Grammar processing in aphasia

Wanda Jakobsen
Abstract
This paper examines the processing of grammar in four Swedish subjects with aphasia: one with left hemisphere frontoparietal lesions (HD), one with left hemisphere temporoparietal lesions (SN), one with left hemisphere mainly frontoparietal lesions but also posterior (AGP), and one with left hemisphere occipital lesions (SS).
This study was carried out in order to investigate possible grammar impairment (agrammatism) that aphasic subjects could perhaps be expected to experience. The grammatical phenomena investigated are: e.g. verb/adjective agreement, appropriate use of prepositions, wh-questions, word order in both simple and complex clauses, the use of the sentence adverb inte “not” and the adverbs alltid/aldrig – “always/never”.
Another goal of the study is to find out if there is a relationship between the area where the lesions are situated and the kind of grammar errors the speakers make, i.e. whether the subjects who have the same kind of lesions share the same kind of grammar processing problems.
Possible disturbances of grammar and their processing time were investigated through a set of multiple choice exercises.

Sammanfattning
I den här uppsatsen undersöks processandet av grammatik hos fyra svenska personer med afasi: en med vänstersidiga frontoparietala skador, en med vänstersidiga temporoparietala skador, en med vänstersidiga frontoparietala skador (men även posteriora), och en med vänstersidiga occipitala skador.
Denna studie genomfördes för att undersöka om och hur bearbetning av vissa grammatiska företeelser påverkas av afasi. De grammatiska drag som undersöcktes är: verb/adjektiv böjning, korrekt användning av prepositioner, wh-frågor, ordförd i enkla och sammansatta meningar, användning av negationsadverbialet inte och adverben alltid/aldrig.
Ett annat mål med undersökningen är att komma fram till om det finns ett förhållande mellan området där skador finns och de grammatiska fel som förekommer hos afasiska personer.
Möjliga grammatiska störningar och deras bearbetningstid undersöcktes genom en rad flervalstest.
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1. Introduction

1.1. Disturbances of grammar in aphasia

Disturbances of grammar have been the subject of study by many linguists, since syntax and morphology are central to the language system. This fact has nourished debates and encouraged research related to grammar processing in persons with aphasia (Ahlsén 2006). Grammatical disorders are generally related to two main syndromes, Broca’s aphasia and Wernicke’s aphasia. The former results from frontal lesions (frontoparietal lobe) and it is characterized by nonfluent speech. The speech is simple, short, containing nouns, main verbs and adjectives but with omission of function words. The latter results from posterior lesions (temporal and parietal lobe) and it is characterized by fluent speech (paragrammatism). The speech has frequent self interruptions, restarts, lack of nouns, verbs and adjectives (anomia).

During the years, linguists have tried to investigate whether these grammar disorders affect both comprehension and production or if production can be disturbed while comprehension is maintained. It has been shown that there is great variability in aphasia subjects. Some have disturbances of both comprehension and production; others have only production impairment while abilities for judging whether a sentence is correct or not remain.

1.2. Aphasia and its classification

Aphasia is typically defined as a language disorder caused by acquired brain damage. It is the loss of the ability to produce and/or to comprehend language, caused by damage to brain areas specialized for these functions. These areas are almost always located in the left hemisphere and this is where the ability to produce and comprehend language is found. However, in a very small number of people, language ability is found in the right hemisphere.

The first empirical localizationist models of language (functions are localized in special areas) are most often attributed to the work of the French surgeon Paul Broca (1824-1880) and the German neurologist Carl Wernicke (1848-1905). Broca discovered that symptoms of expressive aphasia were linked to damage to the third inferior frontal convolution of the brain (since then called Broca's area). Wernicke found that symptoms of fluent aphasia could be linked to damage to a part of the first temporal gyrus, an area which is now known as Wernicke's area (Figure 1).
Most commonly it is seen in adults who have suffered a stroke, a brain tumor, infection or head injury. The type of language dysfunction depends on the location and extent of the damaged brain tissue. It is very rare in children.

Symptoms associated with aphasia are the inability to comprehend language, inability to pronounce and form words, inability to name objects, the persistent repetition of phrases, substitution of letters or words (paraphasia), inability to speak in a grammatically correct form (agrammatism), uncompleted sentences, and inability to write and/or read.

1.2.1. Broca’s aphasia (expressive aphasia)

Broca’s aphasia is caused by damage to anterior regions of the brain including the left inferior frontal region known as Broca’s area.

Left hemisphere frontal lesions mainly affect language functions such as grammar and speech fluency. Intonation and stress are also frequently affected (Eriksson, 2001). Subjects who suffer from this form of aphasia exhibit the common problem of agrammatism. For them, speech is difficult to initiate and is not fluent. The language is described as telegraphic and reduced to disjointed words. Sentence construction is poor, with omission of function words and inflections. In extreme cases patients may be only able to produce a single word. The most famous case of this was Broca’s patient Leborgne, nicknamed “Tan”, after the only syllable he could say.

Patients who recover from Broca’s aphasia report that they knew what they wanted to say but could not express themselves.
1.2.2. Wernicke’s aphasia (receptive aphasia)

Wernicke’s aphasia is caused by damage to posterior parts of the superior temporal gyrus of the dominant hemisphere.

Left hemisphere posterior lesions (parietal, temporal and occipital lobes) do not cause problems with speech fluency. Instead, the major problem is the substitution of words and sounds (paraphasia) (Eriksson, 2001).

Subjects who suffer from this form of aphasia may speak in long utterances which sound fluent but which have no meaning, add unnecessary words, substitute a word for another and even create neologisms.

Patients who recover from Wernicke’s aphasia report that they found the speech of others unintelligible and they could neither stop themselves nor understand their own words.

2. The Present Study

2.1. Goals of the present study

The main goal of the present study is to examine the processing of grammar in four Swedish subjects with aphasia: one with left hemisphere frontoparietal lesions, one with left hemisphere temporoparietal lesions, one with left hemisphere mainly frontoparietal lesions but also posterior, and one with left hemisphere occipital lesions.

On the assumption that aphasics, in particular those suffering from more frontal lesions, suffer from reduction in working memory capacity for language (Caspari et al., 1998), it is hypothesized that the aphasic participants would have great difficulties in tasks such as judgment of sentences with long distance tense violation and processing of complex wh-questions.

A further expectation is an increased processing time with negation adverbials, since previous studies showed that sentence adverbs require a more detailed structural parsing to specify their scope (Roll, 2009).

An additional goal of this study is to find out if there is a relationship between the area where the lesions are situated and the kind of grammar errors the participants make. It can be expected that participants with left frontoparietal lesions would have difficulties with tasks which are related to working memory capacity, such as processing of long and complex sentences, tense-adverb agreement and sentence adverbs. Participants with occipital lesions would be expected to have difficulties with the processing of words which are linked to visual
representation of concrete concepts, since the occipital area is responsible for sight (Luria, 1964).

3. Method

3.1. Participants

This study is based on a number of grammar-related tasks carried out by four subjects with aphasia, contacted through the Neurological Department at Umas, Malmö University Hospital and the Afasi- Föreningen (Aphasia Association) in Malmö.

All the participants, three women and one man, had Swedish as their mother tongue. Two of them had frontoparietal lesions in the left hemisphere (one of them had also partly posterior lesions), one had temporoparietal lesions in the left hemisphere and one had occipital lesions in the left hemisphere. They volunteered to participate in the study and their anonymity was guaranteed.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Year of birth</th>
<th>Onset of Aphasia</th>
<th>Diagnosis</th>
<th>CT-scan</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. female</td>
<td>1941</td>
<td>2004 10 08</td>
<td>Cerebral infarct</td>
<td>2004 10 27</td>
<td>LH frontoparietal (front/post)</td>
</tr>
<tr>
<td>2. female</td>
<td>1977</td>
<td>2007 02 17</td>
<td>Cerebral infarct</td>
<td>2007 10 30</td>
<td>LH temporoparietal</td>
</tr>
<tr>
<td>3. female</td>
<td>1966</td>
<td>1989 04 25</td>
<td>Cerebral infarct</td>
<td>2000 08 22</td>
<td>LH frontoparietal (only frontal)</td>
</tr>
<tr>
<td>4. male</td>
<td>1932</td>
<td>2004</td>
<td>Cerebral infarct</td>
<td>2004</td>
<td>LH occipital</td>
</tr>
</tbody>
</table>

Table 1: Participants with aphasia

3.2. Material – Procedure

The material was collected by means of a multiple choice test divided into eight exercises which test several central features of Swedish grammar.

The first six exercises investigate grammar processing at a word level (wh-particles, prepositions, verbs, substantives, adjective agreement) while the last two exercises investigate the grammar at a clause level (the position of the several components in a clause).

More specifically the exercises are structured as follow:

1. Agreement of tense (past, present and future), with pre-posed and post-posed temporal adverbials.
   a. Peter lekte med Andreas igår.
      Peter played with Andreas yesterday.
   b. *Peter leker med Andreas igår.
      *Peter plays with Andreas yesterday.
c. *Peter leka med Andreas igår.
   *Peter play-INF with Andreas yesterday.

a. Förra året flyttade Peter till Spanien.
   Last year moved Peter to Spain.

b. *Förra året flyttar Peter till Spanien.
   *Last year moves Peter to Spain.

c. *Förra året flyttat Peter till Spanien.
   *Last year moved-PAST. PART. to Spain.

2. Agreement between modal verbs and the main verb.
   a. Jag skulle vilja äta glass.
      I would like to eat ice cream.
   b. *Jag skulle vill äta glass.
      *I would like-IND. PRES. to eat ice cream.
   c. *Jag skulle viljer äta glass.
      *I would like (non-existing form) to eat ice cream.

3. Position of the negation adverb inte in main and subordinate clauses.
   a. Kalle kan inte sluta röka.
      Kalle can not stop smoking.
   b. *Kalle inte kan sluta röka.
      *Kalle not can stop smoking.
   c. *Kalle kan sluta inte röka.
      *Kalle can stop not smoking.

   a. Kristin ska meddela om hon inte kan komma.
      Kristin will inform if she not can come.
   b. *Kristin ska meddela om hon kan inte komma.
      *Kristin will inform if she can not come.
   c. *Kristin ska meddela om hon kan komma inte.
      *Kristin will inform if she can come not.

4. Use of wh-words in questions, both with or without a following answer.
      What do you eat? I eat ice cream.
      *When do you eat? I eat ice cream.

   a. Vilken färg har en banan?
      What color has a banana?
   b. *Vem färg har en banan?
      *Who color has a banana?
   c. *Var färg har en banan?
      *Where color has a banana?

5. Agreement between adjective and substantive, both singular and plural.
   a. Stefan bor i ett rött hus.
      Stefan lives in a-NEUT. red-NEUT. house.
   b. *Stefan bor i ett röda huset.
      *Stefan lives in a-NEUT. red-DET. house-DET.
   c. *Stefan bor i ett röd hus.
      *Stefan lives in a-NEUT. red-COM. house.

6. Use of prepositions.
a. Jag ringde efter en taxi eftersom jag inte ville vänta på bussen.
   I called a taxi because I did not want to wait for the bus.
b. *Jag ringde efter en taxi eftersom jag inte ville vänta till bussen.
   *I called a taxi because I did not want to wait to the bus.
c. *Jag ringde efter en taxi eftersom jag inte ville vänta ur bussen.
   *I called a taxi because I did not want to wait out the bus.

7. Word order in both short and long clauses.
   a. Anton lånade ut många böcker till sin kusin.
      Anton lent many books to his cousin.
   *To his cousin lent many books Anton.
   *Many books lent to his cousin Anton.

   a. Anton lånade ut många böcker som var nya till sin kusin.
      Anton lent many books which were new to his cousin.
b. *Många böcker som var nya lånade ut till sin kusin Anton.
   *Many books which were new lent to his cousin Anton.
c. *Till sin kusin lånade ut många böcker som var nya Anton.
   *To his cousin lent many books which were new Anton.

8. Position of adverbs alltid/aldrig “always/never”.
   a. Jag skulle aldrig ta på mig de här kläderna.
      I would never wear these clothes.
b. *Jag aldrig skulle ta på mig de här kläderna.
   *I never would wear these clothes.
c. *Jag skulle ta på mig aldrig de här kläderna.
   *I would wear never these clothes.

Each exercise consisted of four, six or eight sentences and each of them was written in three different ways (a, b, c), one grammatically correct and two incorrect. The exercises contain sentences structured at different degrees of complexity, e.g. long/short, main embedded clauses, since the working memory capacity can be expected to work better or worse depending on the length of the words or the number of words in a sentence.

The three alternatives, (a, b, c), were built following the same pattern, using sentences with the same number of words by just changing the test word (9).

(9) a. *Peter leka med Andreas igår.
   *Peter play-INF. with Andreas yesterday.
b. *Peter leker med Andreas igår.
   *Peter plays with Andreas yesterday.
c. Peter lekte med Andreas igår.
   Peter played with Andreas yesterday.

3.3. Procedure

The test was presented to the participants individually, by sitting next to them with the test form which was read aloud. Usually aphasics have reading impairments of various degrees
which can result in difficulty or even impossibility to complete a test on their own. In order to get reliable results, it was decided to present the test both visually and read aloud versions. The subjects could listen to the test leader reading the sentences and at the same time they could see the sentences in written form.

The participants were instructed to first listen to the three alternatives given and then choose one of them. The subjects were asked to choose the alternative which sounded “best” to them and not the one which was “right”. The awareness that one of the alternatives had to be right while the other two wrong, was thought to perhaps make the test situation stressful for the aphasic persons and as a consequence compromised the results of the test.

Where required, a repetition of the three alternatives was made and even pauses between the exercises, so that the participant could rest and collect new energy for the next step.

The test was performed at the neurological department at the Malmö Hospital, at the Aphasia Association in Malmö and at one of the participants’ private home.

All interviews were recorded with a portable recorder (Marantz PMD660) and a IMG Stage Line ECM-302 B Boundary Microphone.

3.4. Data analysis

In order to evaluate the test results statistically, three different scores were associated with the participant’s answer:

- 2 points if the answer was correct.
- 0 points if the answer was wrong.
- 1 point if the answer was correct but the test leader had to repeat the three alternatives more than one time.

The reasons for evaluating the tasks in this way, instead of just classifying the answers as right or wrong, are several. First of all, there were cases in which the participant was not able to understand the meaning of the sentence and the leader had to explain it; sometimes he/she was not able to make a decision so the leader had to repeat the alternatives two or, in some cases, three times; sometimes the participant chose more than one alternative because they seemed equally good.

This three-degree scale takes into consideration the extent of the participant’s comprehension, if he/she was able to give an immediate correct answer (2 points), if he/she was able to give a correct answer but after having heard the 3 options more than one time (1 point) or giving an incorrect answer (0 points), independently of the number of repetitions.
Through the recording, it was possible to measure the access time which was useful to calculate the time the participant needed to make a decision and give an answer. By access time is meant the point in time extending from the moment the leader stops reading the last alternative to the moment the participant starts uttering the answer, e.g. pointing to the answer and saying “this one” or “b” or even by reading a part or the entire sentence.
However, sometimes it was not possible to measure this time because the participant was not able to choose an answer and started shaking his/her head or saying “I don’t know” and the leader had to repeat the three alternatives once again. Sometimes the participant, instead of giving the answer, made personal observations on a sentence, e.g. whether he/she liked it, or laughing at a funny sentence.

<table>
<thead>
<tr>
<th>Participant 3</th>
<th>Hm…I feel that there is something wrong in it but at the same time it is right…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 3</td>
<td>Commenting on the sentence: “what do you read? A book”:</td>
</tr>
<tr>
<td></td>
<td>…or a newspaper, a magazine…I think that “a” is ok.</td>
</tr>
<tr>
<td>Participant 3</td>
<td>Hm… does it mean that he has a car and…yes, he hits a biker…ok now I know…</td>
</tr>
<tr>
<td>Participant 2</td>
<td>…vid/över (next to/over)…vid/över…they are both right….</td>
</tr>
</tbody>
</table>

Table 2: Example where the participants were not able to give a direct answer and were thinking aloud.
4. Results

4.1. Test score results

<table>
<thead>
<tr>
<th>Participants</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Tot. possible score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scores</td>
<td>86</td>
<td>110</td>
<td>107</td>
<td>115</td>
<td>122</td>
</tr>
<tr>
<td>Wrong answers</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Test score of the participants and the number of wrong answers.

In total the participants produced quite homogeneous scores, without significant differences; participant 4 was almost close to a full score. Singularly the participants’ scores differ more depending on the kind of exercise.

As it is possible to see from Table 1, the relationship between the score and the number of mistakes do not always agree with each other. This depends on the fact that Participant 2 had more mistakes but totally she gave more correct answers on the first trial, while Participant 3 had fewer mistakes but gave more answers after a second or third repetition. Participant 1 had both more mistakes and many more repetitions than 2 and 3.

4.2. Access time

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1a) Tense-Adverb Agreement (post-posed)</td>
<td>1</td>
<td>3,301</td>
<td>2</td>
<td>6,757</td>
<td>3</td>
<td>2,551</td>
<td>4</td>
<td>3,151</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>8,961</td>
<td>3</td>
<td>2,150</td>
<td>2</td>
<td>7,500</td>
<td>3</td>
<td>1,950</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>11,761</td>
<td>1</td>
<td>1,194</td>
<td>2</td>
<td>12,656</td>
<td>2</td>
<td>1,800</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0,914</td>
<td>3</td>
<td>1,851</td>
<td>5</td>
<td>1,371</td>
<td>6</td>
<td>1,257</td>
</tr>
<tr>
<td>1b) Tense-Adverb Agreement (pre-posed)</td>
<td>1</td>
<td>1,950</td>
<td>2</td>
<td>11,718</td>
<td>2</td>
<td>12,656</td>
<td>2</td>
<td>1,800</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1,371</td>
<td>6</td>
<td>1,257</td>
<td>1</td>
<td>2,286</td>
<td>2</td>
<td>1,485</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1,718</td>
<td>3</td>
<td>11,751</td>
<td>3</td>
<td>1,286</td>
<td>4</td>
<td>1,028</td>
</tr>
<tr>
<td>3a) Negation <em>inte</em></td>
<td>1</td>
<td>1,950</td>
<td>2</td>
<td>11,718</td>
<td>2</td>
<td>12,656</td>
<td>2</td>
<td>1,800</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>1,371</td>
<td>6</td>
<td>1,257</td>
<td>1</td>
<td>2,286</td>
<td>2</td>
<td>1,485</td>
</tr>
<tr>
<td>(main clauses)</td>
<td>2</td>
<td>5,702</td>
<td>5,496</td>
<td>7,275</td>
<td>0,914</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>9,004</td>
<td>2,449</td>
<td>2,578</td>
<td>0,628</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6,302</td>
<td>0,537</td>
<td>1,640</td>
<td>0,400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3b) Negation</td>
<td>1</td>
<td>2</td>
<td>9,079</td>
<td>5,318</td>
<td>1,406</td>
<td>0,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(embedded clauses)</td>
<td>2</td>
<td>2</td>
<td>9,502</td>
<td>2,748</td>
<td>2</td>
<td>9,375</td>
<td>0,800</td>
<td></td>
</tr>
<tr>
<td>4a) Wh-questions</td>
<td>3</td>
<td>2</td>
<td>7,073</td>
<td>2</td>
<td>7,407</td>
<td>3</td>
<td>11,718</td>
<td>1,143</td>
</tr>
<tr>
<td>(with answers)</td>
<td>4</td>
<td>2</td>
<td>17,526</td>
<td>6,392</td>
<td>2</td>
<td>2,347</td>
<td>0,514</td>
<td></td>
</tr>
<tr>
<td>4b) Wh-questions</td>
<td>1</td>
<td>2</td>
<td>4,785</td>
<td>0,776</td>
<td>18,750</td>
<td>0,800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1,963</td>
<td>2</td>
<td>15,054</td>
<td>2</td>
<td>17,344</td>
<td>0,457</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2,208</td>
<td>0,171</td>
<td>1,171</td>
<td>0,571</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1,717</td>
<td>1,254</td>
<td>1,640</td>
<td>0,571</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>5</td>
<td>1,472</td>
<td>0,836</td>
<td>1,406</td>
<td>0,400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2,944</td>
<td>0,597</td>
<td>1,406</td>
<td>0,742</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5a) Adj. Agreement</td>
<td>1</td>
<td>2</td>
<td>7,607</td>
<td>8,124</td>
<td>1,875</td>
<td>2</td>
<td>0,914</td>
<td></td>
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<tr>
<td>(singular)</td>
<td>2</td>
<td>2,208</td>
<td>0,657</td>
<td>2,578</td>
<td>0,514</td>
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<tr>
<td>3</td>
<td>4,171</td>
<td>0,358</td>
<td>3,046</td>
<td>0,400</td>
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<tr>
<td>4</td>
<td>1,472</td>
<td>0,657</td>
<td>1,406</td>
<td>0,571</td>
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<tr>
<td>(plural)</td>
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<td>2,208</td>
<td>0,657</td>
<td>2,578</td>
<td>0,514</td>
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<tr>
<td>3</td>
<td>4,171</td>
<td>0,358</td>
<td>3,046</td>
<td>0,400</td>
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<tr>
<td>4</td>
<td>1,472</td>
<td>0,657</td>
<td>1,406</td>
<td>0,571</td>
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<td>1,358</td>
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<td>2,347</td>
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<td>2</td>
<td>5,625</td>
<td>0,514</td>
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<td>7b) Word order</td>
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<td>0,935</td>
<td>3,046</td>
<td>0,971</td>
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</table>
Table 2. Representation of the access time (T) in seconds for the 4 aphasic participants (P) and the number of repetitions (Rep.) that were needed (in the column to the left of the time) in each test exercise (Test ex.). At the bottom, the total average access time in seconds for each participant. The bold characters are associated with wrong answers.

Table 2 gives another perspective for the interpretation of the results. In order to verify what area of the syntax is more affected in aphasic speakers, it is not enough to see if an answer is correct or not. It is important to consider the access time, the point in time which goes from the moment the leader stops reading the last alternative to the moment the participant starts uttering the answer. Sometimes a right answer can have a high access time, while a wrong answer can have a low access time.
5. Discussion

5.1. Test results

Generally, the test results indicate disturbances of grammar in connection with the use of tense – adverb agreement, the use of the sentence adverb *inte* “not”, wh-questions and prepositions. Fewer problems were encountered in the use of adjective agreement and word order. As concerns wh-questions and the position of the negation adverb “*inte*”, it happened very often that the participants had to take a great deal of time in answering the questions. Frequently they relied on an exclusion process to make their decisions. They first eliminated the option that sounded less correct and then they made their decision. Sometimes they even chose two alternatives, that is, they felt that more than one option was correct. On a few occasions, questions were answered before all the three alternatives were read.

After a deeper analysis, it can appear that the results of the tests are in some way connected to the kind of brain damage that the participants have. Participants 2 and 3 have different injuries, the former has posterior lesions (temporoparietal), and the latter has anterior lesions (frontoparietal). Participant 1 has mainly anterior lesions but also posterior.

This leads to the hypothesis that participants 2 and 3 should not share common problems/mistakes in the test, while participant 3 should have something in common with participant 1, since they have, partly, lesions in the same area.

The results of the test show that participants 1 and 3 encountered similar problems, especially in relation to the exercises concerning tense-adverb agreement and the position of the negation particle “*inte*” in subordinate clauses.

Participant 1 and 2 shared the same problem in relation to the exercises involving wh-questions (followed by an answer) and the position of the adverbs *alltid/aldrig* “always/never”. All three participants encountered problems with verb – adverb agreement and sentence negation.

The access time average is around 4 seconds (participant 4 excluded) but there is a great variability between the participants. Sometimes it goes up to 5-8 sec., in some occasions to 10-19 sec.

The problem that the participants share does not necessarily mean that they have given the wrong answer, it can mean that one of the participants has given the wrong answer, while another had to take a great deal of time (over the average) before answering or needed the exercise to be repeated two or three times.
5.1.1. Verb – Adverb morphological mismatches

A number of studies have examined verb – adverb morphological mismatches and local syntactic violations of verb morphology.

Verb – adverb morphology involves an indirect semantic relationship between tense morphology and an adverb which provides temporal context in accordance with the tense form (Dickey et al. 2008).

In Swedish, like in English and other languages, an adverbial can either precede or follow the verb phrase. That is, the mental operations required to detect verb – adverb mismatches are not identical. The temporal context can be either laid out by the adverb when it precedes the verbal phrase or by the verb morphology when the adverb follows the verb phrase.

Differences in processing of pre-posed/post-posed adverbs can explain the nature of the tense deficit; that is, it can depend on whether there is impairment in retrieving the right morphology given temporal information or whether the processing of all the temporal information is impaired.

In the experiment carried out by Faroqi-Shah et al. (2009), aphasics were slower and less accurate in the pre-posed adverb sentences.

In my experiment, the purpose was to examine the grammatical aphasics’ ability to judge sentences with long distance tense violation, checking whether a tense marker is compatible with the temporal information carried by an adverb.

The exercise contained three sentences with post-posed temporal adverbials and three sentences with pre-posed temporal adverbials. The results can be summarized in the following table.

<table>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1a) post-posed</td>
<td>1</td>
<td>-</td>
<td>3,301</td>
<td>2</td>
<td>-</td>
<td>8,961</td>
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<td>-</td>
<td>11,761</td>
<td>2</td>
<td>-</td>
<td>0,914</td>
</tr>
<tr>
<td>Adv.</td>
<td>2</td>
<td>2</td>
<td>6,757</td>
<td>1</td>
<td>-</td>
<td>2,031</td>
<td>2</td>
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<td>7,500</td>
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<tr>
<td>3</td>
<td>-</td>
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<td>-</td>
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<td>2</td>
</tr>
<tr>
<td>1b) pre-posed</td>
<td>4</td>
<td>-</td>
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<td>2</td>
<td>-</td>
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<td>-</td>
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<td>2</td>
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<tr>
<td>Adv.</td>
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<td>11,718</td>
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<td>-</td>
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<tr>
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<td>2</td>
<td>12,656</td>
<td>0</td>
<td>-</td>
<td>1,257</td>
<td>2</td>
</tr>
<tr>
<td>Average</td>
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<td>2,817</td>
<td>12</td>
<td>9,968</td>
<td>7</td>
<td>1,543</td>
<td>10</td>
<td></td>
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</tbody>
</table>
Several interesting patterns emerged in the experiment. First, the aphasic participants all showed some impairment in the processing of tense morphology, either with a wrong answer or with a long reaction-time. Second, as shown in Table 2, the results are more heterogeneous than those presented in Faroqui-Shah et al.’s experiment. Participant 1 gave two wrong answers out of three where the adverb was pre-posed but the test leader also had to repeat twice a set of sentences where the adverb was post-posed. Participant 2 did not have any particular problem but had a long reaction-time in the exercise with post-posed adverbs. Participant 3 gave a wrong answer for both pre-posed and post-posed adverb exercises but needed more repetitions for pre-posed adverb sentences. This person also gave a wrong answer where a repetition was given. The reaction-time was high in both exercises. Participant 4 made only one mistake, in a sentence with a post-posed adverb but the reaction-time was clearly higher than all the other exercises of the test (over 1 second).

Generally it can be said that there were difficulties both with pre-posed and post-posed adverbials. In participants 1 and 3, who share the same kind of brain lesions (frontoparietal), the match between a tense morpheme and the temporal context given by an adverb was more difficult when the adverb was sentence-initial. This probably means that selecting a tense morpheme is more challenging than interpreting the temporal content.

Lapointe suggested that verb inflection errors in agrammatic aphasia result from a reduction in available processing resources which limit the ability to perform an extensive search through the mental lexicon. If this is true, it means that the difficulty in agrammatic aphasics
is in relating semantic information (time adverbial) to grammatical forms, in this case tense morphology. (Goodglass et al. 1993)

This leads to the hypothesis that aphasics suffer from reduction in working memory capacity for language. They still have intact structural and procedural knowledge to parse various sentences, but suffer from consequences of reduced working memory resources. Experiments proved that aphasics have difficulties precisely on those parts of a sentence that are computationally most demanding, such as verbs.

My suggestion is that these aphasic participants suffer from reduction in working memory capacity with different degrees of difficulty and this affects the comprehension and processing of language.

My hypothesis is that aphasics with a reduced working memory have more problems in processing sentences where the time adverbial is pre-posed, since memory needs to be activated to a greater degree in order to process temporal information coming before the verb.

Several investigations have suggested that people with aphasia have a working memory deficit and this deficit may contribute to the language processing difficulties found in these individuals (Caspari et al., 1998). Working memory has been conceptualized as a “single resource pool for attentional, linguistic, and other executive processing” (Just & Carpenter, 1992). Moreover aphasic persons may exhibit differential difficulty processing distinct types of linguistic information, such as phonological, syntactic, and semantic information which can contribute to their overall difficulties with language. Belleville, Caza and Pertz (2003) found that individuals with anterior lesions present structural (i.e. phonological, syntactic) deficits in processing information. This means that there is a relationship between the lesion location and processing of different types of linguistic information.

This hypothesis agrees with the results of my experiment. Participants 1 and 3 have mainly anterior brain lesions and their test results show the same kind of problem, those in processing sentences where the time adverbial was pre-posed. By contrast, participants 2 and 4, who have respectively temporoparietal and occipital lesions, did not show any particular impairment with pre-posed adverb sentences. In any case they showed a relatively small deficit in processing sentences with post-posed adverbial.
5.1.2. WH-questions

Another kind of operation which could be related to working memory capacity is the processing of wh-questions, especially if the questions are long and complex or, as in the present experiment, which involved choosing the right combination of a wh-question and answer as in (10).

       Who is Karl Gustav? Karl Gustav is Sweden’s king.
       When is Karl Gustav? Karl Gustav is Sweden’s king.
       Why is Karl Gustav? Karl Gustav is Sweden’s king.

In behavioral studies on sentence comprehension, there is evidence that indicates that shorter dependencies are preferred over longer dependencies, and that longer dependencies have a greater processing cost (Phillips et al. 2005).

One of the properties of natural language is its ability to build vast numbers of different expressions from a relatively small store of words thanks to the ability to combine words into hierarchically organized sentence structures and the buffering capacity of working memory.

When working memory capacity is reduced, effects on the processing of complex sentences can be expected.

The comprehension of a sentence requires the construction of an internal representation that encodes the meaning of individual lexical items as well as the syntactic and semantic relations among those items. This constructive process is believed to provide the basis for the representation of sentences in working memory. The representation that is initially constructed may undergo further abstraction and integration into more complex ideas consistent with contextual information. There is a brief period of time following the presentation of a sentence in which a person has available the representation of that sentence – a representation from which detailed information about specific lexical items and about the exact syntactic form of the sentence can be retrieved (Caramazza, 1978).

In the present study, the element whose processing was at the centre of focus was the Wh-particle, which is always at the beginning of a question. The task included well-formed and non-well formed wh-questions followed by potential answers. One of the question-answer sequences was correct. For aphasic speakers it can be expected that keeping the wh-question-answer combination activated in working memory is a complex task.
This could be explained by the fact that function words and other grammatical morphemes play a crucial role in language processing, especially comprehension. It is these grammatical markers that form the basis for most of the syntactic strategies involved in parsing and assigning a syntactic structure to sentences. Inability to make use of these grammatical elements leaves the patient with a very impoverished set of processing strategies.

The results of this task are represented in the following table.

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<td>1,640</td>
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<tr>
<td></td>
<td>1,472</td>
<td>-</td>
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<td>1,406</td>
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<td>-</td>
<td>0,742</td>
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<tr>
<td>Total average time</td>
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<td>3,29325</td>
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</tbody>
</table>

*Table 4. Processing time (T) (sec.) for wh-question exercise (with and without answers). The number of repetitions (Rep.) needed and the time associated with wrong answers (in bold characters).*

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<tr>
<th>WH-questions without answer</th>
<th>Time (sec.) with answer</th>
<th>P. 1</th>
<th>5,966</th>
<th>2,515</th>
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<td></td>
<td></td>
<td>P. 2</td>
<td>5,802</td>
<td>3,115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. 3</td>
<td>4,277</td>
<td>6,953</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. 4</td>
<td>1,450</td>
<td>0,590</td>
</tr>
<tr>
<td>Total average time</td>
<td></td>
<td></td>
<td>4,37375</td>
<td>3,29325</td>
</tr>
</tbody>
</table>

*Table 5. Average Time (sec.) (for each participant and total) for wh-questions exercise (with and without answers).*
Table 4 shows that all the participants had difficulty processing wh-questions with answers. Participant 1 needed two or three repetitions for almost every question-answer and gave two wrong answers. Participants 2, 3 and 4 needed only one repetition. Participant 4 needed a repetition for the first combination question-answer but did not exhibit any particular difficulty in retrieving the right options. This is no doubt due to the fact that the speaker has occipital brain lesions while the others have fronto-temporoparietal brain lesions. His main problem can therefore be assumed to be connected to visual processing. More about this speaker will be discussed in the next section.

Wh-questions without answers were also judged by the test participant. Table 5 shows that, generally, the processing time average for the wh-questions with answers is higher than for the wh-questions without answers (4,374 sec. and 3,293 respectively). However, considering the time/average and not every single sentence, for participant 3 there is an opposite situation; the average for the questions without answers is higher. As concerns sentences (without answer) (11) - (12), the processing time is 18,750 sec. and 17,344 with a repetition of sentence 2.

(11) a. Vad heter du?
   What’s your name?

b. Vem heter du?
   Who’s your name?

c. Var heter du?
   Where’s your name?

(12) a. Vad ligger Malmö?
   What is Malmö located?

b. Var ligger Malmö?
   Where is Malmö located?

c. När ligger Malmö?
   When is Malmö located?
My suggestion is that not only the syntax but even the phonology could play an important role in language processing for the aphasics. In these two sentences, two of the three options were represented by the particles *vad* “what” and *var* “where” which in Swedish are both read *va*. The phonology could, in this case, mislead the aphasic person who seems to hear two sentences which sound exactly the same. Since there is no answer that can help to retrieve the right question, the participant cannot decide which is the correct version and tends to give both options as possible answers. It could also have to do with the fact that aphasic speakers have difficulties in processing proper names and place names.

The capacity limitation observed may result from a generalized language processing difficulty in the sense that language processing is so difficult for these aphasic patients that considerably more effort is involved in retaining verbal material in memory.
5.1.3. Negation and syntax

The focus of this part of the study is on negation and the contrast between affirmative and negative sentences.

All human systems of communication contain a representation of negation. That is, negation is a universal linguistic category (Christensen, 2005). In Swedish, as in many other languages, negation can be realized as a negative adverbial, such as inte “not” or aldrig “never”. In Swedish, as well as in English and other languages, both types of negative marker are often in the middle of the clause in order to carry the sentential negation.

Christensen (1986) noted that the negative adverbial in the Scandinavian languages has an unusual distribution that suggests some interesting syntactic properties. Main clauses in Swedish are V2 structures, that is, depending on whether the initial phrase is a subject or a non-subject, the verb is in the second position. In main clauses, sentence adverbials are post-verbal; in embedded clauses, where V2 structures are usually absent, sentence adverbials are pre-verbal.

Roll’s investigation (2009) shows that sentence adverbs increase the processing load since sentence adverbs require a more detailed structural parsing to specify their scope. On the syntactic side, there is a contrast between affirmative and negative sentences. Negative sentences have a more complex syntactic structure than affirmatives since part of the syntactic structure is dedicated to negation (Christensen, 2005; Haegeman, 1995). In psycholinguistics, it has also been argued that negation clauses introduce two propositions, namely, the proposition itself plus its cancellation, the negated version (Jordan, 1998). Furthermore, it has been argued that negation is in fact, an affirmative with a negative operator added to it, and that negation is initially interpreted as affirmation (Carpenter & Just, 1975).

Carpenter et al. (1999) and Christensen (2009) present data from an fMRI study on negation in which the experimental task was a sentence-to-picture matching task. They found that subjects responded slower to negatives than to affirmatives. Furthermore, they report that negatives resulted in significantly more activation than affirmatives, but only in the left hemisphere: posterior temporal cortex (BA 21, 22, 37), the inferior parietal cortex (the supramarginal gyrus BA 40), and especially in the precentral cortex (BA 6).
As regards the present experiment, it can be said that the results agree with the previous investigations. The behavioral data showed that a negation sentence adverbial significantly increased response times compared to the affirmatives, especially those with an embedded clause.

<table>
<thead>
<tr>
<th></th>
<th>Time (sec.)</th>
<th></th>
<th>Time (sec.)</th>
<th></th>
<th>Time (sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Affirmative</td>
<td></td>
<td>Neg. (main C)</td>
<td></td>
<td>Neg. (embedded C)</td>
</tr>
<tr>
<td>P.1</td>
<td>1,717</td>
<td></td>
<td>5,665</td>
<td></td>
<td>10,795</td>
</tr>
<tr>
<td>P.2</td>
<td>1,283</td>
<td></td>
<td>3,479</td>
<td></td>
<td>5,466</td>
</tr>
<tr>
<td>P.3</td>
<td>1,288</td>
<td></td>
<td>3,517</td>
<td></td>
<td>6,211</td>
</tr>
<tr>
<td>P.4</td>
<td>0,429</td>
<td></td>
<td>0,628</td>
<td></td>
<td>0,714</td>
</tr>
<tr>
<td>Average time</td>
<td>1,17925</td>
<td></td>
<td>3,32225</td>
<td></td>
<td>5,7965</td>
</tr>
</tbody>
</table>

Table 1: Average reaction time (sec.) (for each participant (P.) and total) for affirmative vs. negative clauses (in main and embedded clauses).

Diagram 3. Representation of the reaction time average (sec.) for the negative adverbials mismatches.
Table 2: Access Times (sec.) and their relative average for the sentence adverbial inte “not” (in main and embedded clauses) and alltid/aldrig “always/never”

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>main clauses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5,702</td>
<td>5,496</td>
<td>7,275</td>
<td>0,914</td>
</tr>
<tr>
<td>3</td>
<td>9,004</td>
<td>2,449</td>
<td>2,578</td>
<td>0,628</td>
</tr>
<tr>
<td>4</td>
<td>6,302</td>
<td>0,537</td>
<td>1,640</td>
<td>0,400</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>5,665</td>
<td>3,479</td>
<td>3,517</td>
<td>0,628</td>
</tr>
<tr>
<td><strong>3b) inte - embedded clauses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9,079</td>
<td>5,318</td>
<td>1,406</td>
<td>0,400</td>
</tr>
<tr>
<td>2</td>
<td>9,502</td>
<td>2,748</td>
<td>9,375</td>
<td>0,800</td>
</tr>
<tr>
<td>3</td>
<td>7,073</td>
<td>7,407</td>
<td>11,718</td>
<td>0,714</td>
</tr>
<tr>
<td>4</td>
<td>17,526</td>
<td>6,392</td>
<td>2,347</td>
<td>0,621</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>10,795</td>
<td>5,466</td>
<td>6,211</td>
<td>0,714</td>
</tr>
<tr>
<td><strong>8) Alltid/Aldrig</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“always/never”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,956</td>
<td>4,359</td>
<td>1,757</td>
<td>0,800</td>
</tr>
<tr>
<td>2</td>
<td>2,347</td>
<td>18,177</td>
<td>10,898</td>
<td>0,571</td>
</tr>
<tr>
<td>3</td>
<td>5,320</td>
<td>5,153</td>
<td>1,054</td>
<td>0,514</td>
</tr>
<tr>
<td>4</td>
<td>2,816</td>
<td>6,388</td>
<td>1,171</td>
<td>0,400</td>
</tr>
<tr>
<td><strong>Average access time</strong></td>
<td>3,110</td>
<td>8,519</td>
<td>3,720</td>
<td>0,571</td>
</tr>
</tbody>
</table>

Table 1 shows that subjects responded significantly slower to negated clauses than to affirmative clauses. The response time for affirmative clauses had an average of 1,179 sec. while the negated clauses had an average of 3,322 and 5,796 sec. Further, the parsing time was higher in the embedded clauses than in the main clauses (table 2). In participants 1, 2 and 3 the parsing time of the embedded clauses ranged between 1,406 sec. and 17,526 sec. (average 7,491), including a wrong answer (participant 2) and several repetitions of the sentences for all of them.

As concerns the embedded clauses, a problem was created by the position of the negation. In one sentence participant 2 chose the alternative with negation after the verb, as if it were a main clause. The other participants (1 and 3), those who needed the test sentences repeated more than once, were not able to make a choice between two of the three alternatives. One was grammatically correct, with the negation before the verb; the other had the negation after the verb (13).

(13) a. Katja undrade om Stefan inte kan köra bil.

Katja wondered if Stefan not can drive car.

b. *Katja undrade om Stefan kan inte köra bil.

Katja wondered if Stefan can not drive car.

As regards exercise 8, involving position of the adverbs alltid/aldrig “always/never”, the first and third sentences contained the adverb alltid “always”, and the second and fourth sentences contained the adverb aldrig “never”. Both sentence adverbials caused problems for the participants, either in terms of parsing time or in terms of repetitions.

Participant 4, with an occipital lesion, made no mistakes and did not need any repetition. The parsing-time is clearly shorter than for the other participants.
As already mentioned above, one of the areas which is activated during negation processing, is BA 6. This area plays a role in motor programming and execution (Joseph, 1996) and is also engaged in a number of structure-dependant non-motor mental tasks, including working memory, linguistic, spatial, and numerical tasks (Ben-Shachar, Hendler, Kahn, Ben-Bashat, & Grodzinsky, 2003).

It appears, then, that at least part of the function of BA 6 has to do with structure processing. The inferior parietal cortex is involved in multimodal association, categorization, and labelling and, hence, can be expected to involve high-level semantic representations (Fuster, 2003; Joseph, 1996; Jung-Beeman, 2005; Mesulam, 1998, 2002). As argued above, negative sentences involve increased syntactic hierarchical structure and this factor is easily compatible with the cognitive functions of (BA 6) and the inferior parietal cortex.

The fact that negatives engage an area in the left hemisphere is compatible with the fact that linguistic impairments that affect the systems for structure building (morphology and syntax) tend to correlate with left-hemisphere lesions (in the present case with damage to Broca’s area).

On the basis of what has been presented above, it could be suggested that Broca’s area is crucially involved in the computation of syntactic movement and people with Broca’s aphasia have impairments in negation processing because of damage to the areas which are involved in this syntactic operation. If a person without aphasia needs a higher processing time for this kind of operation (negatives) it is probable that an aphasic needs even more time or that (s)he will make mistakes in finding the correct syntactic form.
5.2. Participant 4 – an interesting case

The investigation of this paper is based on interview material from four aphasic subjects. Focus has been on the results of three of them, that is those subjects who had lesions in the frontoparietal and temporoparietal areas of the brain. Participant n. 4 had left hemisphere occipital lesions and his results did not follow the pattern of the other three. Since his results were so different from the others but at the same time unique and interesting, it is perhaps worth dedicating a section to this participant.

As has already been mentioned above, this aphasic subject has lesions in the left occipital hemisphere but no lesions in the fronto- or temporoparietal area of the brain. This means that he does not share any kind of grammatical errors with the other subjects. He has instead problems which are related to the occipital lesion.

The occipital lobe is the smallest of the four lobes in the human cerebral cortex. The most important functional aspect of the occipital lobe is that it contains the primary visual cortex. The primary visual cortex is BA 17, commonly called V1 (visual one). Human V1 is located on the medial side of the occipital lobe; the full extent of V1 often continues onto the posterior pole of the occipital lobe. Occipital lesions are associated with color agnosia, movement agnosia, and agraphia and in extreme cases can cause visual hallucinations.

Most of the time, the participant just listened to the test leader reading the sentences but on a few occasions he read them aloud together with the leader. He did not exhibit any kind of impairment in understanding the sentences in the experiment, especially when he was listening to the test leader reading. This is probably because, as has been suggested, no brain areas other than the posterior inferior frontal and the temporal cortex are reliably activated during passive listening to speech (Indefrey, Cutler, 2004). Since he does not have damage in these areas, but only in the left occipital lobe, language understanding and syntactic processing are not affected. However, he showed difficulties in reading certain kinds of sentences by himself. The major problem was not the reading itself, which was fluent, but to distinguish visually the letters/morphemes having grammatical functions. (see underlined forms in (14 a-b)-(15 a-b), (16 a-b)-(17a-b))

(14) a. *Jag dukar ett gul bord.
   b. Jag dukar ett gult bord.
   (I set a yellow table)

   (I go to Stockholm tomorrow)

(16) a. Malin vill köpa en katt.
   b. *Malin vill köper en katt.
   (Malin wants to buy a cat)


(Who/what is Karl Gustav? Karl Gustav is Sweden’s king)

The participant was not able to see a physical difference between *ett gul bord* and *ett gult bord* “a yellow table” and often said *de ser alla likadana ut* ”they all look the same”.

This can be related to several lesion studies of reading which have reported that lesions in the left occipital lobe (BA 39) cause impairments in processing orthographic representations (Benson, 1979; Black and Behrmann, 1994). The brain/function mapping demonstrated in the reading system lies in alphabetic/orthographic processing; this has been reliably associated with the occipitotemporal region of the left hemisphere (Pugh et al., 2001; McCandliss, Cohen, and Dehaene, 2003). According to the analysis by Cohen and colleagues, there seems to be a whole hierarchy of representations in this region, with the more posterior areas (in the occipital lobe) being specifically visual and perhaps related to processing of letter shapes, while they seem to get progressively more abstract as they get more anterior in the ventral temporal lobe.

In Mårtensson’s thesis work (2008) the same participant had greater problems in processing concrete nouns than abstract nouns in two different kinds of tests. Words for animals, plants and food were particularly difficult for him. In my study there is something in common with Mårtensson’s study; this is the words that created problems for the participant were proper names, including names of cities, and animals. Moreover, words which belonged to the verb class (especially movement) were problematic.

Luria suggests that people with lesions in the occipital area have difficulties with the processing of words which are linked to visual representations of concrete concepts. Visual perception involves understanding color, form, size and direction. This perception is connected to the spatial ability which assumes that sight, hearing and feeling function normally. Luria suggests a brain model called PTO-area, the parietal-temporal-occipital lobes. All the intellectual, perceptual and motor activities are organized through the interaction of these areas, which give the ability to recognize objects or understand differences among them. If the area responsible for sight, for some reason, does not function properly, there will be impairment in the perception of concrete objects or concepts. The test results from participant n.4 seem to agree with Luria’s suggestion since this person shows difficulties mostly with substantives and adjectives. However, he has problems in processing verbs of movement as well. This is not unexpected since this kind of verb, in some way, is connected to a spatial representation; sight impression is used to control room coordinates, understand distances and coordinate movements. At the same time, it is important not to forget that,
more generally, all the participants interviewed presented difficulties with verbs, independent of the brain lesions.

5.3. Spontaneous speech

The last part of this study is dedicated to features of spontaneous speech, even though it was possible to collect material only from two of the four participants and to a limited extent.

As has already been mentioned in the introduction, the main goal of this essay is the analysis of grammar (agrammatism) in aphasic subjects and the recording of spontaneous speech is a method that well suits this kind of study. Agrammatism is defined as a disorder of sentence production characterized by the selective omission of freestanding and bound grammatical morphemes (Miceli & Silveri, 1989).

The speech corpora analyzed in this study were collected during the pauses between the several exercises that the participants had to solve. The material includes a simple conversation between the test leader and the participants. One participant had left hemisphere frontoparietal lesions (HD), the other, left hemisphere temporoparietal lesions (SN).

Participant n. 2 exhibited cases of phonological paraphasias, in terms of additions and deletions. Paraphasias involve the substitution, addition, or rearrangement of speech sounds so that the error can be identified as sounding like the target. Goodglass and Kaplan (1972) used the criterion that more than half of the intended word is preserved. Examples of additions and deletions are given in (18):

(18) a. Addition: koncentration “concentration” → konstreration
    b. Deletion: koncentration → konceration/koncertion
       interju “interview” → interju

These are examples of anomia, word finding difficulty. The participant was unable to retrieve or recall a word, particularly nouns, probably because nouns constitute a large proportion of a speaker's word use. An interesting example is the word koncentration “concentration”. The aphasic person first tries to substitute the word and then, when the word-retrieval process broke down, she tried to use gestures, she put her hands up to her temples to explain the meaning of the word.

There are no examples of neologisms, perhaps due to the limited material recorded.

Participant n. 3 presented examples of phoneme paraphasias (19), neologisms (20) and stuttering (21). She also showed impairment at the sentence level (22).

(19) phoneme paraphasias:
    Addition/substitution:
    a. ledsen “sad” → ledsant
    b. Kusin “cousin” → kansin
    c. Hjälper “to help” → hjälter
    d. Dricka vodka “to drink vodka” → bricka volka
e. Apan “the monkey” → atan
f. Meddela “inform” → beddela
g. Blir “become” → blur
   Inversion:
h. Lärare “teacher” → rälare
   Addition/deletion:
i. Vattnar “to water” → vlattar

(20) Word paraphasias:
   Form-based:
   a. Barn “child” → bak
   Meaning-based:
   b. Kan “can” → ska
c. Garaget “the garage” → bagagearet
d. Bränner “to burn” → bränse/sbrända

(21) a. ...hon kan ka-kan kan ka-ka-kan inte komma...
    ...she can ca-can can ca-ca-can not come...
b. ...han är så f-f-f-fantastisk bra...
    ...he is so f-f-f-fantastic good..
c. ...jag tänker på människor i S-S-Sverige nu...
    ...I think about people in S-S-Sweden now...

After a brief comparison of example (18) with examples (19) and (20), it is possible to see some interesting differences. Example (18) presents a list of substantives which can be said to involve sound additions or deletions, while (19) and (20) present words which went exhibit more than one kind of change. For example, in (19b), the word kusin “cousin” shows a change of u to a and then an addition of n. E.g. (19 i), the word vattnar “to water” gets an l and at the same time loses the n. In example (20 b-c), I have classified these words as meaning-based because, in my opinion they have a semantic connection. In (20b), both kan and ska have the same grammatical function, they are modal verbs which stand before an infinitive. In (20c), the word bagagearet is in the context Lars parkerar bilen i garaget “Lars parks the car in the garage”. I can suggest a connection between the bil “car” and the word bagagearet in this term: the baggage can be inside the car, in the trunk, which in Swedish is called bagageutrymme; these two words, phonetically similar, could be mixed together into one: bagagearet.

(22) a. Resan fram till Kastrup var tråkig eftersom tåget var försenat.
    The trip to Kastrup was boring because the train was delayed.
b. Förra veckan körde Pelle på en cyklist som inte stannade vid rödljuset.
    Last week Pelle run over a biker who did not stop at the traffic light.

Participant 3 was not able to process sentence (22a). She could not understand the word Kastrup (Copenhagen’s airport) and she could not understand the meaning of the entire sentence. The
following text is the transcription of the dialogue between the test leader (TL) and the participant (P):

(23)
P: Kastrup? Jag förstår inte…
TL: Kastrup är flygplatsen i Köpenhamn
P: …men jag fattar ingenting.
TL: Kastrup är flygplatsen och tågstationen. Tåget stannar under flygplatsen. Om du tar tåget från Malmö mot Köpenhamn, är första stationen Kastrup.
P: men "resan från Kastrup" förklara för mig…
TL: Ok, jag tar tåget och reser mot Kastrup…
P: ok, du tar tåget i Malmö, t.ex. och du ska åka till Rom…
TL: ok, jag tar tåget i Malmö och reser till Kastrup. När jag kommer till Kastrup går jag av tåget, går en trappa upp och jag är på flygplatsen
P: och du tar flyget
TL: ja, och här meningen säger att resan var tråkig eftersom tåget var försenat.

The participant, who travels abroad to meet relatives, has definitely been several times to Kastrup airport but still she could not understand what it was. Further the entire sentence could not be processed and the test leader had to explain in detail all the stages, also what was not explicitly mentioned in the sentence.

This aphasic person seems to have a kind of disturbance in the comprehension of spoken language; she hears the speaker but has difficulty understanding what is being said. The problem tends to become worse as utterance length or complexity is increased. In example (22 b) she was not able to understand the relationship between the components of the sentence so that an explanation of the components’ function was necessary.
The patient's ability to comprehend may depend upon the general familiarity of the words used, the length, and informational content of the message, grammatical complexity and especially proper names (in this case personal and geographical names).

Caramazza suggests that patients who make errors in spontaneous speech rarely make only one type of error – for instance, only semantic or only phonological paraphasias (substitutions). The typical patient presents a complex pattern of error types, including semantic, phonological and morphological paraphasias, ‘no responses,’ circumlocutions, perseverations, and fragmentary responses (Caramazza et al., 2000). An explanation for the occurrence of error mixtures is that at least in some cases they reflect qualitatively different forms of damage to different levels of the system. For example, semantic errors might arise from damage to semantic representations and phonological errors from damage to the sound representations.

This theory agrees with the results of my study because, especially in participant 3, there is not only one type of error. There are phonological, morphological and semantic paraphasias as well as perseveration.

It is nevertheless important to keep in mind that these results are not completely reliable due to the limited size of the spontaneous speech corpora.

6. Conclusions

In the present study, the processing of grammar (agrammatism) in four Swedish aphasics was investigated. The grammatical phenomena investigated covered a number of features of Swedish grammar, i.e. verb-adverb agreement according to tense, adjective agreement, wh-particles, prepositions, sentence adverbials and word order.

The test results showed disturbances of grammar in connection with the use of verb agreement, especially in pre-posed adverbial sentences. There is evidence that shorter dependencies are more easily processed than longer dependencies, and that the latter have a greater processing cost. Function words and other grammatical morphemes were found to play a key role in language processing, especially for comprehension; i.e. wh-particles. These results seem to lead to the conclusion that aphasics suffer from a reduction in working memory capacity which affects both the comprehension and the processing of language.

Further, there was some evidence supporting the idea that structures involving sentence adverbs such as inte “not” increase the processing load since the adverbs require a detailed structural parsing to specify their scope. The processing time was high especially in embedded clauses.
In the present study there is an attempt to investigate spontaneous speech even if to a reduced extent. Participants (2 and 3) presented phonological aspects of agrammatism such as paraphasias, neologisms, anomia and stuttering, which are present mainly in Broca’s aphasia.

As concerns the relationship between the area where the lesions are situated and the kind of grammar processing problems observed, there is evidence of a connection. Results show that participants 1 and 3, who share left frontoparietal lesions, tend to have the same kind of impairment, i.e. with verb agreement and sentence adverbs. Participant 4, with left hemisphere occipital lesions, shows impairments which are related to the nature of the lesion: vision. The major problem was to distinguish, while reading, morphemes with a grammatical function.

7. Suggestions for improvement and future studies

In the present study, it was difficult to generalize about the group of aphasics due to the limited number of aphasic participants and the heterogeneity of their brain lesions. It would be much more useful to have a greater number of participants and with more homogeneous lesions.

There are a number of aspects of the test that should be improved in different ways for future studies.

The task involving verb – temporal adverbial was well structured; it included sentences with pre-posed and post-posed adverbial but to a limited extent, only six for each group. In order to use the test results for statistical purposes it would be better to have at least 50 sentences for each group. Results obtained here indicate that it would be interesting to investigate two aspects of the aphasics’ speech: (a) the ability to detect local violations of verb morphology, i.e. sentences without adverbials where the resulting auxiliary-verb inflection combination is ill-formed; (b) the ability to detect the type of tense (past, future, present) since some previous results show that agrammatic speakers have difficulties with tense forms that refer to a time other than the present (Stavrakaki & Kouvava, 2003).

Another important aspect that should be investigated further is the ability to distinguish between different categories of verbs. Dickey et al. (2008) suggest stative verbs since previous studies have found that agrammatic speakers are less likely to accept agentive/eventive verbs. A task which investigates the contrast between stative verbs and verbs of movement would be interesting, since it seems that aphasics have difficulties with these verb categories.

Another idea for a further study would be to include a task involving the contrast between active and passive sentences. It seems that aphasics tend to apply a linearly ordered (non grammatical)
“agent-first” strategy (Bever, 1970), incorrectly interpreting the first NP (noun phrase) encountered as the agent of the action.

Another possibility is to test the processing of both syntactic and semantic features. That is the creation of sentences which are syntactically well-formed but semantically anomalous (24).

(24) a. Barnet har inte haft glass.
    The child has not got ice-cream.

b. Barnet har inte ätit någon idé.
    The child has not eaten any idea.

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I would like to thank my supervisor Merle Horne for giving me the opportunity to investigate this interesting field of neurolinguistics. I am grateful for her support, valuable advice and guidance through this project from the beginning to the end. I also thank Mikael Roll who helped during the preparation of the test.

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8. References


