	9.266	2	4.633	1.655	.214	3.309	.311
		Greenhouse-Geisser	9.266	1.325	6.993	1.655	.224	2.192	.249
		Huynh-Feldt	9.266	1.437	6.450	1.655	.222	2.377	.260
		Lower-bound	9.266	1.000	9.266	1.655	.225	1.655	.217
	Error(CONDICAO)	Sphericity Assumed	61.604	22	2.800				
		Greenhouse-Geisser	61.604	14.575	4.227				
		Huynh-Feldt	61.604	15.803	3.898				
		Lower-bound	61.604	11.000	5.600				
ROI_Frontal_Mid	CONDICAO	Sphericity Assumed	4.162	2	2.081	.645	.534	1.291	.144
		Greenhouse-Geisser	4.162	1.291	3.224	.645	.474	.833	.123
		Huynh-Feldt	4.162	1.389	2.995	.645	.484	.897	.127
		Lower-bound	4.162	1.000	4.162	.645	.439	.645	.114
	Error(C	Sphericity	70.919	22	3.224				

	ONDICAO)	Assumed								
		Greenhouse-Geisser	70.919	14.199	4.995					
		Huynh-Feldt	70.919	15.283	4.640					
		Lower-bound	70.919	11.000	6.447					
ROI_Frontal_Right	CONDICAO	Sphericity Assumed	1.844	2	.922	.322	.728	.643	.095
		Greenhouse-Geisser	1.844	1.196	1.542	.322	.620	.384	.084
		Huynh-Feldt	1.844	1.260	1.464	.322	.631	.405	.085
		Lower-bound	1.844	1.000	1.844	.322	.582	.322	.081
	Error(CONDICAO)	Sphericity Assumed	63.090	22	2.868				
		Greenhouse-Geisser	63.090	13.154	4.796				
		Huynh-Feldt	63.090	13.856	4.553				
		Lower-bound	63.090	11.000	5.735				
ROI_Parietal_Left500800	CONDICAO	Sphericity Assumed	2.505	2	1.252	.406	.671	.812	.107
		Greenhouse-Geisser	2.505	1.574	1.591	.406	.624	.639	.100
		Huynh-Feldt	2.505	1.792	1.398	.406	.650	.728	.104
		Lower-bound	2.505	1.000	2.505	.406	.537	.406	.090
	Error(CONDICAO)	Sphericity Assumed	67.845	22	3.084				
		Greenhouse-Geisser	67.845	17.315	3.918				
		Huynh-Feldt	67.845	19.710	3.442				
		Lower-bound	67.845	11.000	6.168				
ROI_Parietal_Mid	CONDICAO	Sphericity Assumed	5.993	2	2.997	1.101	.350	2.203	.218
		Greenhouse-Geisser	5.993	1.846	3.246	1.101	.347	2.033	.210

		Huynh-Feldt	5.993	2.000	2.997	1.101	.350	2.203	.218
		Lower-bound	5.993	1.000	5.993	1.101	.316	1.101	.160
	Error(CONDICAO)	Sphericity Assumed	59.866	22	2.721				
		Greenhouse-Geisser	59.866	20.308	2.948				
		Huynh-Feldt	59.866	22.000	2.721				
		Lower-bound	59.866	11.000	5.442				
ROI_Parietal_Right	CONDICAO	Sphericity Assumed	6.371	2	3.185	1.524	.240	3.048	.289
		Greenhouse-Geisser	6.371	1.485	4.289	1.524	.244	2.264	.247
		Huynh-Feldt	6.371	1.663	3.831	1.524	.243	2.535	.262
		Lower-bound	6.371	1.000	6.371	1.524	.243	1.524	.204
	Error(CONDICAO)	Sphericity Assumed	45.978	22	2.090				
		Greenhouse-Geisser	45.978	16.338	2.814				
		Huynh-Feldt	45.978	18.294	2.513				
		Lower-bound	45.978	11.000	4.180				

a. Computed using alpha = ,05

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

chlabel			Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	CONDICAO	Linear	.954	1	.954	.552	.473	.552	.104
		Quadratic	.608	1	.608	.137	.718	.137	.063
	Error(CONDICAO)	Linear	18.990	11	1.726				
		Quadratic	48.649	11	4.423				
ROI_Center	CONDI	Linear	.351	1	.351	.224	.645	.224	.072

_Mid	CAO	Quadratic	2.895	1	2.895	.718	.415	.718	.121
	Error(CONDICAO)	Linear	17.238	11	1.567				
		Quadratic	44.358	11	4.033				
ROI_Center_Right	CONDICAO	Linear	.253	1	.253	.303	.593	.303	.080
		Quadratic	2.637	1	2.637	.702	.420	.702	.120
	Error(CONDICAO)	Linear	9.179	11	.834				
		Quadratic	41.323	11	3.757				
ROI_Frontal_Left	CONDICAO	Linear	4.615	1	4.615	3.094	.106	3.094	.362
		Quadratic	4.651	1	4.651	1.132	.310	1.132	.164
	Error(CONDICAO)	Linear	16.409	11	1.492				
		Quadratic	45.196	11	4.109				
ROI_Frontal_Mid	CONDICAO	Linear	2.922	1	2.922	1.734	.215	1.734	.226
		Quadratic	1.240	1	1.240	.260	.620	.260	.075
	Error(CONDICAO)	Linear	18.532	11	1.685				
		Quadratic	52.387	11	4.762				
ROI_Frontal_Right	CONDICAO	Linear	1.039	1	1.039	.759	.402	.759	.125
		Quadratic	.805	1	.805	.184	.676	.184	.068
	Error(CONDICAO)	Linear	15.046	11	1.368				
		Quadratic	48.044	11	4.368				
ROI_Parietal_Left500800	CONDICAO	Linear	.007	1	.007	.004	.952	.004	.050
		Quadratic	2.498	1	2.498	.577	.463	.577	.107
	Error(CONDICAO)	Linear	20.261	11	1.842				
		Quadratic	47.584	11	4.326				
ROI_Parietal_Mid	CONDICAO	Linear	.186	1	.186	.095	.764	.095	.059
		Quadratic	5.807	1	5.807	1.668	.223	1.668	.219
	Error(CONDICAO)	Linear	21.575	11	1.961				
		Quadratic	38.291	11	3.481				
ROI_Parietal_Right	CONDICAO	Linear	.211	1	.211	.241	.633	.241	.073
		Quadratic	6.159	1	6.159	1.864	.199	1.864	.239
	Error(CONDICAO)	Linear	9.627	11	.875				
		Quadratic	36.350	11	3.305				

a. Computed using alpha = ,05

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

chlabel		Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power[a]
ROI_Center_Left	Intercept	37.790	1	37.790	3.210	.101	3.210	.373
	Error	129.503	11	11.773				
ROI_Center_Mid	Intercept	.869	1	.869	.069	.798	.069	.057
	Error	138.508	11	12.592				
ROI_Center_Right	Intercept	6.840	1	6.840	.705	.419	.705	.120
	Error	106.692	11	9.699				
ROI_Frontal_Left	Intercept	41.719	1	41.719	5.394	.040	5.394	.563
	Error	85.080	11	7.735				
ROI_Frontal_Mid	Intercept	19.397	1	19.397	2.207	.165	2.207	.274
	Error	96.656	11	8.787				
ROI_Frontal_Right	Intercept	3.422	1	3.422	.354	.564	.354	.085
	Error	106.186	11	9.653				
ROI_Parietal_Left500800	Intercept	111.989	1	111.989	7.117	.022	7.117	.681
	Error	173.100	11	15.736				
ROI_Parietal_Mid	Intercept	37.461	1	37.461	2.145	.171	2.145	.268
	Error	192.140	11	17.467				
ROI_Parietal_Right	Intercept	2.181	1	2.181	.127	.728	.127	.062

Error	188.514	11	17.138				

a. Computed using alpha = ,05

Estimated Marginal Means

CONDICAO

Estimates

Measure: MEASURE_1

chlabel		Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
ROI_Center_Left	1	1.132	.563	-.106	2.370
	2	1.208	.940	-.860	3.277
	3	.733	.542	-.459	1.926
ROI_Center_Mid	1	.076	.621	-1.291	1.443
	2	.556	.922	-1.473	2.586
	3	-.166	.529	-1.330	.998
ROI_Center_Right	1	-.525	.449	-1.514	.465
	2	-.053	.855	-1.935	1.829
	3	-.730	.508	-1.848	.388
ROI_Frontal_Left	1	1.769	.539	.584	2.955
	2	.568	.789	-1.168	2.304
	3	.892	.446	-.090	1.874
ROI_Fronta	1	1.214	.552	-.002	2.430

l_Mid	2	.472	.836	-1.367	2.311
	3	.516	.516	-.619	1.652
ROI_Frontal_Right	1	.005	.501	-1.098	1.109
	2	-.520	.818	-2.321	1.281
	3	-.411	.601	-1.734	.913
ROI_Parietal_Left500800	1	1.560	.635	.163	2.958
	2	2.136	.960	.024	4.248
	3	1.595	.708	.036	3.153
ROI_Parietal_Mid	1	.648	.661	-.806	2.102
	2	1.588	.926	-.449	3.625
	3	.824	.785	-.903	2.552
ROI_Parietal_Right	1	-.632	.623	-2.003	.738
	2	.339	.917	-1.679	2.357
	3	-.445	.740	-2.075	1.185

Pairwise Comparisons

Measure: MEASURE_1

chlabel			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
ROI_Center_Left	1	2	-.076	.648	.908	-1.503	1.351
		3	.399	.536	.473	-.782	1.579
	2	1	.076	.648	.908	-1.351	1.503
		3	.475	.911	.612	-1.529	2.479
	3	1	-.399	.536	.473	-1.579	.782
		2	-.475	.911	.612	-2.479	1.529

ROI_Center_Mid	1	2	-.481	.656	.479	-1.924	.963
		3	.242	.511	.645	-.883	1.367
	2	1	.481	.656	.479	-.963	1.924
		3	.723	.842	.409	-1.130	2.575
	3	1	-.242	.511	.645	-1.367	.883
		2	-.723	.842	.409	-2.575	1.130
ROI_Center_Right	1	2	-.471	.625	.467	-1.848	.905
		3	.205	.373	.593	-.615	1.026
	2	1	.471	.625	.467	-.905	1.848
		3	.677	.786	.408	-1.053	2.406
	3	1	-.205	.373	.593	-1.026	.615
		2	-.677	.786	.408	-2.406	1.053
ROI_Frontal_Left	1	2	1.201	.598	.070	-.115	2.517
		3	.877	.499	.106	-.220	1.974
	2	1	-1.201	.598	.070	-2.517	.115
		3	-.324	.891	.723	-2.285	1.637
	3	1	-.877	.499	.106	-1.974	.220
		2	.324	.891	.723	-1.637	2.285
ROI_Frontal_Mid	1	2	.743	.634	.266	-.652	2.138
		3	.698	.530	.215	-.468	1.864
	2	1	-.743	.634	.266	-2.138	.652
		3	-.045	.964	.964	-2.167	2.077
	3	1	-.698	.530	.215	-1.864	.468
		2	.045	.964	.964	-2.077	2.167
ROI_Frontal_Right	1	2	.525	.584	.388	-.761	1.812
		3	.416	.477	.402	-.635	1.467
	2	1	-.525	.584	.388	-1.812	.761
		3	-.109	.930	.909	-2.156	1.937
	3	1	-.416	.477	.402	-1.467	.635
		2	.109	.930	.909	-1.937	2.156
ROI_Pariet	1	2	-.576	.686	.419	-2.086	.935

al_Left500800		3	-.034	.554	.952	-1.254	1.185
	2	1	.576	.686	.419	-.935	2.086
		3	.542	.874	.548	-1.382	2.465
	3	1	.034	.554	.952	-1.185	1.254
		2	-.542	.874	.548	-2.465	1.382
ROI_Parietal_Mid	1	2	-.940	.699	.206	-2.478	.598
		3	-.176	.572	.764	-1.435	1.082
	2	1	.940	.699	.206	-.598	2.478
		3	.764	.739	.323	-.862	2.390
	3	1	.176	.572	.764	-1.082	1.435
		2	-.764	.739	.323	-2.390	.862
ROI_Parietal_Right	1	2	-.971	.649	.163	-2.400	.457
		3	-.188	.382	.633	-1.028	.653
	2	1	.971	.649	.163	-.457	2.400
		3	.784	.691	.281	-.738	2.305
	3	1	.188	.382	.633	-.653	1.028
		2	-.784	.691	.281	-2.305	.738

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

chlabel		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[b]
ROI_Center_Left	Pillai's trace	.048	,251[a]	2.000	10.000	.783	.502	.079
	Wilks' lambda	.952	,251[a]	2.000	10.000	.783	.502	.079
	Hotelling's trace	.050	,251[a]	2.000	10.000	.783	.502	.079
	Roy's largest root	.050	,251[a]	2.000	10.000	.783	.502	.079

ROI_Center_Mid	Pillai's trace	.063	,338[a]	2.000	10.000	.721	.676	.090
	Wilks' lambda	.937	,338[a]	2.000	10.000	.721	.676	.090
	Hotelling's trace	.068	,338[a]	2.000	10.000	.721	.676	.090
	Roy's largest root	.068	,338[a]	2.000	10.000	.721	.676	.090
ROI_Center_Right	Pillai's trace	.063	,337[a]	2.000	10.000	.722	.675	.090
	Wilks' lambda	.937	,337[a]	2.000	10.000	.722	.675	.090
	Hotelling's trace	.067	,337[a]	2.000	10.000	.722	.675	.090
	Roy's largest root	.067	,337[a]	2.000	10.000	.722	.675	.090
ROI_Frontal_Left	Pillai's trace	.485	4,715[a]	2.000	10.000	.036	9.430	.650
	Wilks' lambda	.515	4,715[a]	2.000	10.000	.036	9.430	.650
	Hotelling's trace	.943	4,715[a]	2.000	10.000	.036	9.430	.650
	Roy's largest root	.943	4,715[a]	2.000	10.000	.036	9.430	.650
ROI_Frontal_Mid	Pillai's trace	.308	2,229[a]	2.000	10.000	.158	4.458	.350
	Wilks' lambda	.692	2,229[a]	2.000	10.000	.158	4.458	.350
	Hotelling's trace	.446	2,229[a]	2.000	10.000	.158	4.458	.350
	Roy's largest root	.446	2,229[a]	2.000	10.000	.158	4.458	.350
ROI_Frontal_Right	Pillai's trace	.232	1,511[a]	2.000	10.000	.267	3.022	.249
	Wilks'	.768	1,511[a]	2.000	10.000	.267	3.022	.249

	lambda							
	Hotelling's trace	.302	1,511[a]	2.000	10.000	.267	3.022	.249
	Roy's largest root	.302	1,511[a]	2.000	10.000	.267	3.022	.249
ROI_Parietal_Left500800	Pillai's trace	.060	,321[a]	2.000	10.000	.733	.642	.088
	Wilks' lambda	.940	,321[a]	2.000	10.000	.733	.642	.088
	Hotelling's trace	.064	,321[a]	2.000	10.000	.733	.642	.088
	Roy's largest root	.064	,321[a]	2.000	10.000	.733	.642	.088
ROI_Parietal_Mid	Pillai's trace	.143	,834[a]	2.000	10.000	.462	1.668	.155
	Wilks' lambda	.857	,834[a]	2.000	10.000	.462	1.668	.155
	Hotelling's trace	.167	,834[a]	2.000	10.000	.462	1.668	.155
	Roy's largest root	.167	,834[a]	2.000	10.000	.462	1.668	.155
ROI_Parietal_Right	Pillai's trace	.172	1,041[a]	2.000	10.000	.389	2.081	.183
	Wilks' lambda	.828	1,041[a]	2.000	10.000	.389	2.081	.183
	Hotelling's trace	.208	1,041[a]	2.000	10.000	.389	2.081	.183
	Roy's largest root	.208	1,041[a]	2.000	10.000	.389	2.081	.183

Appendix 5: STIMULI – ACTIVE – CONTROL CONDITION

Stim	Agent/ Subject	Verb	Object	PostText
1	The chiropracter	adjusted	the hurt wrestler	after the fight.
2	The reporter	announced	the lottery winner	during the news.
3	The crowd	applauded	the funny comedian	excitedly.
4	The inspector	approved	the regional bank	at noon.
5	The detective	arrested	the sneaky thief	in New York.
6	The secretary	assisted	the spry executive	with the project.
7	The bear	attacked	the audacious hiker	on the trail.
8	The oven	baked	the tasty cake	for the birthday.
9	The editor	banned	the crude author	last year.
10	The pitbull	bit	the old mailman	at the park.
11	The groom	carried	the glowing bride	at the wedding.
12	The angler	caught	the red fish	at the lake.
13	The hunter	chased	the male deer	in the forest.
14	The maid	cleaned	the dirty vacuum	yesterday.
15	The mountaineer	climbed	the high ledge	during the day.
16	The pastor	consoled	the widowed wife	last month.
17	The accountant	consulted	the business owner	during the lunch.
18	The frog	consumed	the luscious fly	by the pond.
19	The chef	cooked	the delicious dish	at the restaurant.
20	The controller	coordinated	the airport crew	from the tower.
21	The tutor	counted	the small class	before the bell.
22	The movie reviewer	critiqued	the film director	in the article.
23	The butcher	cut	the fresh meat	for each customer.
24	The bodyguard	defended	the sly politician	from the attacker.
25	John	devoured	the hearty meal	at the table.

26	The producer	directed	the novice actress	during the new movie.
27	The designer	discovered	the exotic supermodel	after the show.
28	The mother	dressed	the young daughter	for school.
29	The citizens	elected	the popular senator	last month.
30	The CEO	evaluated	the company staff	frequently.
31	The physician	examined	the terminal patient	quickly.
32	The zookeeper	fed	the cuddly chimpanzee	with love.
33	The deputy	fingerprinted	the bad criminal	at the station.
34	The pilot	flew	the modern airplane	in the storm.
35	The offender	fooled	the fair judge	during court.
36	The outfielder	grabbed	the pop fly	with the glove.
37	The advisor	graded	the smart scholar	during the internship.
38	The butler	helped	the stubborn boss	for brunch.
39	The homeowner	hired	the rude electrician	to fix the wires.
40	The family	identified	the accident victim	at the hospital.
41	The parrot	imitated	the crazy vet	at the zoo.
42	Oprah	interviewed	the famed singer	during the summer.
43	The researcher	invented	the great machine	at the university.
44	The agent	investigated	the government bureau	thoroughly.
45	The player	kicked	the rubber ball	twice.
46	The terrorist	kidnapped	the wise diplomat	at the conference.
47	The assassin	killed	the poor tramp	instantly.
48	The professor	lectured	the good student	at length.
49	The athlete	lifted	the heavy dumbell	at the gym.
50	The priest	married	the happy couple	at the church.
51	Millions of people	mourned	Mother Theresa	around the world.
52	The biologist	observed	the rare bird	in the field.
53	The manager	paid	the new employee	on Friday.

54	The artist	painted	the personal portrait	on the canvas.
55	The paparazzo	photographed	the famous celebrity	during the premiere.
56	The police	questioned	the crime suspect	for six hours.
57	The president	received	the national press	after the election.
58	The firefighter	rescued	the elderly lady	last night.
59	The scientist	researched	the intriguing topic	through the experiment.
60	The burglar	robbed	the naive tourist	in the hotel.
61	The monster	scared	the little girl	immensely.
62	The cat	scratched	the kind neighbour	on the nose.
63	The jury	sentenced	the cruel assailant	to life in prison.
64	The waitress	served	the patient customer	promptly.
65	The barber	shaved	the bearded guy	delicately.
66	The gunman	shot	the skinny teenager	at the school.
67	The painter	sketched	the nice watercolor	at work.
68	The beggar	solicited	the rich businessman	on the street.
69	The python	squeezed	the wild boar	in the jungle.
70	The doctor	stitched	the reckless teen	expertly.
71	The plaintiff	sued	the savvy defendant	for millions.
72	The whale	swallowed	the blue krill	in the Atlantic ocean.
73	The defense	tackled	the football player	at the goal line.
74	The teacher	taught	the biology course	in the morning.
75	The quarterback	threw	the leather football	into the air.
76	The busy man	tipped	the taxi driver	as he left the car.
77	The warden	transferred	the sinewy prisoner	to the courthouse.
78	The specialist	treated	the ill convalescent	at the clinic.
79	The magician	tricked	the interested fan	with ease.
80	The grandmother	visited	the lovely newborn	at the maternity ward.
81	The sitter	walked	the teeny dog	every weekend.

Appendix 6: STIMULI – ACTIVE – ROLE-REVERSED CONDITION

Stim	Agent/Subject	Verb	Object	PostText
1	The hurt wrestler	adjusted	the apt chiropracter	after the fight.
2	The lottery winner	announced	the TV reporter	during the news.
3	The comedian	applauded	the large crowd	excitedly.
4	The regional bank	approved	the strict inspector	at noon.
5	The sneaky thief	arrested	the mature detective	in New York.
6	The spry executive	assisted	the clever secretary	with the project.
7	The audacious hiker	attacked	the angry bear	on the trail.
8	The gas oven	baked	the metal pan	for the birthday.
9	The crude author	banned	the magazine editor	last year.
10	The old mailman	bit	the callous pitbull	at the park.
11	The glowing bride	carried	the nervous groom	at the wedding.
12	The red fish	caught	the expert angler	at the lake.
13	The male deer	chased	the lethal hunter	in the forest.
14	The dirty vacuum	cleaned	the young maid	yesterday.
15	The sweet toddler	climbed	the able mountaineer	during the day.
16	The widowed wife	consoled	the beloved pastor	last month.
17	The business owner	consulted	the short accountant	during the lunch.
18	The luscious fly	consumed	the muddy frog	by the pond.
19	The hot sun	cooked	the ordinary chef	at the restaurant.
20	The airport crew	coordinated	the alert controller	from the tower.
21	The small class	counted	the math tutor	before the bell.
22	The film director	critiqued	the movie reviewer	in the article.
23	The portly surgeon	cut	the obese butcher	for each customer.
24	The sly politician	defended	the loyal bodyguard	from the attacker.
25	John	devoured	the hungry lion	at the table.
26	The novice actress	directed	the genious producer	during the new movie.

27	The exotic supermodel	discovered	the fashion designer	after the show.
28	The young daughter	dressed	the benign mother	for school.
29	The popular senators	elected	the american citizen	last month.
30	The company staff	evaluated	the company CEO	frequently.
31	The terminal patient	examined	the focused physician	quickly.
32	The cuddly chimpanzee	fed	the sad zookeeper	with love.
33	The bad criminal	fingerprinted	the eager deputy	at the station.
34	The modern airplane	flew	the calm pilot	in the storm.
35	The fair judge	fooled	the repeat offender	during court.
36	The pop fly	grabbed	the outfielder	with the glove.
37	The smart scholar	graded	the clever advisor	during the internship.
38	The stubborn boss	helped	the amiable butler	for brunch.
39	The rude electrician	hired	the homeowner	to fix the wires.
40	The accident victim	identified	the foreign family	at the hospital.
41	The crazy vet	imitated	the green parrot	at the zoo.
42	The famed singer	interviewed	popular Oprah	during the summer.
43	The great machine	invented	the lively researcher	at the university.
44	The government bureau	investigated	the FBI agent	thoroughly.
45	The rubber ball	kicked	the soccer player	twice.
46	The wise diplomat	kidnapped	the scary terrorist	at the conference.
47	The poor tramp	killed	the quiet assassin	instantly.
48	The good student	lectured	the jolly professor	at length.
49	The heavy dumbell	lifted	the strong athlete	at the gym.
50	The happy couple	married	the pious priest	at the church.
51	Mother Theresa	mourned	millions of people	around the world.
52	The rare bird	observed	the quiet biologist	in the field.
53	The new employee	paid	the powerful manager	on Friday.
54	The personal portrait	painted	the excentric artist	on the canvas.

55	The famous celebrity	photographed	the nasty paparazzo	during the premiere.
56	The crime suspect	questioned	the reliable officer	for six hours.
57	The national press	received	the latest president	after the election.
58	The elderly lady	rescued	the brave firefighter	last night.
59	The intriguing topic	researched	the noisy scientist	through the experiment.
60	The naive tourist	robbed	the silly burglar	in the hotel.
61	The little girl	scared	the slimy monster	immensely.
62	The kind neighbour	scratched	the fluffy cat	on the nose.
63	The cruel assailant	sentenced	the biased jury	to life in prison.
64	The patient customer	served	the glad waitress	promptly.
65	The bearded guy	shaved	the friendly barber	delicately.
66	The skinny teenager	shot	the insane gunman	at the school.
67	The nice watercolor	sketched	the brilliant painter	at work.
68	The rich businessman	solicited	the drunk beggar	on the street.
69	The wild boar	squeezed	the long python	in the jungle.
70	The reckless teen	stitched	the gentle doctor	expertly.
71	The savvy defendant	sued	the mean plaintiff	for millions.
72	The blue krill	swallowed	the white whale	in the Atlantic ocean.
73	The football player	tackled	the tough defense	at the goal line.
74	The biology course	taught	the best teacher	in the morning.
75	The leather football	threw	the tall quarterback	into the air.
76	The taxi driver	tipped	the busy man	as he left the car.
77	The sinewy prisoner	transferred	the angry warden	to the courthouse.
78	The ill convalescent	treated	the cardio specialist	at the clinic.
79	The interested fan	tricked	the American magician	with ease.
80	The lovely newborn	visited	the jolly grandmother	at the maternity ward.
81	The teeny dog	walked	the fat sitter	every weekend.

Appendix 7: STIMULI – ACTIVE – ANOMALOUS CONDITION

Stim	Agent/ Subject	Verb	Object (Anomaly)	PostText
1	The chiropracter	adjusted	the violet scarf	after the fight.
2	The reporter	announced	the clean window	during the news.
3	The crowd	applauded	the shiny shoe	excitedly.
4	The inspector	approved	the vertical blind	at noon.
5	The detective	arrested	the faint ghost	in New York.
6	The secretary	assisted	the plastic stapler	with the project.
7	The bear	attacked	the large battery	on the trail.
8	The oven	baked	the school library	for the birthday.
9	The editor	banned	the mild earthquake	last year.
10	The pitbull	bit	the yellow bicycle	at the park.
11	The groom	carried	the strong wind	at the wedding.
12	The angler	caught	the loud music	at the lake.
13	The hunter	chased	the new television	in the forest.
14	The maid	cleaned	the nice paper	yesterday.
15	The mountaineer	climbed	the black light	during the day.
16	The pastor	consoled	the metal hanger	last month.
17	The accountant	consulted	the soft pillow	during the lunch.
18	The frog	consumed	the ice truck	by the pond.
19	The chef	cooked	the waxed car	at the new restaurant.
20	The controller	coordinated	the old radio	from the tower.
21	The tutor	counted	the pure water	at the party.
22	The movie reviewer	critiqued	the linen sheet	in the article.
23	The butcher	cut	the color printer	for each customer.
24	The bodyguard	defended	the clean kitchen	from the attacker.
25	John	devoured	the dirty tabletops	at the table.
26	The producer	directed	the snowboard	for the new movie.

27	The designer	discovered	the pretty smile	after the show.
28	The mother	dressed	the living room	for school.
29	The citizens	elected	the italian cheese	last month.
30	The CEO	evaluated	the warm sock	frequently.
31	The physician	examined	the blunt pencil	quickly.
32	The zookeeper	fed	the stinky bathroom	with love.
33	The deputy	fingerprinted	the wood table	at the station.
34	The pilot	flew	the bony elbow	in the storm.
35	The offender	fooled	the silver doorknob	during court.
36	The outfielder	grabbed	the melody	strongly.
37	The advisor	graded	the silk blanket	during the internship.
38	The butler	helped	the birthday card	for brunch.
39	The homeowner	hired	the office shelf	to fix the wires.
40	The family	identified	the bad feeling	at the hospital.
41	The parrot	imitated	the tv remote	at the zoo.
42	Popular Oprah	interviewed	the jean jacket	during the summer.
43	The researcher	invented	the blue sky	at the university.
44	The agent	investigated	the queen bed	thoroughly.
45	The player	kicked	the long book	twice.
46	The terrorist	kidnapped	the noisy siren	at the conference.
47	The assassin	killed	the thin wall	instantly.
48	The professor	lectured	the bird feather	at length.
49	The athlete	lifted	the ironed suit	at the gym.
50	The priest	married	the fat hip	at the church.
51	Millions of people	mourned	the bath tub	around the world.
52	The biologist	observed	the good idea	in the field.
53	The manager	paid	the dangerous rocket	on Friday.
54	The artist	painted	the fast computer	on the canvas.

55	The paparazzo	photographed	the white noise	during the premiere.
56	The police	questioned	the steep roof	for six hours.
57	The president	received	the dry air	after the election.
58	The firefighter	rescued	the rolling thunder	last night.
59	The scientist	researched	the elegant lamp	through the experiment.
60	The burglar	robbed	the super tsunami	in the hotel.
61	The monster	scared	the small desk	immensely.
62	The cat	scratched	the baked potato	on the nose.
63	The jury	sentenced	the worst electronic	to life in prison.
64	The waitress	served	the big comet	promptly.
65	The barber	shaved	the beige telephone	delicaltely.
66	The gunman	shot	the basketball	at the school.
67	The painter	sketched	the intense hurricane	at work.
68	The beggar	solicited	the green tree	on the street.
69	The python	squeezed	the sharp needle	in the jungle.
70	The doctor	stitched	the bright star	expertly.
71	The plaintiff	sued	the warm sunshine	for millions.
72	The whale	swallowed	the steamy attic	in the Atlantic ocean.
73	The defense	tackled	the dim garage	at the goal line.
74	The teacher	taught	the broken chair	in the morning.
75	The quarterback	threw	the strange notion	into the air.
76	The busy man	tipped	the wet sink	as he left the car.
77	The warden	transferred	the alarm clock	to the courthouse.
78	The specialist	treated	the gold ring	at the clinic.
79	The magician	tricked	the little worm	with ease.
80	The grandmother	visited	the musky towel	at the maternity ward.
81	The sitter	walked	the town aquarium	every weekend.

Appendix 8: STIMULI – PASSIVE – CONTROL CONDITION

Stim	Patient / Subject	Verb	Object	PostText
1	The hurt wrestler	was adjusted	by the chiropracter	after the fight.
2	The lottery winner	was announced	by the reporter	during the news.
3	The funny comedian	was applauded	by the crowd	excitedly.
4	The regional bank	was approved	by the inspector	at noon.
5	The sneaky thief	was arrested	by the detective	in New York.
6	The spry executive	was assisted	by the secretary	with the project.
7	The audacious hiker	was attacked	by the bear	on the trail.
8	The tasty cake	was baked	by the oven	for the birthday.
9	The crude author	was banned	by the editor	last year.
10	The old mailman	was bitten	by the pitbull	at the park.
11	The glowing bride	was carried	by the groom	at the wedding.
12	The red fish	was caught	by the angler	at the lake.
13	The male deer	was chased	by the hunter	in the forest.
14	The dirty vacuum	was cleaned	by the maid	yesterday.
15	The high ledge	was climbed	by the mountaineer	during the day.
16	The widowed wife	was consoled	by the pastor	last month.
17	The business owner	was consulted	by the accountant	during the lunch.
18	The luscious fly	was consumed	by the frog	by the pond.
19	The delicious dish	was cooked	by the chef	at the new restaurant.
20	The airport crew	was coordinated	by the controller	from the tower.
21	The small class	was counted	by the tutor	at the party.
22	The film director	was critiqued	by the movie reviewer	in the article.
23	The fresh meat	was cut	by the butcher	for each customer.
24	The sly politician	was defended	by the bodyguard	from the attacker.
25	The hearty meal	was devoured	by John	at the table.
26	The novice actress	was directed	by the producer	for the new movie.

27	The exotic supermodel	was discovered	by the designer	after the show.
28	The young daughter	was dressed	by the mother	for school.
29	The popular senator	was elected	by the citizens	last month.
30	The company staff	was evaluated	by the CEO	frequently.
31	The terminal patient	was examined	by the physician	quickly.
32	The cuddly chimpanzee	was fed	by the zookeeper	with love.
33	The bad criminal	was fingerprinted	by the deputy	at the station.
34	The modern airplane	was flown	by the pilot	in the storm.
35	The fair judge	was fooled	by the offender	during court.
36	The pop fly	was grabbed	by the outfielder	strongly.
37	The smart scholar	was graded	by the advisor	during the internship.
38	The stubborn boss	was helped	by the butler	for brunch.
39	The rude electrician	was hired	by the homeowner	to fix the wires.
40	The accident victim	was identified	by the family	at the hospital.
41	The crazy vet	was imitated	by the parrot	at the zoo.
42	The famed singer	was interviewed	by Oprah	during the summer.
43	The great machine	was invented	by the researcher	at the university.
44	The government bureau	was investigated	by the agent	thoroughly.
45	The rubber ball	was kicked	by the player	twice.
46	The wise diplomat	was kidnapped	by the terrorist	at the conference.
47	The poor tramp	was killed	by the assassin	instantly.
48	The good student	was lectured	by the professor	at length.
49	The heavy dumbell	was lifted	by the athlete	at the gym.
50	The happy couple	was married	by the priest	at the church.
51	Mother Theresa	was mourned	by millions of people	around the world.
52	The rare bird	was observed	by the biologist	in the field.
53	The new employee	was paid	by the manager	on Friday.
54	The personal portrait	was painted	by the artist	on the canvas.

55	The famous celebrity	was photographed	by the paparazzo	during the premiere.
56	The crime suspect	was questioned	by the police	for six hours.
57	The national press	was received	by the president	after the election.
58	The elderly lady	was rescued	by the firefighter	last night.
59	The intriguing topic	was researched	by the scientist	through the experiment.
60	The naive tourist	was robbed	by the burglar	in the hotel.
61	The little girl	was scared	by the monster	immensely.
62	The kind neighbour	was scratched	by the cat	on the nose.
63	The cruel assailant	was sentenced	by the jury	to life in prison.
64	The patient customer	was served	by the waitress	promptly.
65	The bearded guy	was shaved	by the barber	delicaltely.
66	The skinny teenager	was shot	by the gunman	at the school.
67	The nice watercolor	was sketched	by the painter	at work.
68	The rich businessman	was solicited	by the beggar	on the street.
69	The wild boar	was squeezed	by the python	in the jungle.
70	The reckless teen	was stitched	by the doctor	expertly.
71	The savvy defendant	was sued	by the plaintiff	for millions.
72	The blue krill	was swallowed	by the whale	in the Atlantic ocean.
73	The football player	was tackled	by the defense	at the goal line.
74	The biology course	was taught	by the teacher	in the morning.
75	The leather football	was thrown	by the quarterback	into the air.
76	The taxi driver	was tipped	by the busy man	as he left the car.
77	The sinewy prisoner	was transferred	by the warden	to the courthouse.
78	The ill convalescent	was treated	by the specialist	at the clinic.
79	The interested fan	was tricked	by the magician	with ease.
80	The lovely newborn	was visited	by the grandmother	at the maternity ward.
81	The teeny dog	was walked	by the sitter	every weekend.

Appendix 9: STIMULI – PASSIVE – ROLE-REVERSED CONDITION

Stim	Patient/Subject	Verb	Object	PostText
1	The apt chiropracter	was adjusted	by the hurt wrestler	after the fight.
2	The TV reporter	was announced	by the lottery winner	during the news.
3	The large crowd	was applauded	by the funny comedian	excitedly.
4	The strict inspector	was approved	by the regional bank	at noon.
5	The mature detective	was arrested	by the sneaky thief	in New York.
6	The clever secretary	was assisted	by the spry executive	with the project.
7	The angry bear	was attacked	by the audacious hiker	on the trail.
8	The metal pan	was baked	by the gas oven	for the birthday.
9	The magazine editor	was banned	by the crude author	last year.
10	The callous pitbull	was bitten	by the old mailman	at the park.
11	The nervous groom	was carried	by the glowing bride	at the wedding.
12	The expert angler	was caught	by the red fish	at the lake.
13	The lethal hunter	was chased	by the male deer	in the forest.
14	The young maid	was cleaned	by the dirty vacuum	yesterday.
15	The able mountaineer	was climbed	by the sweet toddler	during the day.
16	The beloved pastor	was consoled	by the widowed wife	last month.
17	The short accountant	was consulted	by the business owner	during the lunch.
18	The muddy frog	was consumed	by the luscious fly	by the pond.
19	The ordinary chef	was cooked	by the hot sun	at the new restaurant.
20	The alert controller	was coordinated	by the airport crew	from the tower.
21	The math tutor	was counted	by the small class	at the party.
22	The movie reviewer	was critiqued	by the film director	in the article.
23	The obese butcher	was cut	by the portly surgeon	for each customer.
24	The loyal bodyguard	was defended	by the sly politician	from the attacker.

25	The hungry lion	was devoured	by John	at the table.
26	The genious producer	was directed	by the novice actress	for the new movie.
27	The fashion designer	was discovered	by the exotic supermodel	after the show.
28	The benign mother	was dressed	by the young daughter	for school.
29	The american citizen	was elected	by the popular senator	last month.
30	The company CEO	was evaluated	by the company staff	frequently.
31	The focused physician	was examined	by the terminal patient	quickly.
32	The sad zookeeper	was fed	by the cuddly chimpanzee	with love.
33	The eager deputy	was fingerprinted	by the bad criminal	at the station.
34	The calm pilot	was flown	by the modern airplane	in the storm.
35	The repeat offender	was fooled	by the fair judge	during court.
36	The outfielder	was grabbed	by the pop fly	strongly.
37	The clever advisor	was graded	by the smart scholar	during the internship.
38	The amiable butler	was helped	by the stubborn boss	for brunch.
39	The homeowner	was hired	by the rude electrician	to fix the wires.
40	The foreign family	was identified	by the accident victim	at the hospital.
41	The green parrot	was imitated	by the crazy vet	at the zoo.
42	Popular Oprah	was interviewed	by the famed singer	during the summer.
43	The lively researcher	was invented	by the great machine	at the university.
44	The FBI agent	was investigated	by the government bureau	thoroughly.
45	The soccer player	was kicked	by the rubber ball	twice.
46	The scary terrorist	was kidnapped	by the wise diplomat	at the conference.
47	The quiet assassin	was killed	by the poor tramp	instantly.
48	The jolly professor	was lectured	by the good student	at length.
49	The strong athlete	was lifted	by the heavy dumbell	at the gym.
50	The pious priest	was married	by the happy couple	at the church.
51	The quiet biologist	was observed	by the rare bird	in the field.

52	The powerful manager	was paid	by the new employee	on Friday.
53	The excentric artist	was painted	by the personal portrait	on the canvas.
54	The nasty paparazzo	was photographed	by the famous celebrity	during the premiere.
55	The reliable officer	was questioned	by the crime suspect	for six hours.
56	The latest president	was received	by the national press	after the election.
57	The brave firefighter	was rescued	by the elderly lady	last night.
58	The noisy scientist	was researched	by the intriguing topic	through the experiment.
59	The silly burglar	was robbed	by the naive tourist	in the hotel.
60	The slimy monster	was scared	by the little girl	immensely.
61	The fluffy cat	was scratched	by the kind neighbour	on the nose.
62	The biased jury	was sentenced	by the cruel assailant	to life in prison.
63	The glad waitress	was served	by the patient customer	promptly.
64	The friendly barber	was shaved	by the bearded guy	delicaltely.
65	The insane gunman	was shot	by the skinny teenager	at the school.
66	The brilliant painter	was sketched	by the nice watercolor	at work.
67	The drunk beggar	was solicited	by the rich businessman	on the street.
68	The long python	was squeezed	by the wild boar	in the jungle.
69	The gentle doctor	was stitched	by the reckless teen	expertly.
70	The mean plaintiff	was sued	by the savvy defendant	for millions.
71	The white whale	was swallowed	by the blue krill	in the Atlantic ocean.
72	The tough defense	was tackled	by the football player	at the goal line.
73	The best teacher	was taught	by the biology course	in the morning.
74	The tall quarterback	was thrown	by the leather football	into the air.
75	The busy man	was tipped	by the taxi driver	as he left the car.
76	The angry warden	was transferred	by the sinewy prisoner	to the courthouse.

77	The cardio specialist	was treated	by the ill convalescent	at the clinic.
78	The American magician	was tricked	by the interested fan	with ease.
79	The jolly grandmother	was visited	by the lovely newborn	at the maternity ward.
80	The fat sitter	was walked	by the teeny dog	every weekend.
81	Millions of people	were mourned	by Mother Teresa	around the world.

Appendix 10: STIMULI – PASSIVE – ANOMALOUS CONDITION

Stim	Patient/Subject	Verb	Object	PostText
1	The violet scarf	was adjusted	by the chiropracter	after the fight.
2	The clean window	was announced	by the reporter	during the news.
3	The shiny shoe	was applauded	by the crowd	excitedly.
4	The vertical blind	was approved	by the inspector	at noon.
5	The faint ghost	was arrested	by the detective	in New York.
6	The plastic stapler	was assisted	by the secretary	with the project.
7	The large battery	was attacked	by the bear	on the trail.
8	The school library	was baked	by the oven	for the birthday.
9	The mild earthquake	was banned	by the editor	last year.
10	The yellow bicycle	was bitten	by the pitbull	at the park.
11	The strong wind	was carried	by the groom	at the wedding.
12	The loud music	was caught	by the angler	at the lake.
13	The new television	was chased	by the hunter	in the forest.
14	The nice paper	was cleaned	by the maid	yesterday.
15	The black light	was climbed	by the mountaineer	during the day.
16	The metal hanger	was consoled	by the pastor	last month.
17	The soft pillow	was consulted	by the accountant	during the lunch.
18	The ice truck	was consumed	by the frog	by the pond.
19	The waxed car	was cooked	by the chef	at the new restaurant.
20	The old radio	was coordinated	by the controller	from the tower.
21	The pure water	was counted	by the tutor	at the party.
22	The linen sheet	was critiqued	by the movie reviewer	in the article.
23	The color printer	was cut	by the butcher	for each customer.
24	The clean kitchen	was defended	by the bodyguard	from the attacker.
25	The dirty tabletops	was devoured	by John	at the table.
26	The snowboard	was directed	by the producer	for the new movie.

27	The pretty smile	was discovered	by the designer	after the show.
28	The living room	was dressed	by the mother	for school.
29	The italian cheese	was elected	by the citizens	last month.
30	The warm sock	was evaluated	by the CEO	frequently.
31	The blunt pencil	was examined	by the physician	quickly.
32	The stinky bathroom	was fed	by the zookeeper	with love.
33	The wood table	was fingerprinted	by the deputy	at the station.
34	The bony elbow	was flown	by the pilot	in the storm.
35	The silver doorknob	was fooled	by the offender	during court.
36	The melody	was grabbed	by the outfielder	strongly.
37	The silk blanket	was graded	by the advisor	during the internship.
38	The birthday card	was helped	by the butler	for brunch.
39	The office shelf	was hired	by the homeowner	to fix the wires.
40	The bad feeling	was identified	by the family	at the hospital.
41	The tv remote	was imitated	by the parrot	at the zoo.
42	The jean jacket	was interviewed	by popular Oprah	during the summer.
43	The blue sky	was invented	by the researcher	at the university.
44	The queen bed	was investigated	by the agent	thoroughly.
45	The long book	was kicked	by the player	twice.
46	The noisy siren	was kidnapped	by the terrorist	at the conference.
47	The thin wall	was killed	by the assassin	instantly.
48	The bird feather	was lectured	by the professor	at length.
49	The ironed suit	was lifted	by the athlete	at the gym.
50	The fat hip	was married	by the priest	at the church.
51	The bath tub	was mourned	by millions of people	around the world.
52	The good idea	was observed	by the biologist	in the field.
53	The dangerous rocket	was paid	by the manager	on Friday.
54	The fast computer	was painted	by the artist	on the canvas.

55	The white noise	was photographed	by the paparazzo	during the premiere.
56	The steep roof	was questioned	by the police	for six hours.
57	The dry air	was received	by the president	after the election.
58	The rolling thunder	was rescued	by the firefighter	last night.
59	The elegant lamp	was researched	by the scientist	through the experiment.
60	The super tsunami	was robbed	by the burglar	in the hotel.
61	The small desk	was scared	by the monster	immensely.
62	The baked potato	was scratched	by the cat	on the nose.
63	The worst electronic	was sentenced	by the jury	to life in prison.
64	The big comet	was served	by the waitress	promptly.
65	The beige telephone	was shaved	by the barber	delicaltely.
66	The basketball	was shot	by the gunman	at the school.
67	The intense hurricane	was sketched	by the painter	at work.
68	The green tree	was solicited	by the beggar	on the street.
69	The sharp needle	was squeezed	by the python	in the jungle.
70	The bright star	was stitched	by the doctor	expertly.
71	The warm sunshine	was sued	by the plaintiff	for millions.
72	The steamy attic	was swallowed	by the whale	in the Atlantic ocean.
73	The dim garage	was tackled	by the defense	at the goal line.
74	The broken chair	was taught	by the teacher	in the morning.
75	The strange notion	was thrown	by the quarterback	into the air.
76	The wet sink	was tipped	by the busy man	as he left the car.
77	The alarm clock	was transferred	by the warden	to the courthouse.
78	The gold ring	was treated	by the specialist	at the clinic.
79	The little worm	was tricked	by the magician	with ease.
80	The musky towel	was visited	by the grandmother	at the maternity ward.
81	The town aquarium	was walked	by the sitter	every weekend.