UNIVERSIDADE DO ALGARVE

STUDY OF THE CORRELATION BETWEEN WORKING MEMORY AND DISCOURSE PROCESSING

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Study of the correlation between working memory and discourse processing

Declaração de autoria de trabalho:

Declaro ser a autora deste trabalho, que é original e inédito. Autores e trabalhos consultados estão devidamente citados no texto e constam da listagem de referências incluída.

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Abstract:

Background: The comprehension of the d-linked relations and local-binding relations, is a pivotal matter to understand the mechanisms underlying discourse comprehension (Avrutin, 2000). According to Acheson, Postle and Macdonald (2010) and Wright and Shisler, (2005) a preserved working memory (WM) is essential for language processing effectiveness, being an essential tool for resolving structural and lexical ambiguity during the discourse processing and comprehension.

Aim: The aim of this research is to address the relationship between working memory and comprehension of discourse, and compare the performance in sentences with d-linked and local-binding relations in three groups: right hemisphere lesion group (without language impairments), left hemisphere lesion group (with aphasia) and controls.

Method & Procedures: We measured the accuracy and response times (RT) for working memory; and for sentences with pronouns and reflexives of three groups of participants. The experimental tasks consisted in a one-back task and a sentence–picture matching task where pronouns and reflexives were manipulated. For the follow up study we did an error prevalence study with another sentence–picture matching task.

Outcomes & Results: In all groups we observed a better performance in reflexives comparing to pronouns, and also longer RTs for pronouns. The aphasic group has the poorer performance of the three, followed by right hemisphere group. We only found correlation for accuracy results between WM and pronouns for right hemisphere group and control group and between WM and reflexives for the same groups.

Conclusions: In different ways, both lesion sites have distinct functions that are relevant for processing anaphors, being LH more crucially engaged in anaphoric resolution.

The working memory results of patients groups combined with the different levels of impairment in the language task between LH and RH patients point to the assumption that WM

has a limited but relevant contribution for the processing of pronouns and reflexives. The finding in the correlational study lead us to the conclusion that, probably, the different groups rely on different cognitive skills in the processing of both reflexives and pronouns.

Key words: Anaphors, Discourse, Working Memory, Language, Pronouns, Reflexives

Resumo:

Revisão Teórica: Compreender o processamento de pronomes e reflexos assume suma importância para o conhecimento dos mecanismos subjacentes à compreensão do discurso (Avrutin, 2000). Segundo Acheson, Postle e Macdonald (2010) e Wright e Shisler, (2005) uma memória de trabalho (MT) preservada é um mecanismo cognitivo essencial para resolver as ambiguidades estruturais e lexicais durante o processamento e compreensão do discurso.

Objetivos: Este trabalho tem como objetivo investigar a relação entre a memória de trabalho e a compreensão de discurso e comparar o desempenho para pronomes e reflexos em três grupos de participantes: grupo de participantes com lesão no hemisfério direito (sem alterações de linguagem), grupo de participantes com lesão no hemisfério esquerdo (com afasia) e um grupo de controlo.

Método e Procedimento: Foram avaliados os tempos de resposta (TR) para uma tarefa one-back de memória de trabalho, e foi avaliada acuidade da compreensão da linguagem oral com uma tarefa de associação frase-imagem onde os pronomes e os reflexos foram manipulados nos três grupos de participantes.

Análise e Resultados: Em todos os grupos observámos desempenho superior para os reflexos face aos pronomes e um TR mais alto para os pronomes. O grupo com afasia apresentou um desempenho inferior na tarefa de compreensão de frases comparativamente aos outros grupos, seguido pelo grupo com lesão à direita. Foram encontradas correlações entre o desempenho na MT e a compreensão de pronomes para o grupo com lesão à direita e para os controlos e entre a MT e os reflexos para os mesmos grupos.

Conclusões: De forma diferente, os dois grupos de doentes demonstraram funções distintas que são relevantes para o processamento de anáforas, sendo o hemisfério esquerdo o mais envolvido neste processo.

Os resultados no teste de memória de trabalho dos doentes combinados com os diferentes níveis de alteração de linguagem verificados entre os dois grupos apontam para uma contribuição limitada mas relevante da memória de trabalho para o processamento de pronomes e reflexos. Os achados dos estudos correlacionais também apontam para o facto de, provavelmente, os diferentes grupos dependerem de diferentes capacidades cognitivas para o processamento de pronomes e reflexos.

Palavras-Chave: Discurso, Memória de Trabalho, Linguagem, Pronomes, Reflexos

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1. GENERAL INTRODUCTION

Language comprehension loss is one of the most common features across the aphasic population. However, comprehension isn't impaired in a random manner, some process seem preserved (or partially preserved), others not. The main question that we can formulate is why? Why some processes seem untouched, and others apparently similar are not? Are the aphasic patients the only population suffering a decrease in discourse comprehension? Or is it also observable in right hemisphere patients? Is that an impairment exclusively due to language loss, or can it be related with other cognitive capacities (such as working memory)?

The speech particles that we approach are anaphors, specifically personal pronouns (henceforth, pronouns) and reflexive pronouns (henceforth, reflexives), small particles that play a fundamental role in co-reference. As far as we know, pronouns and reflexives are particles that would be processed differently (Avrutin, 2000). The first will be processed as discourse, requiring this way higher processing resources. To process this kind of structure we need a way to storage information for a short period of time, in a very accessible way. Perhaps that's why some authors (Dopkins & Ngo, 2005; Martin & Reilly, 2012; Santi & Grodzinsky, 2007; Wright & Shisler, 2005) defend that those resources could be somehow related with working memory. It's our aim trying to enrich research in this field. For that we will measure performance and response times of sentences with pronouns and reflexives, in three different groups: a left hemisphere lesion group, a right hemisphere lesion group and a healthy control group. We will also assess working memory and study its correlation with discourse processing.

The first chapters in thesis aim to provide an overview on co-reference (Chapter 2) and on working memory and discourse comprehension (Chapter 3). The research questions and the predictions that trigger this investigation will be presented (Chapter 4), followed by a description of the research method. Chapter 5 is used for the exposition of the results and on

Chapter 6 results will be discussed. Our conclusions will be exposed on Chapter 7 followed by a brief view of what could be the future studies on this matter (Chapter 8).

2. THEORETICAL BACKGROUND IN COREFERENCE

2.1. Anaphors and Biding Relations

Coherence should always be a primordial matter when the subject is discourse. Coherence allows the communication to have continuity in meaning and context (Louwerse & Graesser, 2005). Louwerse and Graesser (2005) and Perfetti and Frishkoff (2008) define discourse coherence as "continuity in meaning or the overall interrelatedness of the discourse", in other words, the discourse must make sense, must have a subject or matter. The coherence divides itself into local and global coherence (Glosser, Deser, & Weisstein, 1992; Kurczek & Duff, 2011; Perfetti & Frishkoff, 2008). Local coherence refers to the interrelatedness, or topic maintenance, across adjacent utterances, and global coherence refers to the interrelatedness, or topic maintenance, across larger stretches of discourse (as happens in a common conversation or in a narrative) (Kurczek & Duff, 2011; Louwerse & Graesser, 2005; Perfetti & Frishkoff, 2008).

There are particles in speech, which facilitate creation of discourse coherence, namely anaphors and cataphors. This thesis focuses on anaphors. Citing Louwerse and Graesser (2005) "Anaphoric reference is a backward reference to an antecedent noun phrase or clause that was introduced earlier in the discourse". Dopkins and Ngo (2005), and Vasić (2006) add that anaphors are used to refer to information that can be inferred by the listener, either based on information contained in the sentence, on information contained in discourse or on general knowledge. Anaphors play a very significant role in coherence (Ledoux, Gordon, Camblin, & Swaab, 2007; Vasić, 2006).

In a successful process of coreference, it's necessary to access the meaning of the anaphor. According Choy and Thompson (2010); Nicol and Swinney (1989); and Shake and Stine-Morrow (2011), anaphoric resolution is the process by which the antecedent that an anaphor refers to is identified. The capacity for fast resolution depends, in part, on the

availability of a distinctive representation of the antecedent (Shake & Stine-Morrow, 2011). In other words, this resolution will be as faster as the velocity as the individual can access to the meaning of the antecedent (the word that the anaphor is replacing).

Reflexive pronouns (henceforth, reflexives) and personal pronouns (henceforth, pronouns) are anaphoric structures. As elements of this category, pronouns and reflexives are meaningless by themselves; so these structures will extract the meaning of its antecedent (Choy & Thompson, 2010; Ledoux et al., 2007; Nicol & Swinney, 1989). Reflexives and pronouns connect to the meaning according to different conditions. These elements will connect to its antecedent according to distinct principles postulated by Binding Theory of Chomsky, (1981, 1986).

2.2. Principles of the Binding Theory

The Binding theory is constituted by two main principles: Principle A and B (Chomsky, 1981, 1986). According to Principle A, the reflexive should bind locally (example a), on the other hand, the Principle B states that pronouns should not bind locally (example b). In other words, the reflexive will connect to its local domain, inside the sentence in which it's placed (example 1). Rather, the pronouns will connect the structures outside their local domain, in different sentences (example 2) (Choy & Thompson, 2010; Ruigendijk, Baauw, Zuckerman, & Vasić, 2002). In sentences where such structures emerge, listeners will establish a relationship of co-indexation between the reflexive or the pronoun and respective antecedent (Choy & Thompson, 2010).

Examples:

a) The priest is with the thief. The priest hides himself.

b) The priest is with the thief. The priest hides him.

For this co-indexation process it is necessary to store, and retrieve for a short period of time the information relative to the antecedent. For this reason Dopkins and Ngo, (2005) refer that memory processes are implicated in anaphor resolution. Memory processes may enable the individual to recognize words alterations from a statement with the resolution of an anaphor.

2.3. Processing Pronouns and Reflexives

Avrutin (2000), named D-linking and local-binding to the operations via which pronouns and reflexives (respectively) relate to an antecedent. According to this author D-linked involve the same operations than local-binding, plus discourse-related operations. Local-binding is established within the same clause, while D-linked relations are established across clauses. Picking the anterior example, the second clause of the sentence a) correspond to the local binding relation (a reflexive) and the second clause of the sentence b) correspond to the D-linked relation (a pronoun).

Examples:

a) The priest is with the thief. The priest hides himself.

b) The priest is with the thief. The priest hides him.

In order to be co-indexed, the reflexive and its antecedent should share grammatical features named ϕ features (gender, number and person) (Grodzinsky & Reinhart, 1993). Since reflexives are subject oriented, they bind to the antecedent by getting the subject's features. After that, the listener is able to match reflexives to their antecedent (Grodzinsky & Reinhart, 1993; Simon & Wiese, 2002).

Differently, pronouns are connected to an antecedent via co-reference. Citing Ledoux et al. (2007), "two expressions are said to be coreferencial if they refer to the same semantic entity; the first expression (the antecedent) introduces the entity into the discourse model, and

the second expression (the anaphor) refers to it", in other words, happens when two linguistic expressions refer to the same thing (Gordon, 1998). Coreference can occur not only when applying reduced expressions (like pronouns) instead of the antecedent, but also when using full expressions (like descriptions), instead of it (Grosz, Weinstein, & Joshi, 1995; Ledoux et al., 2007; Shake & Stine-Morrow, 2011). Simon and Wiese (2002) add that pronouns are the only referential elements that are free to choose their referent from the discourse (regardless of whether or not the referent is in the sentence).

Avrutin (2000) and Grodzinsky and Reinhart (1993) declared that the D-linked relations, because of their complexity, will need more processing resources for the implementation of the syntactic and discourse operations. Reuland (2001) established an *economy hierarchy,* predicting that the language processing system will attempt to perform cheaper operations (rather than more costly ones) when possible. Given that there are exceptions in language in which a pronouns may bind to an element within the sentence, co-reference will only be used when this option is excluded (*Rule-I: intra-sentential coreference,* Grodzinsky & Reinhart, 1993). It is for this reason that processing pronouns requires both the syntactic process of "excluding the local binding operation", in addition to the co-referential process (Reuland, 2003).

In his experiments Grodzinsky (2006), found out that the accuracy for reflexives were above operations with syntactic movement. The author observed a better performance in right hemisphere than left hemisphere patients in this task. Evidence for differential processing of pronouns and reflexives is also available from fMRI experiments. These have revealed increased BOLD signal in the Superior Frontal Gyrus in the right hemisphere, for reflexives, and in Broca's region in the left hemisphere for operations with syntactic movement (Grodzinsky, 2006). Accordingly, patients with lesion at Broca's area level express more difficulties in pronoun comprehension (Avrutin, 2006; Grodzinsky, 2006). Avrutin (2000) and

Grodzinsky and Reinhart (1993) explain that as the difficulty increases, the necessity of more processing resources also increases. Given that the cognitive resources of individuals with aphasia are limited, their performance will be poorer in this type of task. These difficulties are more substantial for pronouns, because pronoun processing requires additional to access to the discourse level.

3. THEORETICAL BACKGROUND IN WORKING MEMORY AND DISCOURSE COMPREHENSION

3.1. First Steps in to Memory

Since this research has the aim to address the relationship between working memory and comprehension of speech, it is important to clarify some concepts, namely: Memory in general, Working Memory (WM), Short-Term Memory (STM) and discourse comprehension. Singh and Kent (2000), Brookshire, 2007 and Eysenck and Keane (2010) defined memory as the capacity of encode, store and retrieve information.

Singh and Kent (2000), Brookshire (2007), Cowan, (2008), and Caplan, Waters and Howard (2012) described short term memory as the capacity of maintaining a limited amount of information for a short period of time, in a very accessible way. According to these authors, the working memory system is not completely distinct from the short-term memory system (Brookshire, 2007; Caplan et al., 2012; Cowan, 2008).

Baddeley (2000) proposed a very influential working memory model. This model represents a combined ability to maintain information in an active state for short period of time and to perform operations with that information in a task situation So, according to this model, the working memory system has four components: (1) a modality free central executive, resembling attention; (2) a phonological loop, holding information in a phonological form, and (3) a visuo-spacial sketchpad, specialized for visual and spatial encoding; and (4) an episodic buffer, who can hold and integrate information from the slave systems (2 and 3) and long term memory (Baddeley, 2000). According to Baddeley (2007), working memory takes into account not only storage capacity, but also attention and executive processes.

Because of its function, working memory has a pivotal role in everyday tasks. In this study we will focus on its influence in our capacity of understanding discourse.

3.2. An introduction to Discourse Comprehension

Discourse comprehension, as well as the comprehension of its components (words, phrases), involves the integration of representations of the sentence to enable coherent understanding of discourse as a whole (Perfetti & Frishkoff, 2008). The same authors defined consistency, as meaningful connections that enable the speech to make sense between adjacent sentences and larger units. This concept is also related with coherence (Perfetti & Frishkoff, 2008).

It's appropriate to think that this two types of coherence rely on different mental processes. For example in a reading task, in which the participants have to read a full text or only a list of words, it's expected that readers and listeners have a different way to process words, either they embedded in a sentence or in a word list (Perfetti & Frishkoff, 2008; Ting Huang & Gordon, 2011). The reason why this is expected is because, a word list is meaningless itself, lacks of linguistic structure; in the other hand, sentences have more complexity (idem). The goal of sentence processing is to extract an integrated and coherent message from the linguistic output (idem).

The differences between single words processing, sentence and discourse processing would be reflected in the brain function: the brain areas required to process discourse comprehension are distinct from the ones that take part in the process of comprehension at the word and sentence level (Perfetti & Frishkoff, 2008), what lead us to the necessity of some "extra capacities" that allow us to make the connection between the discourse and the previous knowledge about the subject of the conversation. Such capacity must allow speakers and listeners to storage the needed information in an available way, and easily recalled. Maybe for that reason, discourse comprehension involves areas such as the prefrontal cortex of the left hemisphere, anterior temporal regions, medial frontal cortex and the posterior cingulate. These areas are related with general cognitive mechanisms (such as attention and memory) which are

required for recovery of information over time (Perfetti & Frishkoff, 2008), very useful during a common conversation.

So, in order to have a good comprehension in discourse, the interlocutor should have the processes related to formation of local and global coherence intact. One of the functions that may play a fundamental role in this matter is working memory, especially in decoding the small particles that play an important part in coherence.

3.3. Implication of Memory in Discourse Comprehension

Preserved working memory is pivotal for language processing effectiveness, being an essential tool for resolving structural and lexical ambiguity during the discourse processing and comprehension (Acheson, Postle, & Macdonald, 2010; Wright & Shisler, 2005). Based on this premise, several investigators have suggested that changes in the capacity of working memory will have an impact on the linguistic processing, leading to problems in comprehension of larger units, like discourse (Dopkins & Trinh Ngo, 2005; Martin & Reilly, 2012; Santi & Grodzinsky, 2007; Wright & Shisler, 2005).

Besides, according to Almor (1999) and Just and Carpenter (1992), short-term memory supports the online computation of discourse meaning. On the other hand, long-term memory provides information that the individual needs to make inferences and to preserve the content of the discourse once it is comprehended (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988).

Allen, Martin, and Martin (2012) reported the existence of two structures for retaining verbal information. A structure responsible for phonological information, whose function would be the storage of such information in the Short Term Memory, playing a similar role to the phonological loop; and other structure would be responsible for the lexical-semantic information, also being involved in maintaining linguistic information in Short-Term Memory. Gvion and Friedmann (2012) also refer to the existence of different structures for phonological

or syntactic-semantic information processing. These authors suggest that when there are isolated impairments at the level of phonological working memory, patients still have a good performance in association tasks with images and sentences and judgment of plausibility. That is, the impairments at the level of phonological working memory can preserve syntactic-semantic processing. Several authors (Allen et al., 2012; Gvion & Friedmann, 2012; R. Martin & He, 2004; R.C. Martin, Shelton, & Yaffee, 1994; Randi C. Martin & Feher, 1990; Randi C. Martin & Romani, 1994; Randi C Martin, 2003) point to the existence of specialized domains of Working Memory, each of them specific for different types of linguistic processing: phonology, syntax and semantics. Thus, each subtype of Working Memory would be responsible for the retention and reactivation of verbal information at different levels and in different domains, and each type of processing would address phrases differently.

Martin and Reilly (2012) also state that memory has a role to play in language comprehension. According to these authors, representations of language cover content, but the features that will give access, maintenance and retrieval of these representations, are not linguistic in its nature. Some of the processes involved in working memory, particularly inhibition, updating and changing tasks, are capabilities that operate in the manipulation of linguistic representations in working memory (Martin & Reilly, 2012).

One of the linguistic structures in which Working Memory may play an important role is in the sentences with dependency relations. The comprehension of filler/gap dependencies implies a link between the filler and the gap, and probably this action needs the intervention of Working Memory. The memory components required for the understanding of such utterances will store a limited amount of information for a short period of time between phrases, necessary for the integration of the information (Acheson et al., 2010; Santi & Grodzinsky, 2007).

The study of aphasic individuals has provided an opportunity to analyze the relation between discourse comprehension and working memory. There are some individuals with

lesions on left hemisphere (some of them with aphasia) that also have Working Memory disorders as shown by some researches (David Caplan & Hildebrandt, 1988; Carpenter, Miyake, & Just, 1994; Gvion & Friedmann, 2012; Haarmann, Just, & Carpenter, 1997).

Not just left hemisphere strokes, but also individuals with right hemisphere lesions have been showing disorders related to language processing namely with pragmatics of speech, in other words, with the context and use of language. For instance, Perfetti & Frishkoff (2008) suggest that processing of sentences and text, are usually performed bilaterally, being dominantly performed by the left hemisphere. These authors also report that there is also a right hemisphere activation in discourse comprehension (Perfetti & Frishkoff, 2008; Robertson et al., 2000). The right hemisphere has, then, an important role in terms of discourse comprehension, thus global coherence, recruiting additional memory resources and acting in the processing of non-literal meanings or social and emotional content (Beeman, Bowden, & Gernsbacher, 2000; Hagoort, Brown, & Swaab, 1996; Mason & Adam Just, 2004; Robertson et al., 2000). Hagoort et al., (1996) compared lexic-semantic event-related effects in patients with left hemisphere lesions and aphasia and patients with right hemisphere lesion without aphasia. The authors conclude that most difficulties in left damaged patients are "at the level of integrating individual word meanings into the overall message representation of the whole utterance". On the other hand, right hemisphere damaged patients have more difficulties in semantic matching in more distantly related words, something that will lead to problems in discourse processing when the mutual relationships between the constituting elements are rather loose or indirect (Hagoort et al., 1996).

In a different perspective Acheson et al., 2010, defend that language disorders would affect working memory performance. Theories that suggest that language impairments will have reflection in working memory and not the opposite, are congruent with the classic definition of aphasia, which states aphasia as an exclusively linguistic disorder, without the

compromise of other intellectual or sensorial capacities (Chapey, 2001; Goodglass & Kaplan, 1983). One good example of literature that support the idea that Working Memory relies on language and not the opposite, is the work of Martin and colleagues (1994). The authors state that phonology and semantics affect working memory in different ways. The phonological representations influence serial-ordering processes in verbal working memory tasks (Acheson et al., 2010; Fallon, Groves, & Tehan, 1999; Jacquemot & Scott, 2006), improving memory in some cases (Lian, Karlsen, & Eriksen, 2004).

On the other hand, Acheson et al. (2010) found that lexical-semantic effect influence item representations and phonological effect influence order representations which is, in spite of they are booth linguistic, and both interact in verbal working memory; it was observed a dissociation between this two capacities. As a prove of this statements, Locke and Kutz, (1975) published a study which conclude that children who misarticulate particular phonemes (e.g. /w/ and /r/) without making perception errors, still make errors in phonological short term memory tasks, reflecting their specific phoneme substitutions (such as ring for wing) even without spoken responses. Taken together, these results suggest that Phonological Short Term Memory is closely connected to the speech production system, even when no spoken output is required (Jacquemot & Scott, 2006; Locke & Kutz, 1975).

According to Jefferies, Hoffman, Jones, and Ralph (2008), the interactive activation model and "semantic binding" hypothesis of verbal short term memory are supported by phonological and semantic representations that are employed in language processing more generally. This capacity is supported by multiple levels of representations applied in language production and comprehension, including long-term knowledge of the sounds and meanings of familiar words. This lexical/semantic contribution explains why normal immediate serial recall is better for words vs. nonwords (Jefferies, Hoffman, Jones, & Ralph, 2008). This data is consistent with previous work, which state that prior recognition of a word facilitates

subsequent recognition of that same word later in the passage (Jefferies et al., 2008; Ledoux et al., 2007).

Moreover Potagas, Kasselimis and Evdokimidis (2011) assert that there are common mechanisms underlying aphasia and memory deficits, and found correlations between the severity of language deficits and the degree of memory impairments, even for spatial stimuli, because, according to the authors masked verbal strategies are also used to recall this kind of input. Kasselimis et al. (2013) recurred to the assessment of left hemisphere lesion patients with and without aphasia, to show that the STM/WM (regardless the modality) are dependent on the presence of aphasia.

3.4. Assessment of Working Memory and Discourse Comprehension

Many authors refer the presence of working memory deficits in aphasia patients and the influence of this deficit in their discourse comprehension (Caplan & Waters, 1999; Carpenter, Miyake, & Just, 1995; Gvion & Friedmann, 2012). To assess if this relation does exist, it is necessary to perform a working memory evaluation, using a method compatible with these patients' limitations, otherwise it will be impossible to know if potential errors are due to working memory problems or due to patients' inability to understand task instructions (Christensen & Wright, 2010). Downey et al. (2004), Wright and Shisler, (2005), Wright, Downey, Gravier, Love, and Shapiro (2007) and Christensen and Wright (2010) proposed that the best test to evaluate the working memory performance in aphasic population is the n-back task. N-back tasks can be performed even if the patient has more severe diagnoses, as well as impairments in verbal production. This task requires temporary storage and manipulation of information, and a constant updating of the information stored in Working Memory (Allen et al., 2012; Jonides et al., 1997; Wright & Shisler, 2005). During the task, items are presented (verbally or visually) and the participant is instructed to respond if the current item is the same

item presented *n* items ago (Allen et al., 2012; Christensen & Wright, 2010; Wright & Shisler, 2005). N-back tasks do not require a verbal response (the response can be triggered by pressing a button) and the degree of difficulty can be manipulated by increasing the n-back level (Jaeggi, Buschkuehl, Perrig, & Meier, 2010; Wright & Shisler, 2005).

4. THE CURRENT STUDY

In this study, we intend to investigate the relation between discourse processing and working memory. We will assess whether there are response time (RT) and accuracy differences between reflexives and pronouns in participants with left hemisphere lesions and aphasia, compared to participants with right hemisphere lesions without aphasia and controls. We will verify whether there is a correlation between the RTs for pronouns and for reflexives and the RT's during a working memory task, and whether there is a correlation between the accuracy for pronouns and for reflexives and the accuracy of a working memory task. Since the processing of pronouns requires co-reference across different sentences, that is, at discourse level, it is expected that this correlation occurs selectively for pronouns, or at least, that it proved to be stronger in this condition (based on Grodzinsky, Wexler, Chien, Marakovitz, & Solomon, 1993).

4.1. Research Questions:

This study intends to clarify some questions related to sentence processing and working memory and for that, evaluate the working memory status in left and right hemispheric stroke patients. Do the three groups differ in processing pronouns and reflexives?

If the pronouns need more WM resources, will the individuals, when in doubt, chose answers related to the reflexives? Do the three groups differ in the type of errors done during a sentence verification task with reflexives and pronouns?

Do the three groups differ in their degree of WM impairment? In case that these patients have working memory impairments, does this diminishment affect discourse comprehension? Is there an overall correlation between WM and the processing of reflexives and pronouns, for any of the groups?

Is there any difference between the processing within the same utterance and between two different ones? If there's a difference, what's its origin? Is the time to process these two structures equal?

This research aims to answer these questions, and for that we will test if discourse level processes require further working memory resources. In order to test this, we will measure RTs during discourse processing with pronouns, during sentence level processing with reflexives, and the scores in a working memory measure (n-back task). Furthermore, this work also intends to verify if discourse comprehension tasks will be influenced by specific functions of the right hemisphere, and if injuries at this level will cause disorders in discourse comprehension.

Thus, we compare the performance in different tasks of a right-hemisphere (RH) damaged group of participants, a left-hemisphere (LH) damaged group of participants and a control group to establish the degree of association in these three groups between working memory performance (assessed through an n-back task) and discourse comprehension (assessed by response time to pronouns and reflexives in selected sentences).

4.2. Predictions:

In this work, we will test if there's a relation between working memory resources and discourse comprehension, and if there is a difference in the recruitment of these resources during discourse processing with pronouns and sentence level processing with reflexives.

Do the three groups differ in processing pronouns and reflexives?

If the degree of language impairment is a relevant factor, healthy individuals should present better scores and faster RTs, followed by RH patients. LH patients are expected to perform worse and slower for both pronouns and reflexives.

Assuming that both patients groups will present some degree of WM impairment, if WM contributes particularly for the processing of discourse dependencies, both patients groups

are expected to show differences between pronouns and reflexives (lower accuracy and/or slower RTs for pronouns).

If the processing of discourse dependencies relies on left hemisphere linguistic resources that are not related to WM, the LH patients will present worse performance with pronouns, but the RH patients will not show this effect.

Do the three groups differ in the type of errors done during a sentence verification task with reflexives and pronouns?

If patients present more difficulties with pronouns, it is yet uncertain which type of strategy they may adopt in sentence comprehension. On the one hand, , it's expected that in case of doubt, individuals choose images corresponding to reflexives more often, because this is the more economical option, in terms of processing resources. In other words, is expected that most of the errors in this task are due to chosen more frequently reflexives instead of pronouns, than the opposite. On the other hand, pronouns are more ambiguous, and if patients have doubts they are in a situation of ambiguity. This way, patients may be biased to select pronouns in situations of ambiguity. If the premise is true, we expect a higher number of pronouns chosen unduly compared to reflexives.

Do the three groups differ in their degree of WM impairment?

LH and RH patients may present differential levels of WM impairment, due to their different lesion sites. We will assess whether this occurs. If the groups differ in WM, it is possible that further differences between processing reflexives and pronouns are not related to linguistic, but to WM requirements of the two types of anaphor.

Is there an overall correlation between WM and the processing of reflexives and pronouns, for any of the groups?

If the WM is pivotal to the discourse comprehension is expected that participants with lesions on LH have poor performance on WM and discourse comprehension tasks, and also a

sentence level processing below to the control group, showing a stronger correlation between WM and pronouns. On the right hemisphere and control groups we also expect to find a stronger correlation for pronouns than for reflexives. Differential strengths of correlations across groups and anaphor types will illustrate the differential role of LH, RH and of WM in the processing of reflexives and pronouns.

If we don't find any correlation between working memory and the impairments in discourse comprehension tasks on either group, we can assume that WM in spite of its importance for cognitive functioning, it's not highly engaged in the comprehension of anaphors.

5. METHODS

In this project, we used a between-subjects design. The independent variable is the location of the lesion and the dependent variables are the performance in n-back task and sentence comprehension tasks.

In this section the acceptability pre-test and the methodology of the Reaction Times, *One-back* task and error prevalence study are described.

5.1. Pre-test

The purpose of the acceptability pre-test was to exclude the possibility that the differences between conditions could arise due to differences in the plausibility and/or grammaticality of the experimental sentence pairs.

5.1.1. Participants

The acceptability ratings were completed by four hundred and four native speakers of European Portuguese, which 118 were male. Their ages were between 18 and 65 years old, with a mean age of 28.89 (SD=9.70) and educational levels ranging from nine years of Primary Education to Doctorate, with 68.4% of participants having a Bachelor's degree. History of neurological impairment and use of neuroleptic medication were exclusion criteria.

5.1.2. Stimulus

The experiment was based on de Aguiar, Bastiaanse, Reis and Dragoy (2013). An online questionnaire was developed for the purpose of this study using 1KA (http://www.1cs.si/). First, 40 verbs that can occur with reflexives and pronouns in European Portuguese were selected from a list of 80 verbs. The selection of the verbs was based on a pre-

test made by de Aguiar et al. (2013) in which participants had to match an image specially designed for the effect with the respective sentence with the pronoun or the reflexive. Based on these data, 40 sentences (20 pronoun and 20 reflexive) that had the best percentage of pairing between image and sentence (at least 80% for each version) were selected.

The 40 sentences chosen were used to derive a set of experimental sentence pairs. Items were divided in two lists, so that each participant would see an item in one condition only. Each participant saw a list of 40 experimental sentence pairs and 40 filler sentence pairs (Appendix A).

All experimental sentence pairs had the same order of constituents and included an initial sentence that introduced the characters and a target sentence with the critical word. The introductory sentence was formed with a subject noun phrase, a copular verb and an attribute which consisted of a prepositional phrase (e.g., "The fisherman is with the tourist."). The target sentence was formed with a subject noun phrase, a verb, and critical object noun phrase (a reflexive/pronoun) (e.g., "The fisherman hurts him/himself.") (see table 1).

Table 1: Experimental conditions for the acceptability study

Form	*Introductory Sentence*	*Target Sentence*	*Critical*
Reflexive	The fisherman is with the tourist. *O pescador está com o turista.*	The fisherman hurts *O pescador magoa*	himself. *se.*
Pronoum	The fisherman is with the tourist. *O pescador está com o turista.*	The fisherman hurts *O pescador magoa*	him. *o.*

Across conditions, experimental sentence pairs were formed with exactly the same lexical items differing only in the critical word.

The 40 filler items that were designed had the same sentence structure as the experimental items, also including pronouns. Given that participants had to judge the sentence pairs in terms of plausibility and grammaticality, the filler items were designed to capture these

dimensions: 10 fillers contained pronoun case violations, 10 contained pronoun agreement violations, 10 contained implausible agents and 10 contained implausible themes.

5.1.3. Procedure for the pre-test

The test was administered via Internet (http://www.1cs.si/), participants were instructed to judge the level of acceptability of the sentence pairs on a 5-point scale, with the first point of the scale being 'Totally acceptable' and the fifth 'Totally unacceptable'. Acceptability was defined on two dimensions: grammaticality (the absence/presence of grammatical errors) and plausibility (the degree to which the event described can happen in the real world). The test lasted approximately 25 minutes. No time limit was established (Instructions of the acceptability test in Appendix B).

5.1.4. Analysis and results for the pre-test

The acceptability of each sentence pair was determined by averaging the ratings of all participants. In order to create a list of items with a high level of acceptability and with balanced acceptability across the two conditions (RV and PV), two criteria were defined for item rejection:

- Mean acceptability z-score beyond 1.5 from the overall mean acceptability of the items;
- Large difference (mean > 1.80) in the acceptability of the item between the two conditions.

To verify whether the two versions of the remaining 80 sentence pairs differed in acceptability, a Wilcoxon Signed Ranks Test was conducted, using SPSS (v.20). The results indicate that there are no significant differences in acceptability between the pronominal and reflexive versions, $z=-0.284$, $p=0.776$. The mean acceptability of the sentence pairs was at the

level of 'Totally Acceptable' both for the reflexive version and the pronominal version (mean acceptability of 1.88 and 1.90, respectively) (See table 2).

Table 2 - Acceptability levels of the final 15 items and comparison across conditions

Condition	*Mean*	*Standard Deviation*	*Wilcoxon Signed Ranks Test*	
			Mean Rank	*Mean Rank*
RV	1.88	0.201	9.17	*z*=-0.284, *p*=0.776
PV	1.90	0.399	7.22	

Note: RV: version of sentence pair with reflexive; PV: version of sentence pair with pronoun.

5.2. *One-back* task and response time to reflexives and pronouns

5.2.1. Participants

This work required three experimental groups of 21 participants following some conditions.

- Left-Hemisphere Damaged group (LH), with aphasia, aphasia quotient between 20% and 75% (see detailed aphasia classification in Figure 1).
- Right-Hemisphere Damaged group (RH) without aphasia.
- Control group, matched to the patients groups in age, gender and educational level.

The participants of this study followed specific conditions, namely: age between 16 and 75 years old; native speakers of Portuguese; absence of any sensory deficits, including problems with vision or hearing (if present, these were properly corrected); all participants were right-handed, according to Edinburgh Handedness Inventory (Oldfield, 1971) (the participants with hemiparesis

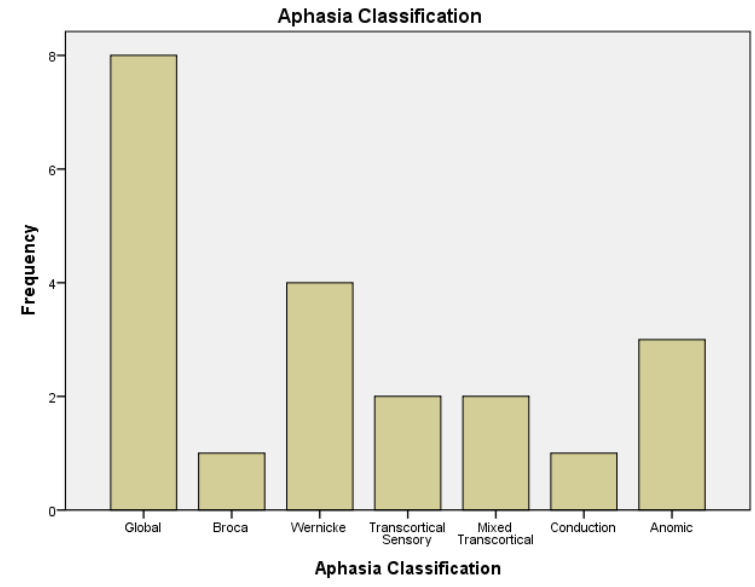

Figure 1:Graph showing the number of participants with each kind of aphasia: Global (8), Broca (1), Wernicke (4), Transcortical Sensory (2), Transcortical Mixed (2), Conduction (1) and Anomic (3).

were premorbidly right-handed); all participants, agreed with the participation and signed an informed consent according to the declaration of Helsinki (Kong & West, 2001); patients with psychiatric disorders, degenerative diseases, and drug abuse history were excluded.

All participants with a left hemisphere lesion presented aphasia but were able to complete the experimental tasks; none of the participants with a right hemisphere lesion presented language deficits. Additionally, all participants performed above the cut-off scores of the Portuguese version of the Mini Mental State examination (Guerreiro et al., 2007); had only one single cerebrovascular accident, without any other neurological diagnoses; in order to obtain a sample comprised with patients with a more focal lesion (Brookshire, 2007; Chapey, 2001).

In total, 106 subjects participated in this study. From these, one participant was excluded because he was classified as ambidextrous according to the Edinburgh Handedness Inventory (Oldfield, 1971), four were excluded because they had an aphasia quotient higher than 75%; one was excluded because he was exposed to a different language in the first years; one was excluded because only had the third grade, eighteen participants were excluded due to atypical performance (more than 2 SDs from the group mean of d-prime and response time); and eighteen were excluded post-hoc in order to ensure that the 3 experimental groups were balanced in age, literacy and time post-onset.

Three balanced groups were formed (Right Hemisphere Lesion Group, Left Hemisphere Lesion Group, and Control Group) each one with 21 participants (9 female participants per group). Normality tests were performed before statistical analyses.

The groups were equivalent for age [$F(2,60)=0.33$, $p=0.72$] and educational level ($\chi 2(2)=5.75$, $p=0.06$) (see Table 3). Right and left hemisphere group were equivalent concerning time onset ($U=197.00$, $p=0.55$).

Table 3: Demographics of the participants of the one-back task and sentence verification

	Left Hemisphere	**Right Hemisphere**	**Control**
Gender	21 ♂=12 ♀=9	21 ♂=12 ♀=9	21 ♂=12 ♀=9
Age	59.38±12.32 (range: 30-74)	61.57±9.31 (range: 44-75)	59.10±10.55 (range: 32-74)
Literacy (years)	6.87±4.32 (range: 4-18)	4.52±1.40 (range: 4-10)	5.81±2.36 (range: 4-12)
Time onset (months)	5.71±4.01 (range: 1-13)	3.10±31.37 (range: 1-144)	N.A.
Q.A.	41.90±17.57 (range: 20.83-70.31)	N.A.	N.A.

Note: ♂: male; ♀: female; N.A.: non applicable

5.2.2. Neuropsychological Assessment

All patients were assessed with Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975) in Portuguese version (Guerreiro et al., 2007). Because some patients have severe difficulties in answering to the MMSE questions due to their language impairments, a communication table with numbers, days of the weak, months and seasons was made, to correctly assess whether these patients were oriented in time. It should be pointed out that some of the difficulties and errors produced by aphasics in this test can be due to the procedures used to assess cognitive functions, which also require communicative abilities (Golper, Rau & Erskine, 1993). Dick et al., (1984) noticed that a group of patients with focal lesions in the left hemisphere had scores ranging from 8 to 30, while a group of patients with right hemisphere focal lesions score ranging from 24 to 30.

The Edinburgh Handedness Inventory consists of a set of questions about the way the subject executes some daily tasks (like which hand is used for writing, drawing or for holding a spoon). It is used to determine the individuals' handedness. In our study, this is relevant due

to the possible relation between cerebral dominance and language representation in brain (Oldfield, 1971).

The Line Bisection Test (Schenkenberg, Bradford, & Ajax, 1980) was also administered. This is a fast test to screen neglect and consists in giving a sheet of paper with a horizontal line and ask the patient to mark the middle of the line (Schenkenberg et al., 1980).

All aphasic patients went through a language evaluation to determine their aphasia quotient and, consequently if they have the comprehension level required to participate in this study. Patients were assessed and classified according to the Bateria de Avaliação das Afasias de Lisboa (Castro-Caldas, 1979; Damásio, 1973; Ferro, 1986), a test based on Multilingual Aphasia Examination (MAE) (Benton & Hamsher, 1976; (Benton & Hamsher, 1976). This battery allows to compute the aphasia quotient (Leal, 2006).

5.2.3. Stimulus

This experimental process involved two procedures: first the Working Memory assessment, using one-back task; and second the sentence verification task.

For the one-back task, eight images of fruits selected from Bramão, Faísca, Petersson and Reis (2010) set were used. These images were equivalent according to prototypicality, familiarity, ambiguity, complexity and diagnostic (Bramão et al., 2010) (Items of the experiment in Appendix E).

The task was similar to the one used by Christensen and Wright (2010). The stimulus were presented for 750ms and the interstimulus interval between images were 2750 ms (Figure 2). Instructions were provided before the task (Appendix F). All participants performed a training trial before the task with 10 items and two targets. A one-back task was used, given that Christensen and Wright (2010) have argued that two-back task are too demanding for the

aphasic population. The task consisted in pressing a key (in this case, the space bar), when the subject saw the same fruit twice in a row. The task was divided in a practice block followed by four experimental blocks. Each block had a variable number of items and targets. A rest period was included between each block. The responses were recorded using the Presentation

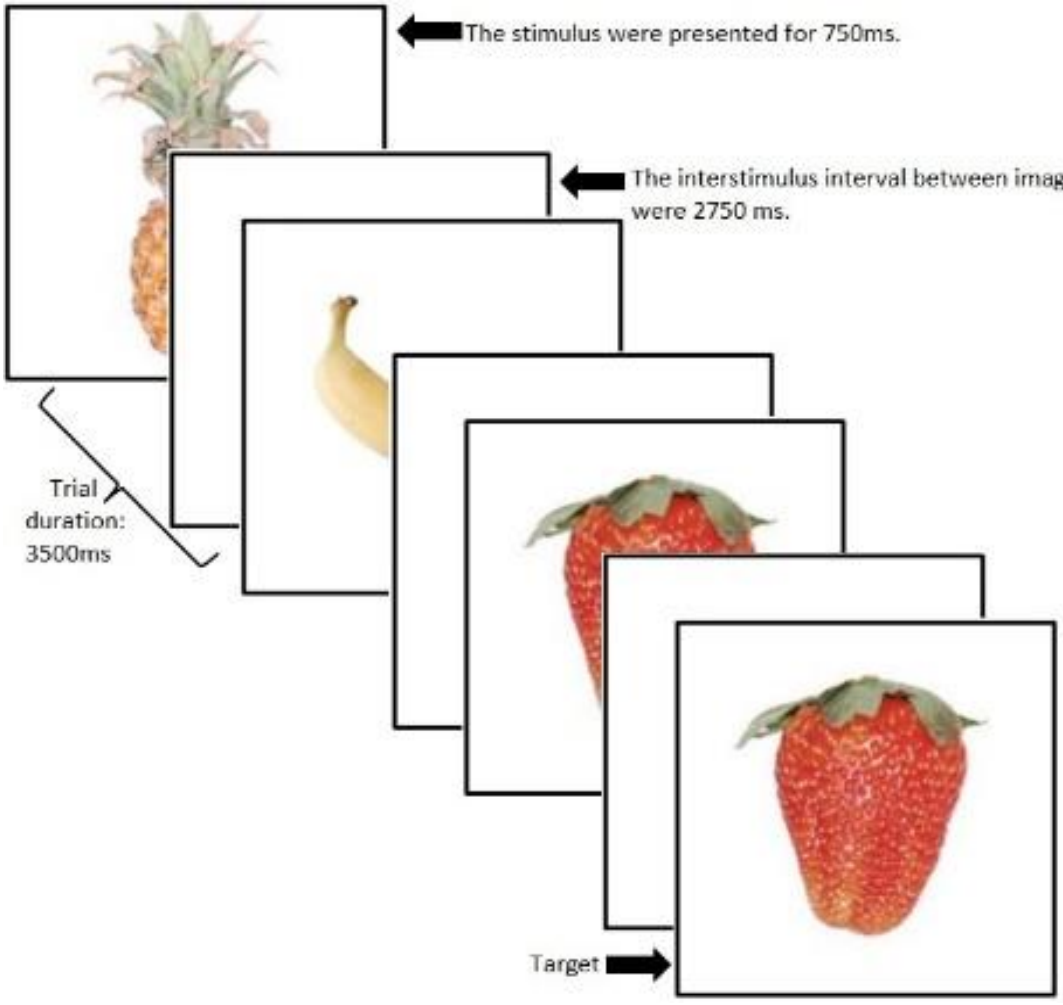

Figure 2: Trial structure with the duration of each event in one-back task.

software.

For the sentence verification task, four conditions with 15 images each were created. These illustrated sentences with pronouns and reflexives (target) and 40 fillers, both from the study of de Aguiar et al. (2013) (Items of the experiment in Appendix G). The targets were chosen according with the results of the acceptability pre-test. The total of target sentences

were 60, and the total number of fillers were 40. Just like Santi & Grodzinsky (2007) we used more targets relatively to fillers to maximize the number of informative trials, and to minimize the duration of the task, hence avoiding fatigue and, consequently, random answers. Each trial had the duration of 10000ms: first the participants saw the image, and then 1000ms after they heard the sentences (Figure 3). Instructions were provided before the task (Appendix H). All participants performed a training trial before the task with 10 items. Given that, the stimuli

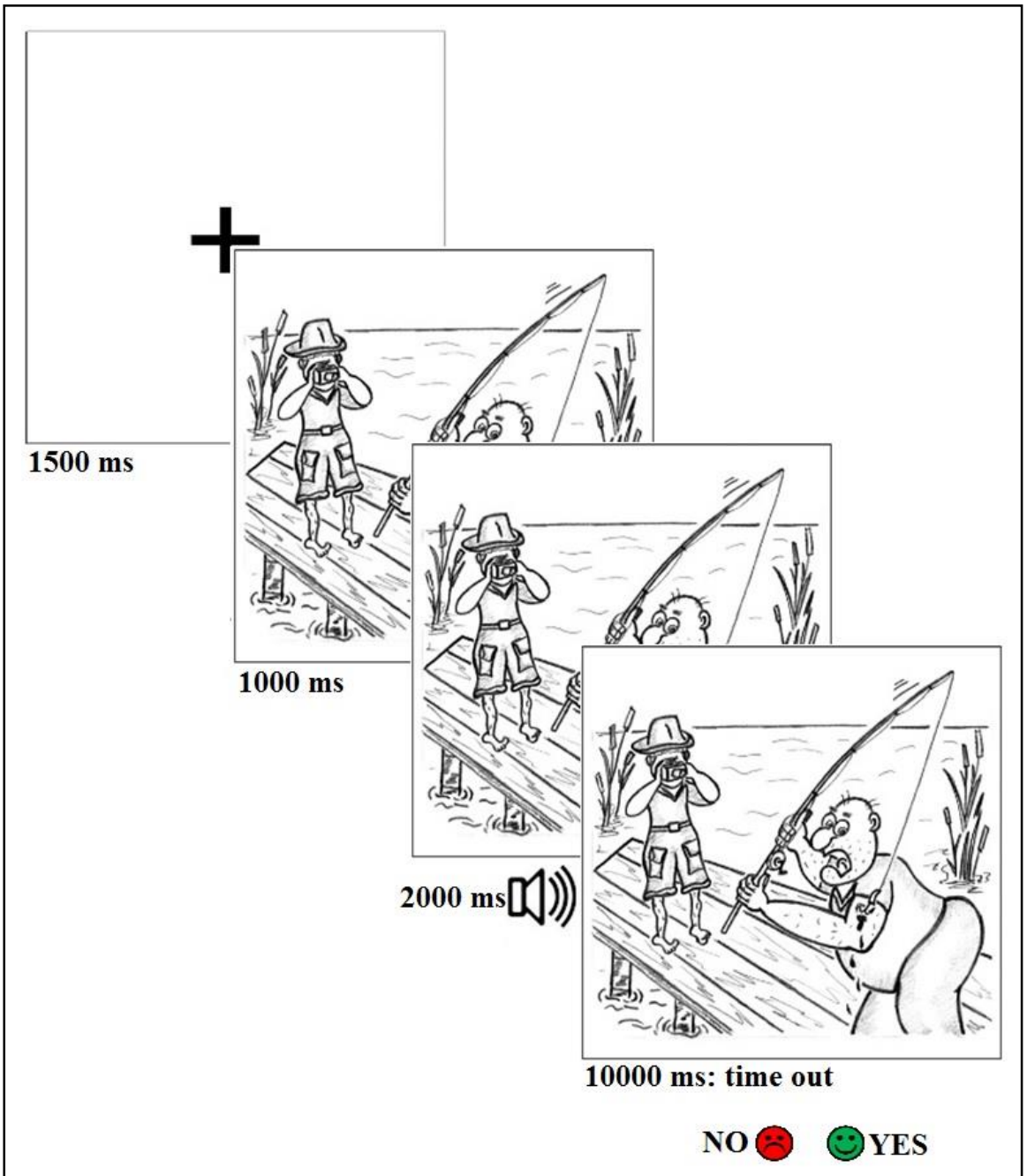

Figure 4: Trial structure of Sentence Verification Task. The duration of each event is indicated at the bottom left of each screen.

sequence was random, the subject could not predict where the target sentences and in what pictures were they matching or mismatching the image. The stimuli presentation had two versions: “sentence verification” and “sentence verification reversed” (consisting of the same items with reversed order), to avoid the influence of exhaustion bias in the results.

The software used to display the stimuli was Presentation 0.7 (nbs.neuro-bs.com/presentation). An Acer Aspire V5 laptop computer screen was used for the stimuli presentation and to register the response times. Headphones QILIVE were used to present the audio stimuli. For both tasks, smiley faces and an arrow were attached to the keys used to give the answer on the computer. For the one-back task were used a green smiley face (☺) to answer and an arrow (→) to continue the experiment. For the sentence verification task were used a green smiley face (☺) to answer when the answer was “Yes”, a red sad face (☹) when the answer was “No” and an arrow (→) to continue the experiment.

Table 4: Experimental sentence pairs for the Sentence Verification study

Condition	*Introductory Sentence*	*Target Sentence*	*Critical*
RM	The fisherman is with the tourist. *O pescador está com o turista.*	The fisherman hurts *O pescador magoa*	himself. *se.*
RN	The fisherman is with the tourist. *O pescador está com o turista.*	The fisherman hurts *O pescador magoa*	himself. *se.*
PM	The fisherman is with the tourist. *O pescador está com o turista.*	The fisherman hurts *O pescador magoa*	him. *o.*
PN	The fisherman is with the tourist. *O pescador está com o turista.*	The fisherman hurts *O pescador magoa*	him. *o.*

Note: RM: Sentences with reflexive with the character performing the action in himself matching the picture; RN: Sentences with reflexive with the character performing the action in another character not matching the picture; PM: Sentences with pronoun with the character performing the action in another character matching the picture; PN: Sentences with pronoun with the character performing the action in himself not matching the picture.

The material was presented in the visual and auditory modalities. The sentence pairs presented were like “The fisherman is with the tourist. The fisherman hurts him/himself." in order to comply with the four conditions explicit on table 4.

The participants had to look at a picture for 1000ms and after that they followed by an auditory presented sentence (de Aguiar et al., 2013). The picture remained on the screen until the end of the trial. Response times were measured from the onset of the reflexive/pronoun to the key-press of response (in correct responses only).

5.2.4. Procedures

After the acceptability pre-test, participants were recruited. First participants with brain lesions were tested, and after that, we recruited matched participants without brain lesions (control group).

The testing procedures were all approved by the ethical committee of the institutions involved (detailed information in figure 4). A questionnaire was filled for each participant, with biographical and clinical data, that was relevant to this study. Some information was provided by the participants such as years of literacy and age; their medical records provided supplementary information, like medical history and, in neurological damaged cases, local of lesion, time after onset, and presence or absence of aphasia. All the participants received and signed an informed consent (Appendix C); and the patients with aphasia signed an aphasia-friendly informed consent, with simpler sentences and pictures to support the information in order to ensure their fully understanding and consent (Rodrigues, 2012) (Appendix D).

The participants were assessed with the MMSE, line bisection test and Edinburgh Handedness Inventory before actually completing the experimental tasks, to ensure that they were eligible to participate.

Figure 4:

1. Centro de Medicina e Reabilitação do Sul – São Brás de Alportel

2. Unidade de Cuidados Continuados da Cruz Vermelha de Tavira – Tavira

3. Unidade de Cuidados Continuados da Associação Cultural e de Apoio Social de Olhão - Olhão

4. Unidade de Cuidados Continuados da Fundação António Silva Leal – Albufeira

5. Unidade de Cuidados Continuados, Al-Vita – Portimão

6. Unidade de Cuidados Continuados da Santa Casa da Misericórdia de Portimão – Portimão

7. Unidade de Cuidados Continuados da Santa Casa da Misericórdia de Silves – Silves

8. Unidade de Cuidados Continuados do Lar Quinta de São Sebastião – Algoz

9. Associação de Reformados Pensionistas e Idosos – Faro

10. Associação de Solidariedade Sócio-Cultural de Montenegro – Faro

11. Unidade de Cuidados Continuados do Hospital D. Manuel Aguiar – Leiria

12. Unidade de Cuidados Continuados do Centro Hospitalar Nossa Senhora da Conceição – Batalha

13. Unidade de Cuidados Continuados do Montepio Rainha D. Leonor – Caldas da Rainha

14. Unidade de Cuidados Continuados do Hospital Casimiro da Silva Marques – Bombarral

15. Centro de Medicina de Reabilitação da Região Centro – Rovisco Pais – Tocha

Figure 4: Identification and distribution of the institutions where the data collection took place.

After agreeing and signing the informed consent, all the patients were instructed about how to perform the first task: the one-back task. This task was the first to be performed to avoid the interference of tiredness, once memory tests are sensitive to fatigue (Moss-Morris, Petrie, Large, & Kydd, 1996).

After the Working Memory task, participants performed the language comprehension task at discourse and sentence level in which they had to see an image and, at the same time listen two sentences. They should anwser “yes” or “no” whether the setence matches the image.

5.2.5. Analyses and Results

The d-prime value for each participant was calculated both for the one-back task and for the sentence verification task. In the last one the d-prime was calculated separately for pronouns and reflexives. In order to remove extreme values we used the Standard Deviation (SD) method, in other words we removed all results that were 2SD above or below mean accuracy and mean RT for each participant. Normality tests were performed before statistical analyses.

Do the three groups differ in processing pronouns and reflexives?

– D-Prime Analyses

To compare the d-prime (D') across conditions and groups, a 2x3 mixed ANOVA considering Condition as a within subject factor ('pronoun' *vs.* 'reflexive') and Group as a between subject factor (HD *vs.* HE *vs.* Control) was conducted for all participants. Follow up tests were pursued when relevant interactions were identified. Greenhouse-Geisser corrections were applied when the data did not meet the sphericity assumption. An alpha level for significance was set at $p<0.05$. A main effect of condition ($F(1.60)=4.90$, $p=0.03$) and a main effect of group ($F(2.60)=62.14$, $p=0.000$) were found. However, there was no interaction between Condition*Lesion ($F(2.60)=2.33$, $p=0.11$). Post hoc comparisons using the Tukey HSD test were pursued, and these revealed statistical significant differences between the LH and the RH ($p=0.009$) and between both patients groups and control group (LH: $p=0.000$; RH: $p=0.000$). A profile plot summarizes the results (Figure 5a & 5b).

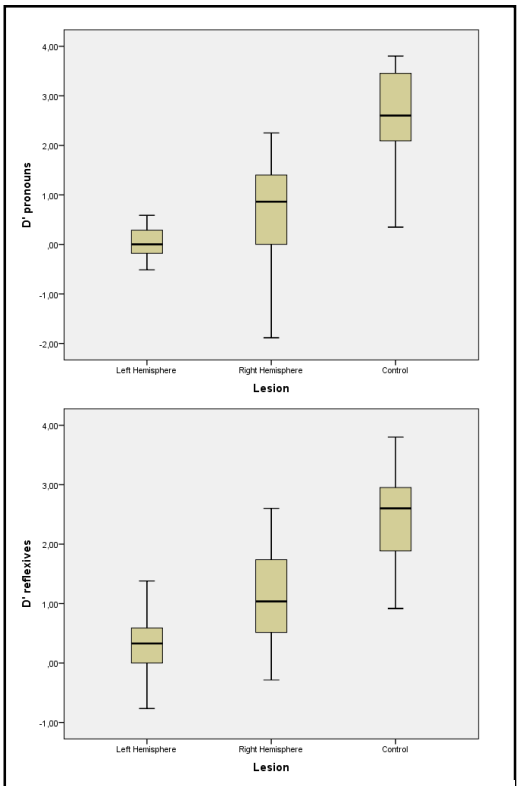

Figure 5a & 5b: The first boxplot shows the performance for the three groups in sentences with pronouns; the second plot show the performance for the three groups in sentences with reflexives.

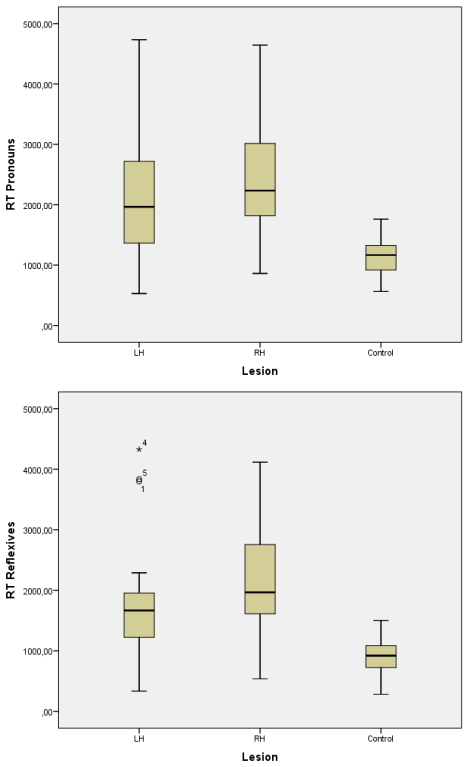

Figure 6a & 6b: The first boxplot shows the RTs for the three groups in sentences with pronouns and the second plot show the RTs for the three groups in sentences with reflexives.

– RT Analyses

A 2x3 mixed ANOVA considering Condition as a within subject factor ('pronoun' *vs.* 'reflexive') and Group as a between subject factor (HD *vs.* HE *vs.* Control) was also computed for all participants to compare the response time (RT) in both conditions. A main effect of condition ($F(1.60)=22.00$, $p=0.000$) and group ($F(2.60)=12.69$, $p=0.000$) were found. However, the patients groups did not significantly differ from each other. Just like in D', there was no interaction between Condition*Lesion ($F(2.60)=0.56$, $p=0.57$). Post hoc comparisons using the Tukey HSD test indicated that the mean score for the LH and for the RH groups were significantly different than the control group (LH: $p=0.001$; RH: $p=0.000$), the patients groups didn't differ from each other ($p=0.526$). A profile plot summarizes the results (Figure 6a & 6b; detailed information on table 5).

Table 5: Means and Standard Deviations for RT and D' for pronouns and reflexives in each group

		LH Group	**RH Group**	**Control Group**
D'	*Pronouns*	0.06±0.33	0.60±1.09	2.55±1.03
	Reflexives	0.31±0.60	1.09±0.77	2.50±0.79
RT	*Pronouns*	2129.48±1041.60	2348.65±967.34	1141.84±342.12
	Reflexives	1840.46±1023.44	2169.83±962.29	951.88±331.39

Note: LH: left hemisphere, RH: right hemisphere, D': d-prime, RT: response time

Do the three groups differ in their degree of WM impairment?

Because the distribution didn't meet the normality assumption, for d-prime we used a non-parametric test (Kruskall-Wallis). The Concerning the working memory test (one-back task), statistically significant differences in performance were found among the groups (K-W, $\chi 2(2)=20.78$, p=0.000). The LH and the control group were different (U=40.00, p=0.000) as well as RH and the control group (U=95.500, p=0.002); however we didn't find differences when LH and RH groups were compared (U=193.500, p=0.497).[1] Similar results were obtained when we compared RT in one-back task across groups with the ANOVA test. A significant effect of RT at the p<0.05 level for the three groups (F(2,60)=6.65, p=0.002) was observed. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the LH and for the RH groups were significantly different than the control group (LH: p=0.018; RH: p=0.003). However, the patients groups did not significantly differ from each other (p=0.814) (detailed information on table 6).

Table 6: Means and Standard Deviations for WM for pronouns and reflexives in each group

	LH Group	**RH Group**	**Control Group**
D'	2.64±0.84	2.89±1.16	3.95±0.54
RT	1178.24±359.21	1247.66±444.33	860.26±278.44

Note: LH: left hemisphere, RH: right hemisphere, D': d-prime, RT: response time

Is there an overall correlation between WM and the processing of reflexives and pronouns, for any of the groups?

Next a correlation test was computed (Spearman) for d-prime and the RT, to determine the relationship between the one-back task and reflexives, and the one-back task and pronouns, for each group separately.

[1] With the ANOVA test the results would be similar (F(2,60)=13.13, p=0.000). Post hoc comparisons using the Tukey HSD indicated that the LH and the control group were different (p=0.000) as well as RH and the control group (p=0.001); however we didn't find differences when LH and RH groups were compared (p=0.640).

– D-Prime Analyses

For LH group no statistically significant correlation was found between one-back task for reflexives and neither for pronouns (D' reflexives: $r_s(19)=0.42$, $p=0.06$, and D' pronouns: $r_s(19)=0.32$, $p=0.16$). For the RH group, a statistically significant moderate positive correlation between D' one-back task and was found for D' reflexives ($r_s(19)=0.598$, $p=0.004$) and for D' pronouns ($r_s(19)=0.502$, $p=0.021$). While for the control group, a significant correlation between D' one-back task and D' reflexives ($r_s(19)=0.465$, $p=0.034$) and between D' one-back task and D' pronouns, ($r_s(19)=0.539$, $p=0.012$) was found.

– RT Analyses

Just like in D', for LH group no statistically significant correlation was found between the one-back task and reflexives or pronouns (RT reflexives: $r_s(19)=0.09$, $p=0.70$, and pronouns: $r_s(19)=-0.01$, $p=0.97$). When we analysed the RH group, we also did not find any correlation between both one-back task and reflexives ($r_s(19)=0.10$, $p=0.68$) and one-back task and pronouns ($r_s(19)=0.24$, $p=0.29$). Similarly to what happened to the LH and RH groups, no correlation was found neither between the RT in the one-back task and the RT for reflexives ($r_s(19)=-0.053$, $p=0.819$), nor between the RT in one-back task and the RT for pronouns ($r_s(19)=-0.049$, $p=0.834$).

5.3. Error Prevalence Study

In order to observe the origin of the errors in the previous task, a new task was created. This task was performed on a different day, after the sentence verification.

5.3.1. Participants

We invited all the participants for a second evaluation, but it was not possible to assess the entire sample. Some participants left the institution (n=11), others were not available to

schedule a second meeting (n=16), refused to continue testing (n=2) or had to be excluded to ensure matching in age and education in the two smaller RH and LH groups, (n=7). Given that the number of participants changed, we considered relevant to remake the statistical analyses to ensure balancing across groups.

In total, 70 subjects answered the error prevalence test. From these, thirteen participants were excluded from this analysis due to atypical performance in the previous task (more than 2 SDs from the group mean of d-prime and response time); and twelve were excluded in order to ensure matching across groups in age, and literacy.

In the error prevalence study, 21 of the 45 participants were female. We formed the same three groups (Right Hemisphere Lesion Group, Left Hemisphere Lesion Group, and Control Group) with 15 participants each. Normality tests were performed before statistical analyses. There were no age differences among groups [$F(2,42)=0.334$, $p=0.718$]. The time onset for left and right hemisphere patients ($U=95.000$, $p=0.464$), and the literacy level (K-W, $\chi 2(2)=4.56$, $p=0.102$) were equivalent (*cfr.*, Table 7).

Table 7: Demographics of the participants of the Error Prevalence Study

	Left Hemisphere	**Right Hemisphere**	**Control**
Gender	15 ♂=8 ♀=7	15 ♂=8 ♀=7	15 ♂=8 ♀=7
Age	60.87±11.11 (range: 35-74)	60.60±10.32 (range: 44-75)	58.20±7.81 (range: 47-73)
Literacy (years)	5.13±2.33 (range: 4-16)	4.73±1.62 (range: 4-10)	5.80±1.70 (range: 4-12)
Time onset (months)	5.73±4.40 (range: 1-13)	13.13±36.30 (range: 1-144)	N.A.
Q.A.	37.90±18.18 (range: 20.83-70.31)	N.A.	N.A.

Note: ♂: male; ♀: female; N.A.: non applicable

5.3.2. Materials

To perform this test, there were used an Acer Aspire V5 laptop computer screen for the stimuli exhibition and headphones QILIVE to present the sound stimuli. The software used was the Microsoft PowerPoint. The position of the stimuli was carefully chosen to be sure that there were exactly the same number of targets in the left, center and right along the task. Furthermore the order was randomized using the Microsoft Excel.

5.3.3. Procedure

The task that was created consists in a presentation in which the individuals will see three images and hear one pair of sentences. The three images will be: one target, one related distractor and one unrelated distractor (Figure 7). The individuals must touch the screen in the corresponding image that would be marked with a red dot (⭘). The dot disappears when the images change. Answers are registered in a record sheet.

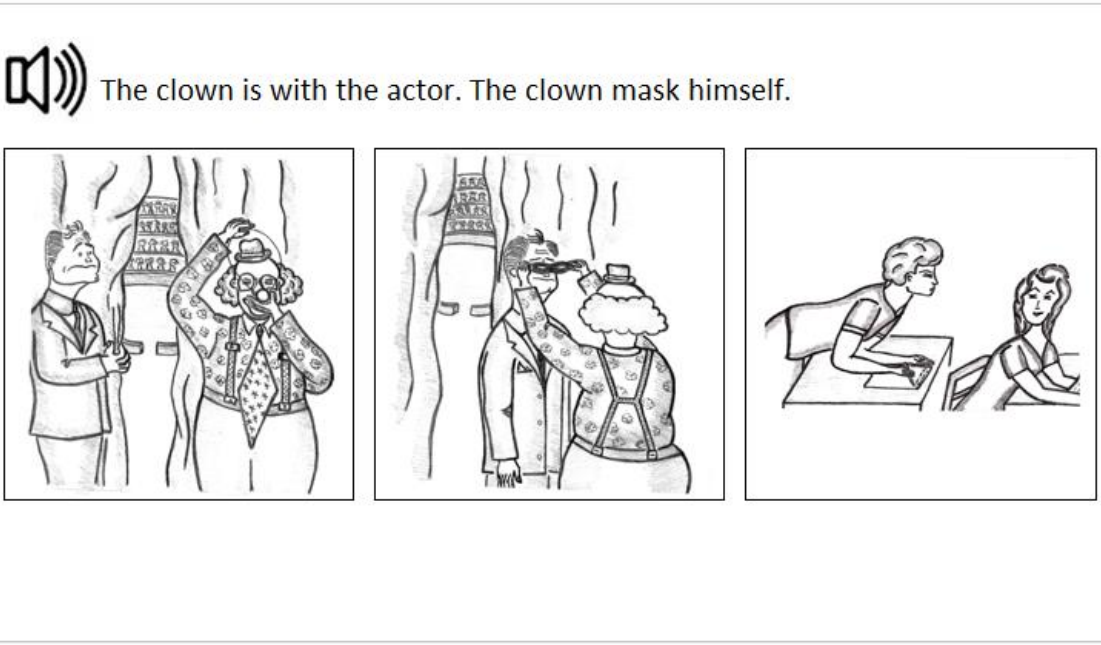

Figure 7: Description of the task for the Error Prevalence Study.

From the performance of the individuals in this task we could understand the origin of the errors on the previous task: if they were due to the difficulty in accessing to the meaning of the anaphor, or if it was in all sentence.

5.3.4. Analyses and Results

Considering the goal of this study, errors made by the participants were taken for further analysis. The percentage number of errors was calculated considering the total number of errors in selecting pronouns or reflexives unduly.

Do the three groups differ in the type of errors done during a sentence verification task with reflexives and pronouns?

To compare the percentage of errors in both conditions: reflexive and pronouns, a Wilcoxon Signed Ranks Test was conducted, using SPSS (v.20). We found statistically significant difference between the two conditions (Z=-19.65, p=0.000).

When errors were analyzed within group, statistically significant differences between percentage for reflexives and for pronouns for all groups was observed (LH: Z=-13.16, p=0.000; RH: Z=-12.46, p=0.000; Controls: Z=-8.37, p=0.000) (detailed information on table 8 and figure 8).

Table 8: Mean percentage and Standard Deviations for the error prevalence study for pronouns and reflexives in each group

	Pronouns	**Reflexives**
Total	41.79±14.49	33.50±13.63
LH	40.05±11.20	36.78±9.12
RH	41.23±15.27	33.30±15.08
Controls	22.70±15.14	12.53±12.74

Note: LH: left hemisphere, RH: right hemisphere

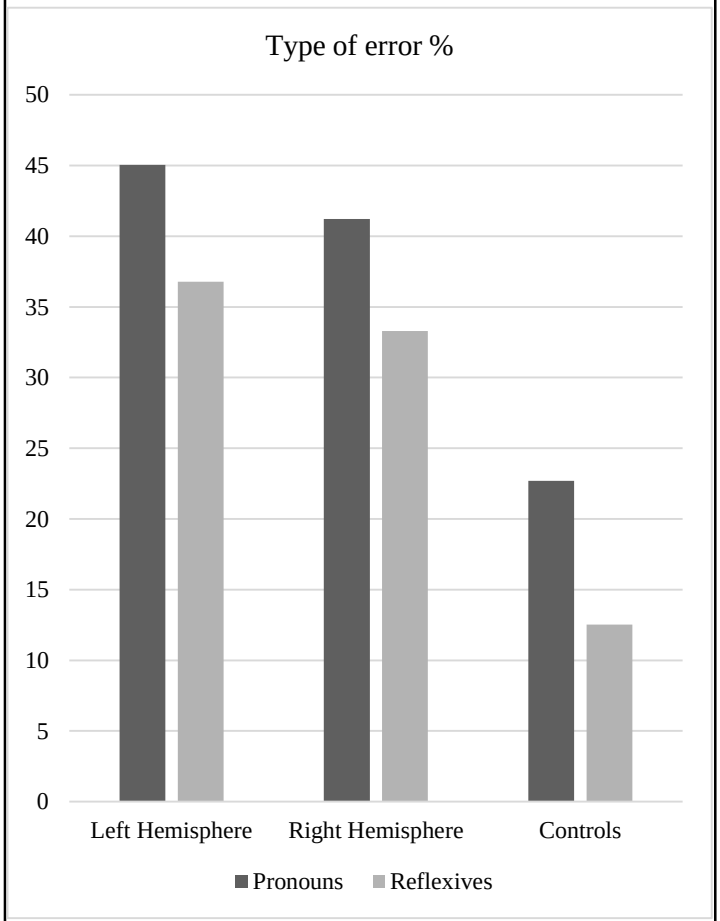

Figure 8: Bar chart describing the mean % of errors in each condition for each group in the Error Prevalence Study.

We decide to perform a comparison between all groups to see the differences between them. When we compared LH patients and controls for reflexives and pronouns, we found statistically significant differences between these two groups for both conditions (U=4560.00, p=0.000 and U=7480.00, p=0.000, respectively). The same happened when we compared RH and control groups (reflexives U=5336.00, p=0.000; and pronouns U=8320.00, p=0.000). The comparison between patients' groups also showed statistically significant differences between these two groups for reflexives (U=132958.50, p=0.04), and for pronouns (U=127332.00, p=0.002).

6. DISCUSSION

Because of its complexity, many authors questioned of what capacities could be involved on discourse processing. One of the capacities most commonly referred is the working memory.

For this study, we purposed to analyse the differences between the processing of d-linked relations (pronouns) and local binding relations (reflexives) on a group of participants with and without language deficits. In addition, we tried to understand the relation between working memory and discourse comprehension.

Overall, our results showed that performance and response time of the participants were highly influenced by the presence or absence of pronouns or reflexives in sentences: better performance and lower RT for reflexives were found compared to pronouns. Specifically, both RH and LH groups performed significantly worse than controls and had higher RT compared to controls in both pronouns and reflexives. However, RH group, outperformed LH group for accuracy but not for RT. In addition, concerning the relation between working memory and language comprehension, the data suggest that the RT in one-back doesn't seem to influence the performance in pronoun or reflexives task for the left hemisphere lesion group. In contrast, we observed that both in RH and the control group there was an association between working memory and sentence processing: in the RH group the influence of the one-back in both the pronouns and reflexives task was clear (being the correlation slightly stronger for reflexives). In the control group, the performance in the one-back was associated to the performance for pronouns and reflexives. The association was stronger for pronouns, as expected. For the RT we didn't find any correlations either for RH or controls (detailed information on table 9).

Table 9: Summary of statistical findings

Accuracy (D')		
Pronouns vs. reflexives in all participants	3 groups (altogether)	Higher D' for reflexives.
Differences between groups in pronouns and in reflexives (altogether)	LH vs. Controls	Controls had higher D'
	RH vs. Controls	Controls had higher D'
	LH vs. RH	RH had higher D'
Correlation between WM and reflexives	LH	No correlation.
	RH	Positive moderate correlation
	Controls	Positive moderate correlation
Correlation between WM and pronouns	LH	No correlation.
	RH	Positive moderate correlation
	Controls	Positive moderate correlation
Differences between groups in WM	LH vs. Controls	Controls had higher D'.
	RH vs. Controls	Controls had higher D'.
	LH vs. RH	No differences.
Response Time (RT)		
Pronouns vs. reflexives in all participants	3 groups (altogether)	Shorter RTs for reflexives.
Differences between groups in pronouns and in reflexives (altogether)	LH vs. Controls	Controls had shorter RTs
	RH vs. Controls	Controls had shorter RTs
	LH vs. RH	No differences between LH and RH
Correlation between WM and reflexives	LH	No correlation.
	RH	No correlation.
	Controls	No correlation.
Correlation between WM and pronouns	LH	No correlation.
	RH	No correlation.
	Controls	No correlation.
Differences between groups in WM	LH/Controls	Controls had shorter RTs.
	RH/Controls	Controls had shorter RTs.
	LH/RH	No differences between LH and RH.
Error Prevalence Study		
Pronouns vs. reflexives in all participants	3 groups (altogether)	There were differences.
Pronouns vs. reflexives for each group	LH	Chose pronoun pictures wrongly more often.
	RH	Chose pronoun pictures wrongly more often.
	Controls	Chose pronoun pictures wrongly more often.
Differences between groups in pronouns and in reflexives (analysed separately)	LH/Controls	LH chose pronoun pictures wrongly more often than Control. LH chose reflexive pictures wrongly more often than Control.
	RH/Controls	RH chose pronoun pictures wrongly more often than Control. RH chose reflexive pictures wrongly more often than Control.
	LH/RH	LH chose pronoun pictures wrongly more often than RH. LH chose reflexive pictures wrongly more often than RH.

Note: LH: left hemisphere, RH: right hemisphere

The error analyses suggest that, when confronted with the decision of matching an enunciation with three images, in general, all participants chose mistakenly the image corresponding to pronouns more often. In this task, patients with LH lesions chose the picture

representing pronominal sentences (wrongly) more often. This tendency was even stronger in the RH group and largest for controls. In other words, with the increase of language impairment, the difference between unduly choosing pronouns and reflexives grows, with pronoun errors occurring with increasing errors. In groups with preserved language, the tendency to choose reflexives incorrectly is lower (detailed information on table 9).

6.1. Do the three groups differ in processing pronouns and reflexives?

Just like we predicted and according to Caplan, Hildebrandt and Makris (1996) and Grodzinsky (2006), right hemisphere patients had a better performance than left hemisphere patients, however it's important to keep in mind that the RH performance was bellow controls, which means that in spite of not showing difficulties in standardized language assessments, they show difficulties in language processing in this complex language task. Some authors have suggested that RH hemisphere also plays a role in discourse comprehension (Caplan et al., 1996; Grodzinsky, 2006; Perfetti & Frishkoff, 2008). Given that no interaction was observed, the data does not support a larger role of the LH or RH in discourse processing than in syntactic processing. Still, the impairment in processing reflexives and pronouns relative to controls suggests that the both the LH and RH play a relevant role for processes that are shared by types of anaphoric dependencies.

The performance of LH patients is congruent with the research that states that individuals with aphasia will have a poor performance due to their impairment of the areas that take part in the syntactic processing (left perisylvian cortex), and consequently, their lack of processing resources (Avrutin, 2000; Caplan, Hildebrandt, & Makris, 1996; Grodzinsky & Reinhart, 1993; Love, Nicol, Swinney, Hickok, & Zurif, 1998). This is in line with Choy and Thompson (2010) who have found that individuals with aphasia present difficulties both in sentences with d-linked relations and local-binding. In spite of the difficulties in both (d-linked

relations and local-binding relations), as predicted by Avrutin (2000), the three groups of participants had poorer performance (both in RTs and D') with pronouns. This pattern reflects the higher complexity of discourse dependencies. Importantly, the pattern is observed in all participant groups, so it suggests that processing of reflexives and pronouns is not particularly represented in either left or right hemisphere and that deficits with both pronouns and reflexives may be due to a processing deficit, rather than a representational deficit.

According to Kolk (1995) individuals with aphasia show a slowing down of lexical activation that lead to a difficulty in reactivating traces in a point in time that such reactivation is needed. According to this author, these limitations in activation could be responsible for the slower performance of the LH patients. However in our study we did not find longer RTs in the LH group than in the RH group. In fact, both groups had similar RTs for pronouns and reflexives (higher than controls, like expected). In spite of the need of extra time to process anaphors in our groups with brain damage, we cannot attribute this to the presence or absence of aphasia, because individuals with and without aphasia had similar RTs.

In spite of taking a similar amount of time to choose the answer, the RH patients were more accurate than the LH patients. Even though RH have a brain lesion, they have available some resources that are lacking in LH patients. This way, they may take as much time to reply, but they ultimately RH patients manage to reply more correctly than LH patients. So LH patients lack some information/processing resources that they cannot compensate for. In the other hand RH patients have some disturbed processing/information, but they still have other available knowledge or process that allows them to complete the task. Whether the impairment that makes both groups slower is the same or a different one is unclear, but given the different location of lesions it is possible that they have different impairments. This supports the idea that LH and RH patients are using different strategies in processing pronouns and reflexives. Hence, both lesion sites hold functions that are relevant for processing anaphors (because both

groups perform lower than controls), but these functions are likely to be of a different nature and LH is more crucially engaged in anaphoric resolution.

6.2. Do the three groups differ in their degree of WM impairment?

In this study, we found that RH and LH groups had a working memory level below controls; however we did not find significant differences between these two patients groups both for RTs and accuracy. According to these results, we can assume that there are no differences in working memory for LH and RH groups. Nevertheless, there are differences in accuracy for pronouns and reflexives for these two groups and both LH and RH patients perform below controls in both the language task and WM, so we cannot exclude involvement of WM. The different levels of impairment in the language task between LH and RH patients indicate that WM has a limited contribution for the processing of pronouns and reflexives. In other words, there should be cognitive skills other than working memory intervening in discourse processing. These results are consistent to the ones found by Christensen & Wright (2010). Importantly, these cognitive skills are impaired in both LH and RH patients.

6.3. Is there an overall correlation between WM and the processing of reflexives and pronouns, for any of the groups?

One of the aims of this work was to attempt to investigate the existence of a correlation between the Working Memory performance and the RT's in this task, and the performance and RT's for pronouns, in order to test whether working memory plays a pivotal role in discourse processing.

In this study, we found correlations between accuracy in the one-back task and both accuracy for pronouns and reflexives in (D') in controls and the RH group. Controls, as

primarily expected, have shown a stronger correlation for pronouns. For RH patients the correlation for reflexives was slightly stronger than that for pronouns. In LH patients we did not find correlations either for D' or RTs.

The results here presented, differ from the ones reported by Caplan and Waters, (1999); Carpenter et al. (1995) and Haarmann et al. (1997). These authors report a relation between Working Memory performance and Discourse processing, however other authors like Christensen and Wright (2010) and Martin, Saffran and Dell (1996) did not achieve the same conclusions. In Christensen & Wright (2010), the conclusion achieved was that working memory is influenced by language. Language deficits will also impair the capacity of using language skills to improve working memory, that is, when confronted with non-linguistic stimuli, controls used their linguist skills to create aids to the task. Individuals with aphasia have shown more difficulties in using such strategies (Christensen & Wright, 2010; Potagas et al., 2011).

These differences across groups in the presence and strength of correlations may indicate that the different groups rely on different cognitive skills in the processing of both reflexives and pronouns. Patients with LH damage have impaired WM and language, and may rely on completely different (probably atypical) processes while processing anaphoric dependencies. Patients with RH damage deal with WM deficits in the presence on an intact language system, and hence are more able to use their residual WM skills together with syntactic processing for reflexives, than with discourse level processing for pronouns (which may rely on additional cognitive resources, possibly also partially depending on RH). Healthy individuals show the most expected pattern: both reflexives and pronouns are processed with some support from WM, and this is more so the case for pronouns.

6.4. Do the three groups differ in the type of errors done during a sentence verification task with reflexives and pronouns?

When we analysed the amount of times that pictures of pronouns or reflexives were incorrectly chosen, we found that pronouns were chosen unduly more often than reflexives. One possible explanation for this is in the task design. In this task, the participants heard two sentences like:

- The priest is with the thief. The priest hides **himself/him**.

In the first sentence, two characters were always introduced, however in the second one, the action may be involve one of the characters or both. The performance in this test lead us to the supposition that, when confronted with the decision of selecting one image of three, and with a prior presentation of the two characters of the pictures, the participants will have a higher tendency to choose images where booth characters have an active participation in the task. Nevertheless, the sentences used were matched for acceptability (plausibility and grammaticality) in their pronominal and reflexive versions. Hence we do not expect this to have created any specific bias.

Another explanation related is the inherent ambiguity of pronouns (Nieuwland & Van Berkum, 2006). It might be then, that when participants find themselves in a position of uncertainty regarding an interpretation, they choose the most ambiguous option. With reflexives being typically unambiguous and pronouns being typically ambiguous it might be intuitive to assume that when an item is difficult, it is "probably a pronoun".

Further investigation is needed to study these hypotheses, using stimuli that do not (possibly) lead to an answer.

6.5. Constraints

The choice of the aphasic population for this study was the presence of a LH lesion, that allows to associate brain areas with determined functions (Grodzinsky, 2006) and, in this

particular case, allows to investigate language linked capacities. However, there are always some constraints that the investigators have to consider namely, the impossibility to guarantee that the participants had a full understanding of the task. In that case the poor results in the working memory task would not be due to a poor working memory capacity, but due to a compromised comprehension of the task. We tried to overcome this difficulty, by explaining slowly and carefully the tasks, and having training trials in all tasks in which the participant had the investigator's help.

In addition, there are some constraints relatively to sampling. Some patients were in rehabilitation units, others were at care units. The first ones have physiotherapy, neuropsychology and speech therapy in a daily basis, meaning that overall they have much more cognitive stimulation than patients that stay at care units. That could have reflected in the performance and in the receptivity and cooperation in the task.

Another potential limitation of the current study concerns the inclusion criteria for all patients concerning lesion size. The major concern in this study was to collect participants either with lesion on right or left hemisphere, however lesion size and site varied, leading (most of the time) to more wide-spread impairments. We tried to overcome these difficulties by assessing all participants with MMSE, to be sure that all of them had the major mental abilities preserved. This evaluation was very difficult in particularly for the aphasic patients, most of them performed (even partially) with the aid of a communication table with letters, numbers, days of the week and months.

7. CONCLUSION

The study allowed us to achieve some conclusions relatively to the participation of right and left hemispheres in discourse comprehension.

We found that both hemispheres play a role on the processing of anaphors, but that their participation seems to be of a different nature. RH group showed difficulties in processing but due to the existent language capacities they are able to compensate for their difficulties with longer RT's. The demands in right hemisphere for d-linked relations were not higher than for local binding relations, but their impairment comparatively to controls tells us that this hemisphere also plays a relevant role in processing both types of anaphors.

The performance of the LH patients allowed us different findings. Compared to RH patients, LH patients had a highest degree of language impairment, thus more difficulties in tasks that rely on language capacities, and the same pattern of more difficulties with pronouns than reflexives. This may be due to the fact that pronouns are more difficult (and hence more impaired) or because they require different processing resources to those of reflexives, which are also impaired in LH lesions.

The previous findings together with the working memory data, suggest that WM has a limited but relevant contribution for the processing of pronouns and reflexives. This contribution is visible in RH patients and controls, meaning that WM contributes particularly to the processing of anaphors when the language system is intact. In the impaired language system, there might be a complex interaction between the language deficit and the residual cognitive resources, and the contribution of WM (if any) is not detectable. In any case, there should be cognitive skills other than working memory intervening in discourse processing. These skills may be those that support the delayed (but relatively efficient) processing of patients with RH damage.

As expected, healthy individuals showed that reflexives and pronouns are processed with some support from WM, being this support more evident for pronouns. Importantly, all groups were more accurate and faster with reflexives. Hence, the higher correlation of WM and pronouns in healthy individuals indicates that healthy individuals rely more in WM during the processing of pronouns, alongside with the claim that pronouns require further processing resources. In addition, aphasia in the presence of WM deficit may prevent LH patients from recruiting this cognitive resource and further impair their processing of both reflexives and pronouns. Patients with RH lesions show more competence in using their residual WM skills together syntactic processing than with discourse level processing.

According to the findings of this study, many individuals with right hemisphere lesions might have (slight) language impairments that frequently are unnoticed. This could be an important finding, because it supports the need of a more detailed language assessment for institutionalized patients, and possibly a future intervention in this area for these patients. However more research is needed to explore the source of the language deficits in right hemisphere.

Christensen and Wright (2010) suggested that language also provides support for working memory capacity, enabling the individuals to use linguistic strategies to easily remember information. From this perspective, language rehabilitation assumes even a more important role, not just as a mean of improving the patients' communication, but also as a potential mean of improving other cognitive capacities.

8. FUTURE DIRECTIONS

In a future it would be interesting to deepen the matter of RH comprehension. In a way to clearly understand what are the linguist limitations of this group and the right hemisphere influence for language. It would be interesting to implement complex language assessments to these patients and verify if the results obtained in this work would co-occur with other RH language deficits. In this experimental work, we used patients with lesion on the right hemisphere; however it would be important to make a more localization specific study, in a way to understand the major location of the linguistic capacities and to predict possible language impairments in future RH patients.

It would also be pertinent to deepen the relation between working memory and language. Perhaps for the next study, assess discourse of patients with Working Memory impairments, without language impairment diagnoses. For the aphasic population it would be interesting to use the n-back task, but with stimuli with less language taxing, and see if there's a significant difference of results and if those results show correlation with the discourse comprehension performance.

Another pertinent matter, stressed by the difficulties found in this study, is the construction and validation of a Mini Mental State appropriate for the aphasic population. This could lead to an evaluation of the cognitive status of the patients, preferably without causing them so much frustration as the language based questions of the MMS do.

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10. APPENDICES

Appendix A. Full set of items for acceptability pre-test

Experimental Items

O pescador está com o turista. O pescador magoa-se/o.

O criado está com o duque. O criado banha-se/o.

O médico está com o estagiário. O médico palpa-se/o.

O médico está com o enfermeiro. O médico examina-se/o.

O treinador está com o ginasta. O treinador pesa-se/o.

O barbeiro está com o freguês. O barbeiro barbeia-se/o.

O palhaço está com o malabarista. O palhaço vê-se/o.

O homem está com o filho. O homem mergulha-se/o.

O aluno está com o instrutor. O aluno pisa-se/o.

O barbeiro está com o freguês. O barbeiro corta-se/o.

O padre está com o noviço. O padre queima-se/o.

O cabeleireiro está com o aprendiz. O cabeleireiro penteia-se/o.

O louco está com o psiquiatra. O louco morde-se/o.

O homem está com o rapaz. O homem abana-se/o.

O pintor está com o modelo. O pintor suja-se/o.

O professor está com o bailarino. O professor alonga-se/o.

O pai está com o bebé. O pai enxagua-se/o.

O idoso está com o jovem. O idoso coça-se/o.

O padrinho está com o afilhado. O padrinho balouça-se/o.

O avô está com o neto. O avô assoa-se/o.

O palhaço está com o ator. O palhaço mascara-se/o.

O rei está com o criado. O rei belisca-se/o.

O tio está com o sobrinho. O tio perfuma-se/o.

O agricultor está com o miúdo. O agricultor debruça-se/o.

O escravo está com o imperador. O escravo lava-se/o.

O carrasco está com o prisioneiro. O carrasco enforca-se/o.

O tio está com o sobrinho. O tio aproxima-se/o.

O padre está com o ladrão. O padre esconde-se/o.

O tio está com o sobrinho. O tio aquece-se/o.

O ladrão está com o polícia. O ladrão esmurra-se/o.

O homem está com o rapaz. O homem abriga-se/o.

O cavaleiro está com o aprendiz. O cavaleiro monta-se/o.

O professor está com o aluno. O professor risca-se/o.

O homem está com o menino. O homem despe-se/o.

O senhor está com o menino. O senhor calça-se/o.

O auxiliar está com o cirurgião. O auxiliar veste-se/o.

O mecânico está com o cliente. O mecânico limpa-se/o.

O rei está com o príncipe. O rei cobre-se/o.

O louco está com o enfermeiro. O louco mata-se/o.

O ladrão está com o polícia. O ladrão afoga-se/o.

Filler items

A menina está com o palhaço. A menina ri-o.

A mãe está com a filha. A mãe ralha-a.

A criança está com a aliança. A criança compra-a.

O árbitro está com o apito. O jogador apita-o.

O jovem está com a vendedora. O jovem vende-lhe.

O engenheiro está com o computador. O engenheiro desliga-lhe.

O agricultor está com as sementes. O agricultor semeia-a.

O cuidador está com o urso. O urso alimenta-o.

A menina está com o cão. A menina passeia-lhe.

O camionista está com o camião. O camionista atropela-se.

O lavrador está com o arado. O arado puxa-o.

O polícia está com o ladrão. O ladrão revista-o.

O condutor está com o carro. O condutor pára-se.

O condutor está com o passageiro. O condutor esquece-lhe.

A rapariga está com o namorado. A rapariga espreguiça-o.

A senhora está com o novelo. A senhora enrola-os.

A menina está com os escuteiros. A menina despede-as.

O carrasco está com o prisioneiro. O carrasco tortura-lhe.

O menino está com a árvore de Natal. A árvore enfeita-se.

O rapaz está com o balão. O rapaz rebenta-se

O dentista está com o doente. O dentista trata-se

O jovem está com a bandeira. A bandeira mostra-o.

O marido está com a mulher. O marido zanga-os.

O pai está com o menino. O pai grita-o.

A menina está com o cão. A menina morde-o.

A ginasta está com o instrutor. A ginasta exercita-lhe.

A turista está com o filho. A turista bronzeia-o

O cozinheiro está com o cliente. O cozinheiro grelha-se

O pastor está com as ovelhas. O pastor pastoreia-lhes.

O caçador está com a arma. O caçador carrega-as.

A mãe está com o filho. O filho maquilha-a.

O condutor está com o carro. O condutor atesta-a.

O lenhador está com o machado. O lenhador corta-o

A galinha está com os ovos. A galinha choca-lhes.

O agricultor está no campo de trigo. O trigo ceifa-o.

O pugilista está com o adversário. O pugilista bate-lhes.

A psicóloga está com a doente. A doente consola-a.

A enfermeira está com o rapaz. A enfermeira trata-se.

O agricultor está com o burro. O agricultor bate-o.

O professor está com o aluno. O professor ensina-se.

Appendix B. Instructions for acceptability pre-test

Instructions in European Portuguese

Caro(a) participante,

No âmbito da minha tese de mestrado, em Neurociências Cognitivas e Neuropsicologia, estou a realizar um estudo acerca de processamento gramatical. Para o efeito, disponibilizei um questionário online, cujos destinatários são homens e mulheres maiores de 18 anos, sem história de doenças neurológicas ou uso corrente de neurolépticos. Este questionário é confidencial e os dados adquiridos serão utilizados exclusivamente para fins académicos.

Neste questionário, é necessário que indique numa escala de 5 pontos, o nível de aceitabilidade das frases apresentadas. Neste âmbito, uma frase é aceitável se **não tem ERROS GRAMATICAIS** e se **o conteúdo da frase é POSSÍVEL**. Por exemplo, as frases em (1) são corretas do ponto de vista gramatical, mas o evento descrito não é possível, pelo que a sua aceitabilidade é reduzida:

(1) A criança está com a boneca. A boneca veste-a.

As frases (2) apresentam o padrão inverso: o evento descrito é possível, mas a segunda frase está mal formada:

(2) A criança está com o cão. A criança veste-lhe.

Em (3), as frases são corretas em ambos os aspetos, pelo que se espera que tenham elevada aceitabilidade:

(3) A criança está com a boneca. A criança veste-a.

Na sua avaliação de aceitabilidade, baseie-se na **SUA** opinião e intuição acerca das frases.

O tempo estimado de preenchimento é de 25 minutos.

Por favor, carregue em "próxima página" para dar início ao questionário.

Obrigado pela sua participação!

Instructions in English

Dear participant,

For my master's degree in Cognitive Neuroscience and Neurospsychology, I am developing a study about grammatical processing. For this purpose, I created an online questionnaire, targeting male and female individuals above 18 years of age, excluding individuals with history of neurological diseases or under the use of neuroleptic medication. This questionnaire is confidential and the data will be used for academic purposes only.

You are required to mark the level of acceptability of the presented sentences on a 5-point scale. A sentence is considered acceptable if it **does not have GRAMMATICAL ERRORS** and if the **content in the sentence is POSSIBLE**. For example, sentences (1) is correct from the grammatical point of view, but the event is not possible, therefore its acceptability is low. (1) The child is with the doll. The doll dresses her for the party.

Sentences (2) present the opposite pattern: the event is possible, but the second sentence is ill formed.

(2) The child is with the dog. The child dresses he for the party.

In (3), the sentences are correct in both levels, therefore they should have high acceptability.

(3) The child is with the doll. The child dresses it for the party.

While assessing acceptability consider **YOUR** opinion and intuition about the sentences.

The expected duration of the questionnaire is 25 minutes.

Please press 'next page' to begin the questionnaire.

Thank you for participating.

Appendix C. Informed consent

Assunto: Projeto de investigação de Mestrado

Eu, Rita Alexandra Mendes Gonçalves, mestranda no Mestrado de Neurociências Cognitivas e Neuropsicologia a decorrer na Universidade do Algarve, encontro-me neste momento a realizar um projeto de investigação, sob a supervisão da Prof. Doutora. Alexandra Reis, que tem por título: "Study of the correlation between working memory and performance on tasks of language comprehension".

O presente estudo tem como objetivo avaliar a memória de trabalho e a compreensão do discurso, em doentes que tenham sofrido AVC. Esta investigação será importante para a definir estratégias de reabilitação e a população alvo para a intervenção, bem como prioridades aquando a avaliação de indivíduos com lesões cerebrais.

Para a realização deste estudo, será necessária a aplicação dois testes breves. Primeiro será aplicada uma prova que tem como intuito avaliar a memória de trabalho (com duração média de 10 minutos). A prova seguinte consiste em ver uma imagem e ouvir um enunciado e depois responder se o enunciado corresponde à imagem (duração média de 15 entre a 20 minutos). Os dados obtidos destinam-se apenas a fins académicos e científicos, sendo os autores do estudo os únicos a ter acesso aos mesmos.

Venho por este meio pedir a sua colaboração para a realização deste estudo. A não-aceitação de participação no estudo não terá qualquer influência na prestação de serviços médico-terapêuticos. Caso aceite participar no presente estudo agradeço que assine o formulário abaixo.

Grata pela disponibilidade,

_____
(Rita Gonçalves)
Cédula profissional nº C- C-038680181

Pelo presente documento eu, _____,
declaro que fui suficientemente informado dos objetivos e condições de aplicação do estudo.
Pelo presente, manifesto o meu consentimento na participação deste trabalho de investigação.

_____
(nome e assinatura do paciente ou representante no caso de impossibilidade de assinatura)

_____
(local e data)

Appendix D. Informed consent for Individuals with Aphasia

Consentimento Informado – Explicação do Estudo

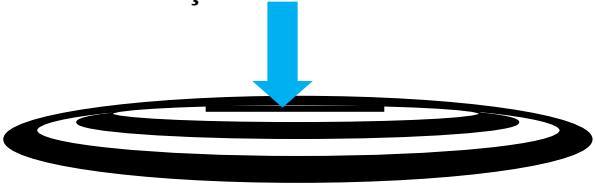
<u>Enquadramento</u>: Estudo Realizado no âmbito de **um MESTRADO em Neurociências Cognitivas e Neuropsicologia**, na Faculdade de Ciências Humanas e Sociais da Universidade do Algarve.

UAlg FCHS
UNIVERSIDADE DO ALGARVE
FACULDADE DE CIÊNCIAS HUMANAS E SOCIAIS

<u>Explicação do estudo</u>: Pretende-se contribuir para um **maior conhecimento das causas das dificuldades de FALA** das **pessoas com afasia**

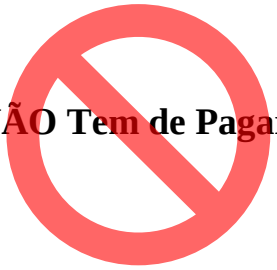
Vai utilizar **2 testes realizados no computador.**

<u>Onde?</u> Na sua Instituição.

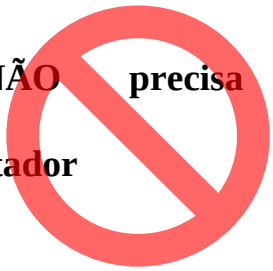


<u>Quanto tempo?</u> Os testes deverão demorar cerca de **40 minutos**.

40 Minutos



NÃO Tem de Pagar



NÃO precisa de ter computador

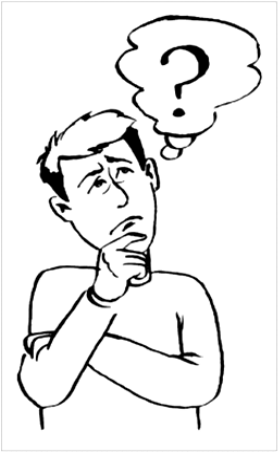
Se CONCORDAR em Participar

Pode DESISTIR a qualquer altura

A sua Identidade NÃO será revelada

Deseja Participar?

SIM



NÃO

Vou pensar

-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-o-

Declaro ter sido **informado** e sinto-me **esclarecido** sobre os objectivos do estudo, em que aceito participar.

Aceito igualmente os métodos utilizados sabendo que **não prejudicam a minha saúde** e estou ciente de que tenho toda a **liberdade para interromper** a participação no estudo em qualquer altura, se assim o desejar.

Autorizo pois, a utilização dos dados obtidos, **apenas para efeitos científicos ou educacionais**, **salvaguardando** sempre a minha **identidade** e a **confidencialidade** de todos os dados.

Nome: … … … … … … … ….... … … … ….... … … … … … … … … … … … … …

Data: …… /…… /……..

Assinatura: … … … … … … … ….... … … … … ... … … … … … … … … … … ..

DECLARAÇÃO DO INVESTIGADOR

DECLARO QUE OS OBJETIVOS, PROCEDIMENTOS, POSSÍVEIS RISCOS E OS BENEFÍCIOS LATENTES RELACIONADOS COM A PARTICIPAÇÃO NESTE ESTUDO, FORAM POR MIM EXPLICADOS À PESSOA ACIMA MENCIONADA E QUE AS QUESTÕES COLOCADAS FORAM RESPONDIDAS SATISFATORIAMENTE.

Nome:_____Data:…/…/……

Assinatura: _____

Contacto: _____

CONSENTIMENTO INFORMADO, LIVRE E ESCLARECIDO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

de acordo com a Declaração de Helsínquia[2], a Convenção de Oviedo[3] e as recomendações para doentes com afasia.

ESTE DOCUMENTO É COMPOSTO POR 4 PÁGINAS FEITO EM DUPLICADO:

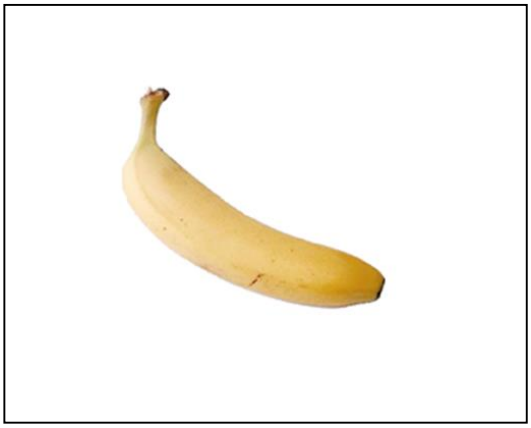
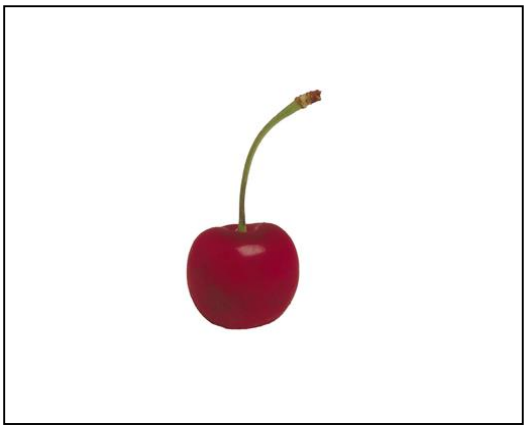
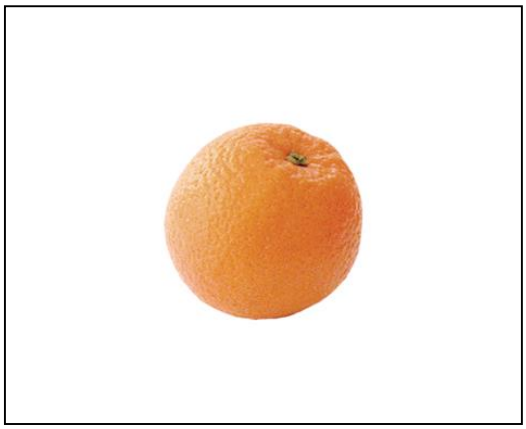
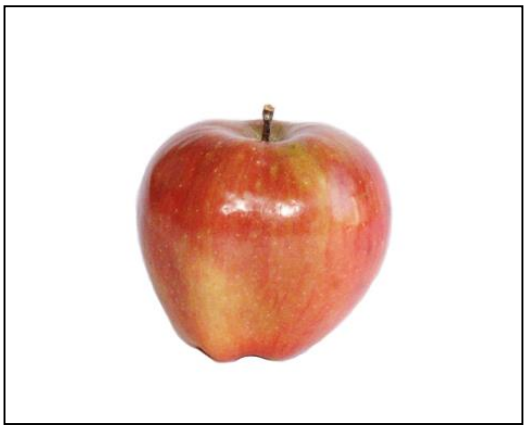
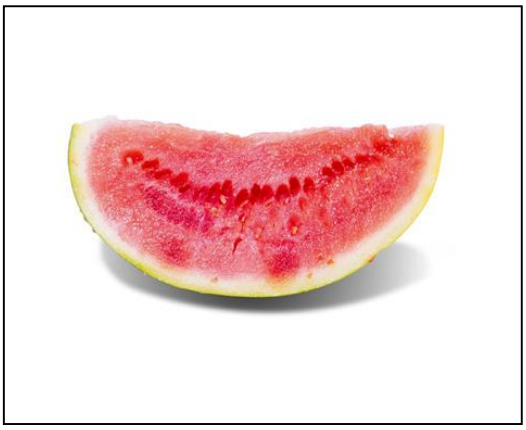
UMA VIA PARA O INVESTIGADOR, OUTRA PARA A PESSOA QUE CONSENTE

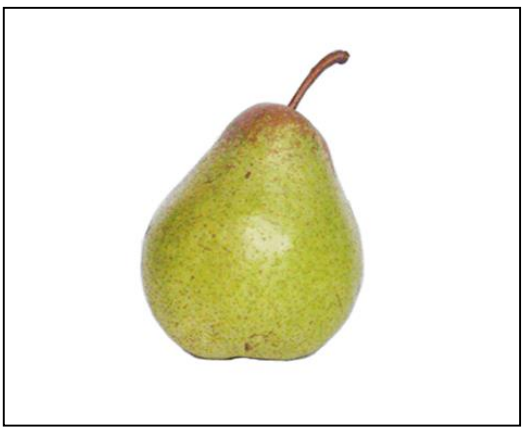
[2] http://portal.arsnorte.min-saude.pt/portal/page/portal/ARSNorte/Comiss%C3%A3o%20de%20%C3%89tica/Ficheiros/Declaracao_Helsinquia_2008.pdf

[3] http://dre.pt/pdf1sdip/2001/01/002A00/00140036.pdf

3 Penn, Frankel & Watermeyer (2009) Informed consent and aphasia: evidence of pitfalls in the process. Aphasiology, 23(1), 3-32.

Appendix E. Full set of items for *One-Back* Task



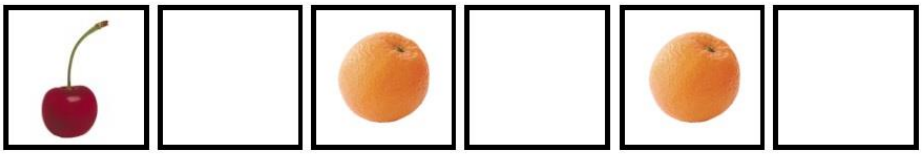
Appendix F. Instructions for One-Back task

Intructions

Caro participante:

Leia por favor as seguintes instruções.

Nesta experiência verá uma série de imagens encadeadas separadas por um ecrã em branco:



Sempre que vir duas imagens iguais seguidas deverá pressionar a tecla.

Primeiro iniciaremos uma fase de treino para que se habitue à tarefa.

Ao longo de toda a experiência faremos intervalos para que repouse. Precione esta tecla no final de cada intervalo para continuar.

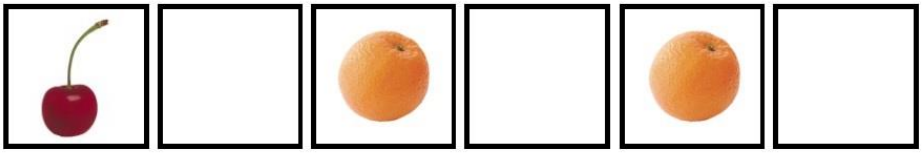
Obrigada

Instructions (translated to English)

Dear Participant:

Please read the following instructions.

In this experiment, you will see a series of images separated by a white screen.



Everytime you see the same image twice in a row, you must press this button.

We will start with a practice phase, so that you will get used to the procedure.

We will have several breaks. Press this key at the end of each break, to continue.

Thank you!

Appendix G. Full set of items for Sentence Verification Task

Experimental items

O pescador está com o turista. O pescador magoa-se/o.

O barbeiro está com o freguês. O barbeiro corta-se/o.

O louco está com o psiquiatra. O louco morde-se/o.

O pintor está com o modelo. O pintor suja-se/o.

O idoso está com o jovem. O idoso coça-se/o.

O avô está com o neto. O avô assoa-se/o.

O palhaço está com o ator. O palhaço mascara-se/o.

O rei está com o criado. O rei belisca-se/o.

O tio está com o sobrinho. O tio perfuma-se/o.

O tio está com o sobrinho. O tio aproxima-se/o.

O padre está com o ladrão. O padre esconde-se/o.

O tio está com o sobrinho. O tio aquece-se/o.

O homem está com o rapaz. O homem abriga-se/o.

O auxiliar está com o cirurgião. O auxiliar veste-se/o.

O louco está com o enfermeiro. O louco mata-se/o.

Filler items

A cozinheira está com a faca. A cozinheira coze os feijões para a sopa.

O agricultor está com o burro. O burro bate-lhe.

A mulher está com o burro. O agricultor traz água para o burro.

O agricultor está com as sementes. O menino lança as sementes na terra.

A noiva está com o noivo. A noiva assina os documentos.

O agressor está com a vítima. O agressor dá um pontapé à vítima.

O pastor está com as ovelhas. O pastor tosquia-as.

O músico está com o tambor. O músico ensaia para o concerto.

O agricultor está com a enxada. O agricultor cava a terra.

A criança está com o urso. A criança está em cima do camião de brincar.

O homem está com a cesta. O homem apanha cogumelos frescos.

A enfermeira está com a doente. A enfermeira faz-lhe uma massagem.

O senhor está com o guarda-chuva. A criança protege-se da chuva.

A cliente está com a vendedora. A cliente paga as compras.

A mulher está com a vassoura. A mulher esconde-se porque está com medo.

O varredor está com a vassoura. O varredor varre a rua.

O trabalhador está com a pá. O trabalhador carrega o camião com areia.

O pastor está com as ovelhas. O pastor veste o casaco porque está com frio.

O rapaz está com o educador. O rapaz ajuda-o a fazer um boneco de neve.

A rapariga está com a flor. A rapariga cheira a flor.

O idoso está com o pássaro. O pássaro ataca-o.

A vaca está com o gato. O rato e o gato fazem barulho.

O pai está com o filho. O pai ajuda-o a enfeitar a árvore de Natal.

O homem está com o carro. O homem empurra-o.

A avó está com o bolo. A avó come o bolo.

O professor está com a aluna. A aluna escreve no quadro.

A mãe está com a criança. A mãe tem receio que a criança passe frio.

O rapaz está com o boneco de neve. O rapaz atira uma bola de neve.

A professora está com o aluno. O aluno aperta os botões do casaco.

A florista está com as flores. A florista muda as flores de vaso.

O menino está com a borboleta. O menino tenta apanhar a borboleta.

A menina está com o professor. O professor escreve a lição.

A cartomante está com o malabarista. O malabarista lê as cartas.

O pintor está com o rolo. O pintor pinta a parede porque estava suja.

A sogra está com a nora. A sogra conta-lhe o segredo da família.

O rapaz está com a foca. A foca está com frio.

A esposa está com o marido. O marido oferece-lhe uma prenda.

O menino está com o amigo. O menino cava um buraco para plantar uma árvore.

O gerente está com o sócio. Os dois homens brindam ao sucesso da empresa.

A menina está com a corda. A menina arruma a corda.

Appendix H. Instructions for Sentence Verification Task

Caro participante,

leia por favor as seguintes instruções.

Nesta experiência, para cada item:
-verá uma imagem no centro do ecrã;
-ouvirá uma frase;
-julgará se a frase corresponde à imagem que é apresentada.

Preste atenção às teclas que deverá utilizar:


Pressione esta tecla se a frase corresponder à imagem.


Se a frase não corresponder à imagem, pressione esta tecla.


Começaremos com uma fase de treino, para que se acostume ao procedimento.
Pressione esta tecla no final do treino, para dar início à experiência.


Faremos vários intervalos para que repouse. Pressione esta tecla no final de cada intervalo, para continuar.

Agora, pressione  para avançar para o treino.

Obrigada!

Instructions

Instructions (translated to English)

Dear Participant:

Please read the following instructions:

In this experiment, for each item:
- You will see an image on the screen;
- You will hear a sentence;
- You will judge whether the sentence matches the picture that is presented.

Pay attention to the keys that you should press:


Press this key if the sentence correspond to the image.


If the sentence does not correspond to the image, press this key.


We will start with a practice phase, so that you will get used to the procedure.
Press this key at the end of the practice, to begin the experiment.


We wil have several breaks. Press this key at the end of each break to continue.

Press  to start the practice phase.

Thank You!