

WORKING MEMORY AND L2 CONSTRAINTS IN APHASIA

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Abstract

This study examined whether aphasia, as a result of a stroke, has any impact on working memory capacity and performance in L2 tasks. Three span tests – operation-word span, reading span and syntactic span – and two L2 tasks – reading comprehension and syntactic analysis – were performed by one adult with left-hemisphere brain damage and three normal individuals. The aphasic subject's performance was significantly impaired in both tasks. These results demonstrate that aphasia interferes in processing and storing mechanisms as well as in reading comprehension and syntactic analysis, thus

providing support for the particular operations performed by different parts of the brain, mostly the role of the left hemisphere in language.

Keywords: aphasia; working memory; L2 development.

Resumo

Este estudo investiga se a afasia, resultante de um derrame cerebral, exerce algum impacto sobre a capacidade de memória operacional e o desempenho em tarefas de L2. Um participante com uma lesão no hemisfério esquerdo e três indivíduos normais foram submetidos a testes de amplitude de memória operacional e a tarefas em L2. O desempenho do participante afásico foi inferior em todas as tarefas. Os resultados demonstram que a afasia interfere nos mecanismos de processamento e armazenamento de informações bem como nas atividades de compreensão de leitura e análise sintática, enfatizando o papel do hemisfério esquerdo no processamento da linguagem.

Palavras-chave: afasia, memória operacional, desempenho em L2.

Introduction

One of the greatest causes of neuropathology is caused by cerebrovascular accident (CVA) or stroke (LaPointe, 1994). CVA is caused by the interruption of blood supply to the brain. This process can result either in hemorrhage or thromboembolic events (blood clots which can either be stationary or moving). According to LaPointe (1994), when interruption of blood flow to the brain lasts longer than 4½ minutes, there can be a permanent damage in the brain, and the neurons may suffer necrosis. Among the areas which may be affected by a stroke, the left cerebral hemisphere, which is known to play an important role in language, is one frequently involved. Most of the times, lesions in this zone result in aphasia. Aphasia means inability to produce or comprehend language. Thus, lexical-semantic and syntactic structures, as LaPointe (1994) explains, are the language functions that are affected primarily by this syndrome, extending to reading, writing and auditory comprehension. Aphasia may also result in cognitive processes disorders affecting working memory, attention, resource allocation and information processing (LaPointe, 1994). The present investigation addresses the relationship between this language syndrome, aphasia, and its effects in working memory capacity.

The purpose of the present study is twofold. Firstly, it was designed to investigate whether a subject who suffered a stroke as a result of a lesion in the left cerebral hemisphere shows any impairment in his working memory capacity, therefore resulting in processing as well as maintenance constraints. In order to achieve such goal, this patient's performance in three working memory span tests is compared to the one of three normal subjects who performed the same tests. Moreover, the present study also aims at investigating the aphasic and normal participants' performance in two L2 tasks, reading comprehension and syntactic analysis, thus providing evidence for the involvement of the classical left-hemisphere language areas in syntactic processing and reading comprehension.

1.0 Review of literature

1.1 Brain lesions and language

Humans can suffer from different forms of brain injuries, varying in the location and extent it affects. Thus, among a variety of consequences, a lesion in the brain can cause certain muscle problems, affecting movements, or cause linguistic deficits, preventing the use of language. The injuries of particular interest in this work are the ones related to the understanding and production of language, called aphasia.

Aphasias, or language deficit caused by brain injury, are syndromes related to damage in different parts of the central hemisphere, more specifically, the left hemisphere of the brain, in the “language area” around the Sylvian fissure (Obler & Gjerlow, 1999). However, despite the fact that this syndrome occurs mostly in the left hemisphere, in “crossed aphasia” the symptoms, which affect right-handers, result from right hemisphere lesion (Caplan, 1992).

Aphasics can have total impairment in communicating language, as in the case of nonfluent global aphasics, or present a less extensive damage proportion, still being able to present some linguistic abilities. Different types of aphasia can be visualized in the table below.

Nonfluent Aphasia	Fluent Aphasia
Broca’s Aphasia	Wernicke’s Aphasia
Transcortical Motor Aphasia	Transcortical Sensory Aphasia
Global Aphasia	Anomic Aphasia
	Conduction Aphasia

(LaPointe, 1994, p. 367).

Broca’s aphasia is caused mostly by damage suffered in the left cerebral hemisphere. Broca’s aphasics present impairment in speech production, causing short phrase length, and agrammatism (bound and free morphemes are omitted in speech causing a telegraphic speech). In the transcortical motor aphasia the lesion is located mostly around the perisylvian region, or “deep below the brain surface in these frontal regions” as suggested by some researchers (LaPointe, 1994, p. 368). This syndrome is characterized by a severely impaired spontaneous speech, although repetition can be flawlessly. Finally, among the nonfluent aphasia, there is the global aphasia. As the name suggests, this syndrome is caused by a severe global inability to speak, read, or write language. Lesions on the anterior, and also posterior part of the cortex are responsible for such disturbance.

Among the fluent Aphasia, there is Wernicke’s, characterized by impaired auditory comprehension, while speech is fluent. Jargons and substitu-

tions, which may be inappropriate to the context, can be observed in the aphasics with such syndrome. Most of the times, this aphasia is caused by damage in “the posterior back parts of the left cerebral hemisphere, around the auditory association areas in the temporal lobe” (LaPointe, 1994, p. 370). The transcortical sensory aphasia, as in the case of motor aphasia, maintain patients’ ability to repeat words, however, causing at the same time overproduction of word substitution, and lack of nouns in sentence construction.

Conduction aphasia, also a fluent type of aphasia, impairs both auditory comprehension and repetition. Conversation is fluent and abundant. The area responsible for this syndrome is the arcuate fasciculus, located below the cortical surface that connects Wernicke and Broca’s areas (LaPointe, 1994). Finally, anomia, causing misnaming and word retrieval problems, results from problems around the PTO cortex. These aphasias, described above, are the commonly observed ones, although, other types called “pure aphasia”, not described in this work, can also be found in the literature.

When addressing the relationship between brain lesions and cognitive behavior, which is the case of the present study, an important phenomenon to consider is plasticity – the fact that the brain tends to adjust its operations as best as it can in the presence of damage (Springer & Deutsch, 1998). Such recovery can be fairly extensive and take place in a period of months in the case of purely cortical damage. In contrast, permanent linguistic deficits can be observed in subcortical brain-damaged patients (Lieberman, 2003). Thus, plasticity may represent an obstacle for those who are engaged in understanding cognitive behavior from clinical data, once mild or dramatic plasticity may take place sometime between the day of the injury and data collection.

Evidence for the role of the left hemisphere in language processing comes from a variety of sources, mainly from studies, similar to this one, which addresses the relationship between aphasia and performance in linguistic tasks. In reading comprehension, Brookshire and Nicholas (1984) showed that aphasic subjects’ overall paragraph comprehension scores were significantly worse than those of non-brain-damaged subjects. Similarly, Huber (1990) found that, although aphasics seem to be able to grasp the main ideas of a text, microprocessing, i.e. linguistic knowledge, is commonly impaired, therefore, hindering overall text comprehension. In the realm of syntax, Sirigu et al (1998), while assessing aphasics and normal subjects’ performance in a syntactic task (sentence ordering), found that “patients with lesions involving the left hemisphere were severely impaired regarding the number of correctly ordered sentences compared to normal subjects.” (1998, p. 774).

Although these studies, briefly reviewed, measure syntactic performance and reading comprehension in the participants’ native language, it has been suggested by studies using fMRI in bilinguals that, at least for semantic processing, two languages share the same cognitive system (Illes et al. 1999). Therefore, we assume that, for assessing text comprehension

and syntactic analysis, the same premise is also true for measuring the degree of impairment regarding the aphasic subject's L2.

1.2 Perspectives on short-term memory and working memory

Experimental psychology has devoted decades investigating and trying to explain the role of short-term memory in human cognition. Short-term memory was firstly conceived as a passive unitary system with limited capacity for storing and retrieving information (Ashcraft, 1994, Baddeley, 1990, Engle & Oransky, 1999, Tomitch, 1995, among others). Following this train of thought, one of the most cited models is the three-stage model of Atkinson and Shiffrin (1968). In such model, information would first pass through different sensory buffers simultaneously. Through rehearsing, the incoming information could go to long-term memory. The amount of rehearsal, then, would be a facilitator for storage. Such view, however, was problematic in two ways and ultimately abandoned. On the one hand, it was deficient in explaining why patients with short-term memory problems showed intact long-term store. On the other hand, the idea of rote rehearsal in short-term memory resulting in long-term storage was falsified by a number of studies (Tulving, 1966), which showed that repetition did not necessarily result in learning.

Nevertheless, the idea of a single system playing different functions of storage and processing (working memory) was challenged by further investigations, such as the seminal idea of working memory as having multicomponents structures (Baddeley, 1990). According to this view, short-term memory would also act as a working memory, that is, it would not only hold information, but also manipulate the cognitive input in performing a task. Thus, according to Baddeley, (1992) working memory is a "brain system that provides temporary *storage* and *manipulation* of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning" (p. 556) (stress added).

Based on the assumption that, if short term-memory was composed by one single limited capacity construct, which was responsible for the execution of many different levels of cognitive demands, once it was overloaded concurrent task would be impaired, Baddeley and Hitch (1974) conducted an experiment on concurrent task technique (reasoning, or learning plus remembering). The researchers found out that, although there was some impairment in the execution of the task given, reasoning was not totally impaired signaling, therefore, to different STS memory systems. Based on such findings, Baddeley and his associates proposed a multi-component working memory system composed by a controlling central executive system, and a number of subsidiary slave systems: the phonological loop responsible for storing and rehearsing information, and the visuospatial sketchpad in charge of keeping in temporary retention the visual-imagery (Baddeley, 1999).

However, in the field of cognitive psychology, controversy regarding the relationship between STM and working memory can still be depicted by concepts found in the literature. Thus, if on the one hand a researcher claims that short-term memory “is often referred to a concept quite similar to working memory (Anderson, 1990, p. 150), on the other hand it is possible to read that “working memory is a more complex construct than short term memory, defined as the set of activated memory elements...” (Cowan, 1995, p. 100). As it can be noticed, while the first definition refers to STM and working memory as being similar constructs, the second depicts them as separate subsets, as explain Engle, Laughlin, Tuholski and Conway (1999). Nevertheless, in spite of some ambiguity, recent theories see STM as a dynamic system capable of storing and processing information (Just & Carpenter, 1992; Cantor & Engle, 1993; Tomitch, 1996). The difference between STM and working memory would rely mostly in the fact that, while STM has limitations in the number of items it can retain while performing a mental activity, working memory presents its limitations in the resources available for processing, and storing information (Tomitch, 1996).

Processing and storage functions differ from individual to individual being one of the crucial aspects in determining their performance on important cognitive tasks, such as: a) reading comprehension in L1 (Just & Carpenter 1980; Kintsch & van Dijk, 1978, among others), b) reading comprehension in L2 (Harrington, 1992; Berquist, 1997; Tomitch, 1996), c) ability to abstract grammatical regularities in both L1 and L2 (Ellis & Sinclair, 1996; Miyake & Friedman, 1998), c) speech production in L2 (Fortkamp, 2000), etc.

What remains controversial in the working memory literature, however, is whether this relationship between working memory capacity and higher-order cognition is task-specific or domain free (Fortkamp, 2000). While advocates of a functional view of working memory capacity (Daneman & Carpenter, 1980) claim that capacity of working memory varies according to the individual’s processing efficiency in a given task, others have found evidence supporting the general capacity hypothesis, which sees working memory capacity as independent of the nature of the task (Turner & Engle, 1989; Engle, Kane, & Tuholski, 1999). This issue is also addressed by this study, which hopes to contribute to this debate.

1.3 Working memory and text comprehension

When reading, readers have to perform different mental activities simultaneously. Thus, from the initial visual stimuli to the resulting mental representation of the text, for example, readers have to use their memories efficiently in order to achieve comprehension. However, readers vary greatly in the way they use their attention resources, therefore, presenting different levels of comprehension.

One of the first attempts to measure individual short-term memory called the *memory span* was developed by Joseph Jacobs when trying to

investigate the mental capacity of one of his students (Baddeley, 1999). This test consisted of presenting a subject with some items and asking him/her to repeat them back verbatim. However, the scope of this test was limited because, as Perfetti and Lesgold (1977) explain, this method of measuring the mental capacity did not reflect reading abilities. Thus, attempting to correlate reading comprehension with the individual trade-off between retrieval and storage capacities, Daneman and Carpenter (1980) developed a new working memory span measure: the reading span test. This test requires readers to process and store sentence for comprehension, and an additional task of maintaining and retrieving the last word of a given sentence.

Results from the reading span test led Daneman and Carpenter (1980) take the assumption that while processing a sentence readers make the same cognitive computations, however, differences in comprehension are due to the speed and efficiency with which mental resources are utilized (Daneman & Carpenter, 1980). Thus, poor readers, contrary to good ones, may have more difficulties in overcoming the constraints imposed by texts.

Although research on working memory has focused heavily on first language reading comprehension, as seen above, recent studies have also addressed the relationship between working memory capacity and L2 reading comprehension¹ (Harrington, 1992; Berquist, 1997; Torres, 2003). In Harrington's study, a significant correlation was found between the L2 reading span, which is believed to reflect L2 working memory capacity, and results on the TOEFL reading section, thus corroborating the findings of L1 reading comprehension studies. Similarly, Berquist (1997) obtained a significant correlation between a submeasure of the L2 reading span test, the L2 cloze test, and L2 proficiency, as measured by the TOEIC. These findings seem to support the claim that L2 working memory, as measured by the reading span test, is a good predictor of L2 reading proficiency.

1.4 Working memory and syntax

Research on individual differences in working memory capacity has focused mainly on first language reading comprehension, as illustrated above. However, some important contributions have also been made on the relationship between working memory and syntax, specially in the field of second language acquisition.

Dealing with the abstraction and application of rules in L2 is also a complex cognitive task, since a great deal of attention has to be allocated to the suppression of the learner's L1 rule system (Ellis & Sinclair, 1996), while simultaneously computing syntactic information from successive words, phrases and sentences in the L2 (Just & Carpenter, 1987).

Ellis and Sinclair (1996) make a strong case for the role of working memory in L2 acquisition of syntax, claiming that individuals with working memory deficits show restricted acquisition of syntax both in native and foreign languages. In their study, subjects who were prevented from rehearsing L2 phrases during a working memory test, were less able to use

metacognitive knowledge of syntactic rules and to abstract grammatical regularities from sentences; therefore, being more prone to making mistakes.

More recently, Fortkamp (2000) examined the relationship between working memory capacity and speech production in L2, considering grammatical accuracy as one of the variables. She found a negative correlation between working memory capacity and accuracy in L2 speech production, as measured by number of errors. These results allowed the researcher to conclude that the individual's working memory capacity is a predictor of his/her accuracy in producing L2 speech.

Having discussed all the aforementioned assumptions, the following methodological procedures are going to be carried out as an attempt to accomplish the aim of the present study, namely to examine working memory capacity constraints in aphasia.

2.0 Method

2.1 Participants

Four volunteers participated in this study: one male aphasic patient and three normal control subjects (1 male and two females), ages ranging from 17 to 20. The patient was an upper-intermediate learner of English as a L2 and had suffered unilateral left hemisphere brain damage as a result of stroke. Neurological data reports that the patient showed symptoms of aphasia, among others (Appendix 1). This aphasic participant performed the working memory tests in this study five months after having suffered the stroke. The controls were in their second semester of the Letras course at Universidade Federal de Santa Catarina.

2.2 Procedure

All participants were required to perform three working memory span tests, one reading comprehension task and one syntactic sentence completion task. In all three working memory tasks, the participants had to perform a dual-task, which consists of holding sequences of words (operation-word span, reading span and syntactic span) while also performing a reasoning or comprehension task (Baddeley, 1990).

It is important to consider that, by performing working memory tasks in L2, as it is the case in the present study, the participants were exposed to a greater cognitive burden (Ellis & Sinclair, 1996) in terms of sensory and motor abilities than if the participants were allowed to do the tasks in their L1. Therefore, further analysis has to take this important aspect into consideration.

2.3 Measures of Working Memory Capacity

2.3.1 The operation-word span test

Following Turner & Engle (1989), the operation-word span test was constructed with 60 operation strings and 60 English words (Appendix 2).

Each operation string was accompanied by a one or two-syllable word to the right of it and presented one at a time on the middle of the computer screen, as shown in the example of a two-pair set below:

3 + 5 = ? house
2 + 4 = ? beach

The 60 combinations of operation plus word in English were arranged in three sets each of two, three, four, five and six. Participants were required to give the results to the operation strings verbally, while retaining the word accompanying the operation for subsequent recall. This procedure was followed until a blank screen signaled that a set had ended. Participants were then required to recall the words in the order they had appeared and in the exact form presented. All this procedure was recorded on a cassette player. Following Turner and Engle (1989), practice trials were given to each subject and the actual span test would begin only when the subject felt comfortable enough. As in Engle, Cantor and Carullo (1992), a participant's operation-word span was his/her total performance on the test, that is, the total number of words correctly recalled, being the maximum 60 in the case of the present study.

2.3.2 The Reading Span

The span test applied was an adapted version of Daneman & Carpenter's (1980) reading span test. In this adapted version, the sentences were shorter and simplified in order to facilitate processing and storing, considering the beginning proficiency level of the control participants (second semester of Letras), and the estimated condition of the aphasic patient. Words were carefully selected as to avoid their repetition, thus preventing from priming. Following the original Daneman & Carpenter's (1980) design, the reading span test in this study required participants to use both functions of working memory during reading comprehension, that is, processing and storing. The processing component is sentence comprehension while the storage component is maintaining and retrieving the final word of each sentence of a presented set.

The reading span test was constructed with 60 true or false sentences (Appendix 3). Each true or false sentence was presented one at a time on the middle of the computer screen, as shown in the example of a two-pair set below:

Rap is music.
Japan is far.

The 60 true or false sentences were arranged in three sets each of two, three, four, five and six, similarly to the operation-word span just described. Participants were asked to read the sentences aloud, immediately answering true or false orally. A blank slide signaled that the participants had to recall the final words of the sentences in the order they appeared. A

participant's reading span was considered the maximum number of sentence-final words recalled in the order they were presented.

2.3.3 The Syntactic Span

The syntactic span test, originally designed by this study to assess the participants' working memory capacity including a syntactic component, was also based on Daneman and Carpenter's 1980 reading span test mentioned before. Similarly, the syntactic span test required subjects to use both functions of working memory: processing and storage (Appendix 4). The processing component was grammatical judgment of the third person in present simple sentences², while the storage component was maintaining and retrieving the final word of each sentence of a presented set, as in the following example:

He buys butter.
The lady bring the key.

Participants were asked to read the sentences aloud and judge them as grammatically correct or incorrect right after. After seeing the blank slide, participants had to recall the last words of the sentences in the order they had appeared. A person's syntactic span, therefore, was considered the maximum number of sentence-final words recalled in the order they were presented. While judging the grammaticality of sentences, the limited capacity of the working memory system had to be shared between this work and the memory for final words. Thus, this test is understood to capture how individuals coordinate these two activities, just as the reading span test does.

2.4 Measures of L2 proficiency

2.4.1 The reading comprehension task

As posed before, reading is an activity that draws heavily on working memory due to the fact that at the same time that readers have to keep some current information available for further processing, they have also come up with the gist. Thus, at the same time that the task required them to keep some of the most important microproposition in working memory, they were also required to understand the macrolevel of the discourse when giving an appropriate title to the story. The present reading comprehension task is an adapted version of Daneman and Carpenter, 1980 (Appendix 5). A simple short story was designed so that participants would not face linguistic constraints, thus avoiding to floor effects. Subjects were asked to read the passage silently, and carefully at their own paces, but only once. After that, they were asked to answer four questions: a) one about pronominal reference, b) one about the theme, c) and two specific questions about the text. *They were not allowed to recur to the text to find or confirm their answers.* Participants' score in this text comprehension activity was the total number of correct answers out of four.

2.4.2 The syntactic task

In order to measure participants' grammatical knowledge in L2, a sentence completion task was designed (Appendix 6). Again, the simple present tense was selected as the target structure, and participants were required to read the sentences and look for syntactic cues that would signal (or not) to the use of the third person 's' after the verb. The participants' final score, out of 10 sentences, would be the total number of correct verb tenses applied.

3.0 Results and Discussion

	Aphasic	Control 1	Control 2	Control 3
OSPAN	6	37	42	36
RSPAN	2	19	33	23
SYSPAN	7	17	20	33

Table 1 – Performance on the three span tests: OSPAN – operation-word span, RSPAN – reading span, and SYSPAN – syntactic span.

	Aphasic	Control 1	Control 2	Control 3
Reading comprehension	3	4	4	4
Sentence completion	6	9	10	10

Table 2 – Performance on the comprehension/production tasks: reading comprehension and sentence completion.

3.1 Working memory and aphasia

As shown by the results presented in Table 1, the aphasic's working memory capacity in this study seems to have been impaired, to some extent, as a result of the stroke. While control participants' operational-word spans ranged from 36 to 42, the aphasic's span was significantly lower, only 6. The same was true for the task-specific spans, with controls' reading spans ranging from 19 to 33, controls' syntactic spans ranging from 17 to 33, while the aphasic's spans were, respectively, 2 and 7.

Together, these results provide evidence for deficits in working memory capacity that result from damage to the left hemisphere after a stroke. They have shown that the aphasic patient is impaired in his ability to process and store information simultaneously as compared to control subjects.

Another aspect worth mentioning is the significant occurrence of recency effect in the aphasic's performance throughout the span tests, as compared to the control subjects. Recency effect, according to Baddeley (1990), refers to the enhanced recall of the most recently presented items.

Finally, it must be acknowledged, at this point, that some degree of plasticity (as defined on page 4) may have occurred between the event, which took place around eight months ago, and the moment of data collection. The researchers hypothesize that, if data had been collected immediately after the stroke, given that the patient was then diagnosed as presenting symptoms of verbal aphasia, which he later on recovered from, results could have been different, showing even greater impairment in his working memory capacity.

3.2 Aphasia and performance in L2 tasks

In the results of the reading comprehension task, presented in Table 2, one can notice that, while all the control subjects scored a 100% (4 correct answers out of 4 questions), the aphasic subject scored 75% (3 correct answers out of 4 questions), in the same task. Regardless the fact that the difference in the results was not significant, it is necessary to bear in mind that the aphasic subject had the highest proficiency level in English among all participants. This aspect could hypothetically have facilitated comprehension. However, it did not in his case, which might lead the researchers to suggest that such simple divergence in results was due to his neurological impairment. Such outcome seem to provide support for the findings of Brookshire and Nicholas (1984) and Huber (1990), who also found limitations in aphasic subjects' reading comprehension as compared to non-brain-damaged subjects.

Table 2 (see above) also shows the results of the sentence completion task. Here, similarly to the reading comprehension task, the aphasic subject could only apply the correct form of the present simple tense in 6 of the 10 sentences in the exercise, showing, therefore, worse performance than the control subjects, who scored 9 and 10 out of a total of 10 sentences. Knowing that the aphasic's level of proficiency in L2 is higher than the one of the controls, as said before, one can assume that his syntactic performance must have been impaired due to the brain lesion he has suffered.

The results in the sentence completion task in this study seem to corroborate those by Sirigu et al. (1998). In assessing aphasics and normal subjects' performance in a syntactic task (sentence ordering) in their L1, those researchers found that patients with lesions involving the left hemisphere were severely impaired regarding the number of correctly ordered sentences compared to normal subjects. Thus, the involvement of the classical left-hemisphere language areas in syntactic processing seems to be evident in studies carried out both in L1 and L2.

Final Remarks

According to Springer and Deutsch (1998), the study of the underlying mechanisms of the psychological processes that are the basis of our mental life – including working memory – not only allow researchers to explain how brain injury disrupts normal function, but they also increase our understanding of the way the normal brain and mind are organized. In this experiment we have tried to observe if a cerebrovascular accident on a

young person had also compromised his working memory capacity and performance in L2 skills since, apparently, he did not present any sign of impairment. Despite the limitations of this study, results were surprising and they seem to corroborate the fact that a brain disorder, such as the one investigated, may directly affect cognitive performance.

Some variables might have influenced the results obtained in this experiment, such as the fact that the span tests were taken in a second language, which might have increased the difficulty of the task, and also the aspect that the stimuli were shown in a computer screen, which could have affected processing. The researchers' lack of access to sophisticated measurement tools also limited the scope of the investigation, allowing them to observe, only tangentially, some of the impairments in working memory capacity and L2 development after the stroke.

Although this study suggests that a lesion in the left hemisphere has impaired the subject's working memory capacity as well as his performance in L2 tasks, more research has to be carried out addressing the same issue, so that more evidence can be gathered and more consistent conclusions about the relationship between aphasia and cognition can be drawn.

Notes

[* File contains invalid data | In-line.JPG *]

- 1 Although L2 and L1 working memory capacities are not directly proportional, Berquist (1997) has shown that there is a correlation between the two (.48), therefore, L2 working memory is shown to be a good predictor of L2 proficiency, just like L1 working memory has been proved to be a good predictor of L1 reading comprehension.
- 2 In order to avoid floor effects, which are common in measures of working memory capacity in L2 because of linguistic constraints, the syntactic span test was designed to be syntactically simple, and a grammatical item which all participants had received formal instruction about, the third person in the simple present tense, was chosen.

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Appendices

Appendix 1 – Clinical data


À UNISANTA

Informo a pedido dos familiares: **I, N.**, 18 anos foi internado na UTI do Hospital de Caridade, através da emergência no dia 26 de agosto de 2003 com crises convulsivas. Apresentava história prévia de déficit motor em hemicorpo direito de 4 dias de evolução. O exame neurológico pós-ictal revelava sonolência, afasia e hemiparesia direita de predomínio fascio braquial. Estudo com ressonância magnética revelava evidências de malformação arteriovenosa profunda (glânglios da base/cápsula interna) em hemisfério cerebral esquerdo.

Tomografia axial computadorizada de crânio em 27/08/03 revelou sinais de hemorragia intracerebral e intraventricular e ligeira dilatação ventricular. Arteriografia cerebral confirmou os achados da Ressonância Magnética: Malformação arterio venosa profunda em área eloqüente e com aproximadamente mais de 5 cm em seu maior diâmetro (SPETZLER IV).

Em 29/08 em função de depressão do nível de consciência repetiu tomografia computadorizada que revelou dilatação ventricular pela hemorragia intraventricular e decidiu-se por colocação de drenagem ventricular externa e monitorização da pressão intracraniana, o que foi realizada no centro cirúrgico.

Em função da localização da lesão em área cerebral nobre e de sua dimensão, os familiares foram informados da impossibilidade de ressecção cirúrgica sem o grande risco de seqüelas neurológicas sérias como hemiplegia e afasia, e mesmo de mortalidade. Foram então orientados a obterem uma segunda opinião e indicado o Dr. Evandro de Oliveira em São Paulo pela sua experiência nessa enfermidade. Isso foi feito no dia 01 de setembro de 2003 e retornaram com a indicação para realização de Embolização e Radiocirurgia no Hospital Beneficência Portuguesa. (relatório em anexo)


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Appendix 2 – The operation-word span

Test 1

1+3 1+3 = ? *fashion*

3+8 3 +8 = ?*hand*

2+9 2 +9 =?*person*

1+7 1+7=? *time*

4+94+9=? *country*

5+8 5+8=? *pain*

8+9 8+9=? *fire*

1+9 1+9=? *couple*

8+88+8=? *guy*

1+5 1+5 = ?*center*

4+7 4+7=?*bag*

5+9 5+9=? *hug*

9+9 9+9=? *woman*

6+7 6+7=? *chef*

1+8 1+8=? *sales*

3+93+9=? *word*

2+2 2+2=? *aunt*

4+8 4+8=? *cap*

5+6 5+6=? *age*

7+9 7+9=? *painter*

Test 2

5+75+7=? *ring*

7+8 7+8=? *pop*

6+6 6+6=? *watch*

6+9 6+9=? *brother*

7+7 7+7=? *Film*

6+86+8=? *tie*

9+3 9+3=? *summer*

7+27+2=? *apple*

8+4 8+4=? *nurse*

9+59+5=? *mother*

4+1 4+1=? *clock*

7+6 7+6=? *moon*

8+1 8+1=? *milk*
6+5 6+5=? *taxi*

9+2 9+2=? *fish*
5+4 5+4=? *Room*
6+4 6+4=? *party*
8+68+6=? *money*
7+3 7+3=? *soccer*
7+4 7+4=? *wife*

Test 3

2+1 2+1=? *sky*
5+2 5+2=? *letter*

4+3 4+3=? *butter*
5+4 5+4=? *mission*
9+99+4=? *key*

9+8 9+8=? *Cow*
4+2 4+2=? *bread*
8+2 8+2=? *toy*
7+5 7+5=? *bomb*

6+2 6+2=? *child*
5+1 5+1=? *street*
8+7 8+7=? *pen*
6+36+3=? *player*
6+16+1=? *door*

3+2 3+2=? *son*
9+1 9+1=? *lion*
3+13+1=? *kid*
5+35+3=? *hell*
8+58+5=? *diet*
9+79+7=? *Author*

Appendix 3 – The reading span

Test 1

Rap is music

Japan is far

Mountains are high

Models are fat

The president is important

chocolate is salad

bananas are blue

A helicopter is slow

Actors are popular

Vitamin is a cake

The moon is brown

Babies are old

Rock music is calm

Guns are dangerous

Lions are mammals

A pencil is heavy

Potatoes are gold

Dogs are things

Alaska is hot

Salt is black

Test 2

People have one head

Rome is in Brazil

Girls have arms

Birds have money

A fish has wings

Noses are in the arm

Mouths have teeth

Dogs speak English

Tables are fruit

Banks close at night

Boys are doctors

A camera is a toy

*Summer is in June
Ice cream is a car*

*Teachers work in bars
Baseball is a sport
Stores sell people
Chairs speak French
A week has seven days
People have hands*

Test 3

*Drugs are bad
Trees are men*

*We live on the moon
Rain is dry
A husband is a woman*

*Cigarettes are drinks
Roads are in the sea
People talk with their ears
Plants play soccer*

*Tomatoes play the piano
Fish can swim
Films are sports
Paper is a dress
The ocean is blue*

*Friends are nice
Doctors help children
Ronaldinho plays tennis
Malu Mader is a doll
Tigers are wild
Fingers have nails*

Appendix 4 – The syntactic span

Test 1

*He wear a jacket
She writes a letter*

*He work as an author
She drinks water
He plays with his toy*

*She go on a diet
She hates rock
He have a son
He play cards*

*She walks with her child
He dance on the street
He buys a rose
He bring a guitar
She study at home*

*She wear a coat
He buys bread
She ride a bike
She writes a letter
He see a cow
He likes fish*

Test 2

*he buys butter
The lady bring the key*

*he see a bomb
The girl writes with a pen
The boy looks at the sky*

*The team has a new player
The girl opens the door
The kid plays with the lion
The mom walks with her kid*

*Nobody go to hell
He wear a hat
The band play jazz*

*He wear brown pants
He never has dinner*

*He like my cousin
he play tennis
She never clean the kitchen
She meets him at the hotel.
He have a good idea
He wears glasses*

Test 3

*He sees a bird
He have a nice wife*

*She practice yoga
he never eat lunch
He invites her to a picnic*

*he works in na office
The child runs in the park
He swims in the lake
He lose his wallet*

*She likes kiwi
He hates winter
The girl have a cold
The boy goes to the market
The baby has fever*

*She live under a lot of stress
He work with a tourist
The woman has dry skin
The boy don't like lemon
She has a visitor
He eat an apple*

Appendix 5 – Reading comprehension task

Short story

Susan and Peter are married. They live in a nice house. *He* is a doctor and she is a teacher. Peter works in a hospital near their house. They have got two children, Jane and Mark. Jane is ten years old and Mark is only five. One Saturday afternoon the Smith family went to the zoo and Mark got lost. It was a terrible day because the police took two hours to find him. He was sleeping under a big tree near the lake. After the incident the family went back home. They were tired but happy.

Questions

1) Give a title to the story above

.....

2) Who was: “**he**” was sleeping under the big tree?

.....

3) When did the family go to the Zoo?

.....

4) Who is ten years old?

.....

Appendix 6 – Sentence Completion – Syntactic task

Name of participant: _____

Group number: _____

Complete the sentences below with the appropriate form of the verb in parentheses using the simple present tense:

1. She _____ Music classes at night. (take)
2. I _____ two brothers and a sister. (have)
3. My friend _____ the soap opera every day. (not/ watch)
4. They _____ to go to the countryside than to the beach. (prefer)
5. He _____ a big apple for breakfast every morning. (eat)
6. _____ she _____ the piano ? (play)
7. I _____ to bed at around ten. (go)
8. He sometimes _____ to Japan on business. (travel)
9. _____ he _____ to work everyday ? (drive)
10. She _____ twice a week. (exercise)