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Interpretation of definite expressions by brain damaged patients

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Contents

Abstract

The aim of this study is to investigate whether there are differences in the interpretation of definite expressions between Broca's aphasics and patients with a lesion in the right hemisphere, compared to non-stroke individuals. To investigate this, research has been carried out on whether different hemispheres support bridging and/or deixis, based on the interpretation of definite expressions. This has been tested using a truth value judgment task. Patients with an affected Broca's area and patients with an affected right hemisphere have more problems with the interpretation of definite expression, by bridging and/or deictic use, compared to non-stroke individuals. Based on the obtained results, further examination is needed to receive more results about possible differences in the interpretation of definite expressions between Broca's aphasics and patients with a lesion in the right hemisphere and possible preferences for bridging or the deictic use.

Keywords: definite expressions, Broca's area, right hemisphere, bridging, deixis, discourse.

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1. Introduction

Do brain damaged patients know which object is referred to in the interpretation of definite expressions? Are they able to move outside the linguistic domain to interpreted these expressions?

This is the first time that research to the interpretation of definite expressions in brain damaged patients has been carried out. The aim of this study is to investigate whether there are differences in the interpretation of definite expressions between Broca's aphasics and patients with a lesion in the right hemisphere, compared to non-stroke individuals.

To investigate this, research has been carried out on whether different hemispheres support bridging and/or deixis, based on the interpretation of definite expressions.

Previous studies have shown that Broca's area is important for linguistic information and that the right hemisphere is important for visual tasks and overlooks the whole context in which the communication takes place. Based on this information it can be assumed that Broca's aphasics have problems with using the linguistic information for bridging and that patients with a lesion in the right hemisphere could get stuck in their linguistic system and have problems with connecting linguistic and visual information in the context, which is important for the deictic way of interpretations.

A truth value judgment task has been used to investigate if these assumptions are true.

The test subjects had to say if a combination of an auditory presented sentence with a definite article is in agreement with a visual presented picture.

Some of the literature relevant to the research goal of this study is presented in this article. In addition to that, the research questions on which this study is based, the experiment to test the assumptions and the results and connected conclusions will be presented in the different chapters of this article.

2. Background

2.1 Previous literature

Different studies on linguistic knowledge and the neurological background of language have been done. Important background information related to the topic of this study is presented in this chapter.

2.1.1 Linguistic background

Knowledge of language enables people to connect sounds with meanings, to understand a spoken or written utterance and to express thoughts through speech or signs. Linguistic knowledge, as represented in the speaker's mind, is called a *grammar*. A grammar includes everything a person knows about the structure of one's language: its lexicon, morphology, syntax, semantics and phonetics and phonology.
Everybody that speaks any kind of language has a dictionary or *lexicon*, with all the words they know, in their head. They also knows how the words are structured, *morphology*.
Part of the linguistic knowledge, *syntax*, tells us what constitutes a well-formed string of words and how to put words together to form phrases and sentences. An important property which governs the syntactic organization is the existence of syntactic dependencies. The fact is that the occurrence of a particular word or morpheme in a string of words can depend on the presence of some other word or morpheme in this string of words.
Speakers also know quite a lot about what the expressions mean or signify and it is this knowledge, *semantics*, which makes the patterns of sounds or gestures 'symbolic'. The knowledge of their language also includes knowledge of the sounds and sound patterns which can occur (Fromkin et al., 2006).

Not only the grammar is divided into different parts. As cited in Van der Weert (2003), Fodor's Modularity of the Mind (1983) theory proposes that also the mind is divided into two parts: firstly, a modular cognitive component, or input systems, which is domain-specific, mandatory, fast and subject to a specific neural architecture. The second part consists of central systems, which are cognitive systems and responsible for beliefs, stored knowledge and thoughts.
The input systems correspond to the different modules of the mind, for example the language module and the visual module. A characteristic trade of the modules is domain-specificity, which is shown according to Fodor, in the fact that language is not affected by vision, or

vision by language. The language module has an internal modular structure with components that are also referred to modules. The modules of language are phonetics, phonology, morphology, syntax, semantics and pragmatics (Van der Weert, 2003).

Also the linguistic knowledge of adults exists of different parts: knowledge about the kinds of mental objects that get expressed in language (semantic knowledge), knowledge of the categories noun, verb, and sentence (syntactic knowledge) and knowledge about the fact that there is an association between the two. The meaning of many linguistic expressions are determined by the context that they are mentioned in: syntactic context and discourse context (Fromkin et al., 2006).

Understanding the meaning of sentences, for example to know which object is referred to, includes understanding the meaning of words. Some words could only be interpreted when they refer to other words. For example pronouns, but also definite articles. The levels of their dependency could differ, as cited by Reuland (2001).

Reuland (2001) proposes an economy-based model for pronominal reference assignment for non-brain-damaged adults. In this model (figure 1) distinct operations take place at different linguistic levels, yielding different interpretations serve to distinguish between various types of anaphoric relations (Vasić et al., 2005).

Level	(Operation)
Narrow syntax	(feature checking)
↓	
Semantics	(bound variable)
↓	
Discourse	(co-reference)
↓	
(Non-linguistic source)	(deixis)

Figure 1: Primitives of Binding

As cited in Van der Weert (2003), Smith and Tsimpli (1995) showed that it is possible to process language perfectly at the syntactic level and have problems at the semantic, pragmatic or non-syntactic levels. According to Smith and Tsimpli (1995) this distinction can be explained by the modularity theory, which distinguishes between pragmatic, semantic and syntactic modules within the linguistic component of the mind (Van der Weert, 2003).

In this study two different ways of interpretation of definite expressions in brain damaged patients, by using the linguistic and/or non-linguistic (visual) components of the mind, will be examined.

Definiteness is indicated by an element (the definite article 'the' or the indefinite article 'a') in the Determiner Phrase, which makes the whole Determiner Phrase either definite or indefinite. In figure 2 the basic syntax of an (in)definite constituent is presented (Van der Weert, 2003).

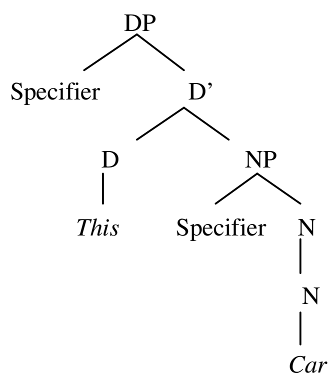

Figure 2: Structure of a Determiner Phrase

"The definition of indefiniteness and definiteness should incorporate that the speaker and hearer both know which object is referred to" (Van der Weert, 2003).

The difference between 'a' and 'the' is such that the speaker that uses the definite article 'the' refers to a specific object. Definiteness triggers reference to an existing element in the discourse, or an element which in any other way has been made striking to the hearer and speaker. The definite use tells the hearer that he/she knows which object is referred to or informs the hearer that he/she can work out which object is referred to.

"One key aspect of definiteness in discourse is the type of reference or association between the definite constituent and its antecedent" (Van der Weert, 2003).

Mostly, a definite Noun Phrase will be introduced with earlier reference in the linguistic context. For example: 'There is *a dog* in the garden. *The dog* lies on the grass'.

Linguistically, the definite Noun Phrase 'the dog' refers directly to the indefinite Noun Phrase 'a dog', so the hearer knows which dog the speaker is referring to.

There are also several ways in which a definite Noun Phrase can be introduced without earlier reference (Van der Weert, 2003).

I. Larger Situation Use (Hawkins, 1978) (1) or Immediate Situation Use (2).

(1) The sun is shining (Van der Weert, 2003).

(2) I wonder where the post office is. (in a new town).

In these ways the definite Noun Phrase refers to an object, concept or person in the immediate situation (Van der Weert, 2003).

II. '*Bridging*'.

Bridging employs a discourse-overt antecedent with which it is associated. An example of bridging (Clark and Marshall, 1981), as cited in Van der Weert (2003), is given in (3).

(3) I read a book and wrote a letter to the author (Van der Weert, 2003).

"The Noun Phrase 'the author' does not contain the same noun as the phrase 'a book', therefore, it cannot refer directly to it. In this case 'the author' can refer back to 'a book' even though the Determiner Phrase has not been mentioned before. The structure is grammatically correct because there is a Determiner Phrase which can function as the referent. The definite Determiner Phrase is not allowed to refer to any object deictically, but only linguistically to the discourse-overt Determiner Phrase 'a book'" (Van der Weert, 2003).

Earlier research to bridging, by children, has been done by Avrutin and Coopmans (2000). "A group of 14 Dutch children aged 2;11-3;11 and a group of English-speaking children, living in the Netherlands, aged 2;8-4;0 participated in the experiment. Sometimes they had problems with non-matching conditions, but the relatively high number of correct responses on the non-matching condition in this study shows that children 'are aware of the bridging possibility and that they can connect a newly introduced definite description to a previous mentioned one'" (Van der Weert, 2003). When the children failed on the non-matching conditions they based their response more on the deictic use, in which they should use visual and linguistic information, compared to bridging.

III. '*Deictic Use*'.

In this way, the definite Noun Phrase refers to an object, concept or person existing in the immediate environment and pointed to by the speaker, as in example (4) (Van der Weert, 2003).

(4) I Like this cat. (pointing) (Van der Weert, 2003).

As cited in Van der Weert (2003), according to Wales (1986), deictic expressions can be pronouns adverbs of place, verbs of motion, definite articles and tenses, which are meeting points for the different aspects of language (Van der Weert, 2003).

For deixis, the interpretative system needs to move outside the linguistic domain and enter other domains such as world-knowledge and visual information (Vasić et al., 2005).

In this study the possible support of different hemispheres to bridging and/or deixis, based on the interpretation of definite expressions in brain damaged patients, is examined.
“A strong link exist between reference and discourse, which mainly reveals itself in the definiteness of constituents” (Van der Weert, 2003).
According to Avrutin, ‘discourse’ refers to “a computational system that operates on symbols that do not belong to the narrow syntax and that is responsible for establishing referential dependencies, for encoding such concepts as old and new information, for determining discourse topics and introducing discourse presuppositions” (Van der Weert, 2003).
Successful production and comprehension of discourse depend on establishing interconnections among the specified aspects of language or grammar, its content domain or lexicon and the pragmatic, cognitive, and information relevant to a particular social-linguistic context (Dennis, 1990).

2.1.2 Neurological background

Not only the grammar and the mind, but also the brain consist out of different parts.
Many studies about the functions of different brain areas, related to language, have been carried out.
“For creating a coherent representation of a story or a dialogue, it is necessary to bring in general world knowledge, to integrate the current utterance with the prior context, or to check the consistency of the resulting interpretation with the communicative situation. Because of these requirements, it is not surprising that neuroimaging studies on text comprehension have unveiled an extended language network of brain regions to be involved during inferencing and interpretation” (Ferstl et al., 2008).
The most standard model of language organization in the brain situates language comprehension and production in the perisylvian areas of the left hemisphere (Martin-Loeches et al., 2008). Broca’s area, which is located in the inferior frontal gyrus and Wernicke’s area, which is located in the left posterior superior temporal gyrus (Stowe et al., 2005). “One of the prime tenets of classical neurological models of language is that language functions are normally located primarily in the left hemisphere, although some aspects of language processing may be supported by the right hemisphere” (Stowe et al., 2005).

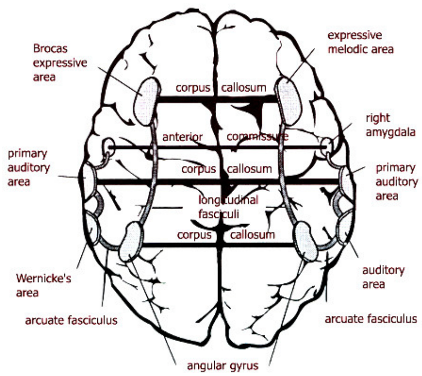

Figure 3: Hemispheres of the brain (http://www.sofiatopia.org/equiaeon/ibrain9.jpg)

In this chapter, the neurological background of the in this study included groups, Broca's aphasics and patients with a lesion in the right hemisphere, will be described.

Broca's area (figure 3) is sometimes defined as Brodmann's area 44 and 45, areas of cytoarchitecture, and is generally found in the left posterior inferior frontal cortex.
The definition of Broca's area is controversial and the precise neuroanatomical boundaries vary between individuals (Davis et al., 2008). There is not a one to one correspondence between Broca's aphasia and lesions in Broca's area. Some patients with an affected Broca's area do not have Broca's aphasia and the other way round (Davis et al., 2008).
One of the things that became obvious from the variety of studies showing activation in the left inferior frontal gyrus (Broca's area) is that this area is central for aspects of language production and comprehension (Stowe et al., 2005).
A number of previous studies have indicated that Broca's area has an important role in understanding and producing syntactically complex sentences and other language functions.

As cited by Davis et al. (2008), many studies have reported that individuals diagnosed Broca's aphasia understand simple active sentences, but fail to understand semantically reversible passive sentences (Friedmann & Shapiro, 2003). A number of studies showed that Broca's aphasics were less able to use syntactic information in understanding sentences than healthy people. Zurif et al. (1972) showed that Broca's aphasics were unable to understand sentences if the syntactic structure could not be inferred on the basis of lexical semantics. Studies like these led to the development of a theory, according to which Broca's area supports syntactic processing in both production and comprehension. This suggests that Broca's patients' ability to comprehend sentences is due to use of lexical semantics, world knowledge and strategies in the absence of syntactic processing (Stowe et al., 2005).

Vasić et al. (2005) examined whether agrammatic patients (Broca's aphasics) can obtain both semantic and discourse interpretations and if one of the two is preferred.
As cited in Vasić et al. (2005), "previous research in adults on reference assignment in agrammatism shown that the interpretation of particular anaphoric elements by agrammatic patients differs from the interpretation of the same elements in unimpaired population. Several researchers have argued, that the problem lies in the speed at which the agrammatic patients construct the syntactic tree. The aphasic syntax is slower than that of non-brain-damaged speakers by examining various phenomena that involve dependencies. This may be related to the slow lexical access in agrammatism, which is crucial for sentence comprehension. The building of the syntactic structure is constrained by temporal factors and if these are affected by a different than normal lexical insertion then the syntactic processing will suffer" (Vasić et al., 2005). To obtain the appropriate interpretation of the second conjunct, first the syntactic representation of the first conjunct needs to be constructed and its meaning computed (Vasić et al., 2005).
Vasić et al. (2005) tested six Dutch-speaking agrammatic aphasic patients and three Wernicke's patients. "The performance of both agrammatic and Wernicke's patients was compared to the performance of a control group of 11 Dutch non-brain-damaged speakers. A picture selection task was used to test the participants' comprehension of target sentences to investigate whether agrammatic patients can obtain semantic and discourse interpretations. The agrammatic patients prefer the semantic interpretation above co-reference on the discourse level. Wernicke's aphasic patients do not have a preference for one interpretation" (Vasić et al., 2005). The preference for the semantic interpretation is in that way no result from the affected left hemisphere, but specific for Broca's aphasia. For this reason, only the Broca's aphasics are included in this study. They are examined on their ability to take other ways for interpret, bridging and deictic use, and use of the discourse level and non-linguistic information for the interpretation of definite expressions.

As cited in Davis et al. (2008) other lesion association studies have found involvement of Broca's area in agrammatic speech (Caramazza & Hillis, 1990), verb production (Hillis et al., 2003), complex verb argument structure (Shapiro et al., 2002) or spelling (Hillis et al., 2004).
Functional imaging studies have also found activation in Broca's area associated with different language tasks and non-linguistic or cognitive processes, for example working

memory, and they showed an activated Broca's area in a variety of semantic tasks (Bookheimer, 2002) or a selection of responses from the semantic memory (Thompson-Schill et al., 1999) (Davis et al., 2008).

Where the left hemisphere is characterized as being dominant, verbal, analytic and intelligent, the right hemisphere is described as non-dominant, non-verbal, visuospatial, holistic and creative (Lindell, 2006). The left hemisphere pays attention to details, whereas the right hemisphere examines the whole and therefore the latter is important for visually spatial tasks (Dharmaperwira-Prins, 2002).

"The *right hemisphere* (figure 3) is the primary mediator of a set of paralinguistic or pragmatic phenomena that accompany the words of an utterance and that can modify or influence its meaning. These higher order language functions are crucial to understanding someone's true communicative intent and thereby integrating effectively into society" (Mitchell et al., 2005). The right hemisphere is also important for the contents of language, the use of language and prosodic aspects (Dharmaperwira-Prins, 2002).
Compared to the left hemisphere, which pays attentions to the details, the right hemisphere is important for visual tasks and overlooks the whole context in which the communication takes place. The context is the communication itself, with the sources for a good interpretation. For example, linguistic knowledge about the conversation and visual information about the people present.

Patients with a lesion in the right hemisphere have among others problems with pragmatic aspects of language. Different aspects of pragmatics are factors connected with the person, for example knowledge of the world, but also important aspects of the communicative situation, for example place and present persons. They could also have problems with reading and writing, developed by visual-spatial problems and problems with concentration (Dharmaperwira-Prins, 2000). As cited in Stowe et al. (2005) "for comprehension, reading sentences (visual information) appears to activate an extensive area of the posterior right hemisphere relative to a passive control" and Robertson et al. (2000) have shown right frontal activation due to increased cohesion between sentences (Stowe et al., 2005).
"Patients with a lesion in this hemisphere could also have problems with, for example, distinguishing significant from irrelevant information, integration and interpretation of contextual information, inhibiting impulsive responses, grasping figurative and implied meaning, topic maintenance and efficiency of expression, appreciation of the communicative

situation and listeners needs and recognizing and/or producing emotional responses" (Love & Webb, 2001). They also have been found to exhibit difficulty with memory (Tompkins et al., 1994), language (Joanette et al., 1983), executive function tasks such as planning, problem solving and organization (Cherney & Halper, 1996) and visuospatial skills (Myers, 1997) (Bartels-Tobin, 2005).

2.2 Research question

Based on information given above, a few assumptions can be made.

A number of studies showed that Broca's aphasics are less able to use syntactic information in understanding sentences compared to healthy people (Stowe et al., 2005), so it is plausible to think that Broca's aphasics have problems with the use of linguistic information, important in bridging.

As cited in Dharmaperwira-Prins (2000), the right hemisphere is important for visual tasks and overlooks the whole context in which the communication takes place. For using the context, linguistic knowledge about the conversation and visual information about, for example, the presents are important. Based on this information it is assumable to think that patients with a lesion in the right hemisphere could get stuck in their linguistic system and have problems with connecting linguistic and visual information in the context, which is important for the deictic way of interpretations.

Never before has research been done on these assumptions in combination with the interpretation of definite expressions by brain damaged patients. Therefore in this study the objective is to investigate whether there are differences in the interpretation of definite expressions between Broca's aphasics and patients with a lesion in the right hemisphere, compared to non-stroke individuals. To investigate this, research has been carried out on whether different hemispheres support bridging and/or deixis, based on the interpretation of definite expressions.

2.3 Hypotheses

When the interpretation of definite expressions in brain affected patients will be examined, it is expected that Broca's aphasics could have problems with using linguistic information and that patients with a lesion in the right hemisphere could get stuck their linguistic system and have problems with connecting linguistic and visual information in the context.

From the results of earlier research it is expected that Broca's aphasics have problems with matching the linguistic and visual information. They could also have problems with interpreting the presented definite expressions based on linguistic information, because this information is stored in Broca's area. Therefore it is expected that Broca's aphasics would base their answers more on the visual information and have a higher chance to reject matching conditions and accept non-matching conditions, compared to patients with a lesion in the right hemisphere and non-stroke individuals.

In patients with a lesion in the right hemisphere, different results are expected. It is expected that patients with a lesion in the right hemisphere could get stuck their linguistic system and have problems with connecting linguistic and visual information in the context. They will probably base their answers on linguistic information. If this is true, there is a higher chance to accept non-matching conditions, compared to Broca's aphasics and non-stroke individuals, because they do not connect the linguistic information to the picture.

3. Methods

3.1 Participants

6 Dutch-speaking Broca's aphasics (3 men and 3 women) and 6 Dutch-speaking patients with a lesion in the right hemisphere (3 men and 3 women) have been tested using a truth value judgment task with pictures.

All Broca's aphasics are diagnosed with the Dutch version of the Aachen Aphasia Test (Graetz et al., 1992) and the lesions in the right hemisphere are diagnosed by a neurologist in a hospital. All the participated brain damaged patients were more than six months post onset. The performances of both agrammatic Broca's aphasics and patients with a lesion in the right hemisphere have been compared to the performance of a control group of 6 Dutch-speaking non-stroke individuals (3 men and 3 women).

All participants were elderly people (above 60 years) and gave written informed consent. One participant has been excluded, because he was only four months post onset.

3.2 Truth value judgment task

A truth value judgment task has been used to test the participants' interpretation of definite Noun Phrases in target sentences. The participant saw a picture and heard a short story. He/she responded with 'yes' or 'no' if the combination of the presented linguistic and visual information was matching or non-matching.

The first answer was written down and after one minute of thinking without a reaction, the score for that item was registered as 'wrong'.

The experiment consisted of 5 warm-up items, two conditions (matching and non-matching combinations of linguistic and visual information) with 10 test-items per condition and 10 filler sentences (total of 5 warm-up items and 30 test-items).

As cited in Van der Weert (2003), Crain & Thornton showed that children and adults manifest a bias to give a 'yes'-response when they are confused or fail to comprehend a sentence.

The effect of this is that when participants judge the structure as incorrect, it may not always be clear whether they disagree with the first or second sentence (Van der Weert, 2003).

To reduce the chance that a participant always would respond with 'yes', 5 warm-up items have been carried out, to explain the intention of the experiment and to conclude if there has been no talk of exclusion criteria (for example agnosia or colour-blindness).

Fillers, which are simple items that always require no-answers, were also included. Fillers are good for the confidence of the participants, because the answer is very clear and with these kind of sentences it was possible to check the participants' concentration.

Before starting the experiment, the items and fillers were all semi-randomized by using a computer program (Research Randomizer) and only one member of the research team performed the task of storyteller during the experiment.

All the sessions started with 5 warm-up items, matching and non-matching conditions, using linguistic utterances with the same discourse format as the test items (5).

(5) 'Er staat *een auto* op de weg. *De lampen* zijn aan' (Translation: 'There is *a car* on the road. *The lights* are on').

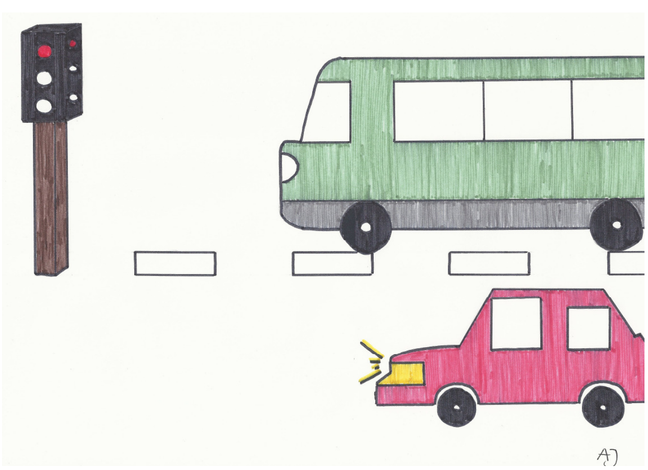

Figure 4: Picture of a matching condition

The discourse in the above stated example is a matching test condition, because the picture shows a car with burning lights.
"For matters of pragmatic felicity, the pictures always had two objects "(Van der Weert, 2003).

In the test condition, the participants were presented with a picture like figure 5.

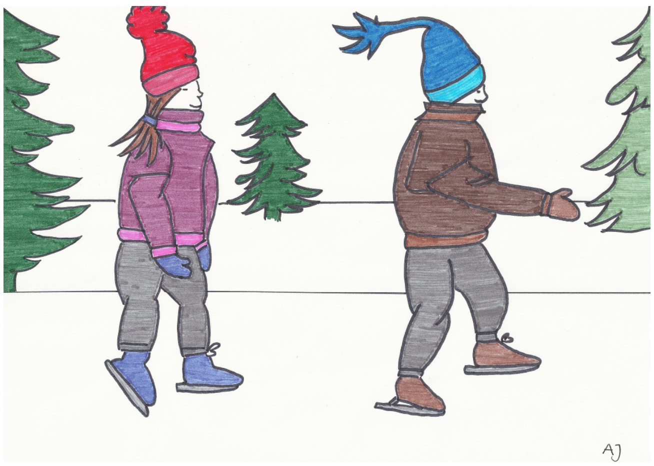

Figure 5: Picture of a non-matching condition

After that, a short story was presented explaining what the participants of the story (children: boy and girl) were doing (skating).
For example: 'Er zijn twee kinderen buiten aan het schaatsen, een jongen en een meisje' (Translation: 'We see two children skating outside, a boy and a girl').
Then, the test-item was presented.
For example: 'Er schaatst *een jongen*. *De muts* is rood' (Translation: 'There skates *a boy*. *The cap* is red').
The participant should say 'no', because 'the red cap' didn't refer to 'a boy'.

All pictures are home-made. To test the experiment, participants from different ages (men and women, 30-80 years) without an affected brain area, have been tested before.
The participants had a few concerns about some of the pictures and sentences, so some pictures and sentences have undergone some adjustments. After testing a few new non-stroke individuals, it was clear that the combinations of pictures and sentences were clear.
That way, it can be ruled out that mistakes that brain damaged patients have made during the experiment are not the consequences of unclear pictures or sentences.

4. Results

4.1 Statistics

In the study, every group (non-stroke individuals, Broca's aphasics and patients with a lesion in the right hemisphere) exists of six participants.
For each group a 120 combinations were possible (10 true and 10 false combinations of linguistic and visual information for each participant, a total of 6 participants in each group, so 60 true and 60 false combinations) and the answers given have been processed by using SPSS 15.
Before starting with processing of the data, the variables were converted into numbers (for example the factor 'Combination': correct combination = 0, incorrect combination = 1 / the factor 'Answer': correct answer = 0, incorrect answer = 1 / the factor 'Group': Controls = 1, Broca's aphasics = 2, patients with a lesion in the right hemisphere = 3).

4.1.1 Analysis I: Number of errors

To investigate if the population averages of the given answers of the control group and the two research groups (Broca's aphasics and patients with a lesion in the right hemisphere) are equal to each other, *analysis of variance* was carried out.
It is calculated by using SPSS, if the average of (wrong) answers from the people from the different groups are equal to each other, in regard to all combinations (true and false combinations of sentences and pictures).
One-way ANOVA was used, because there is one independent variable (location of the brain damage) and one dependent variable (given answer).
A significant (smaller than α = ,05) p-value of ,000 was found for the three groups (controls, Broca's aphasics and patients with a lesion in the right hemisphere). The founded F-value, which reflects the variance between the groups, is larger than 1 (15,608).

When the controls were excluded, to conclude if there were significant differences between the answers of the two research groups (Broca's aphasics and patients with a lesion in the right hemisphere), clear differences compared to above results were found.
A non-significant (larger than α = ,05) p-value of ,096 and a F-value of 2,792 were found.

To conclude something about possible difficulty with a specific combination of the auditory and visual presented information, the average of the (wrong) answers given by people from the different groups were compared for the individual true and false combinations. A significant p-value (,000) for the individual calculated true and false combinations was found between the three groups. When only the correct combinations were included a F-value of 8,014 was found and a F-value of 8,128 was found when the answers on the false combinations were compared.

When the controls are excluded, the differences are not significant based on the results of the individual true combinations (p-value ,081 and F-value 3,092) and individual false combinations (p-value ,504 and F-value ,449).

4.1.2 Analysis II: Type of errors

When the groups are distinguished based on several independent variables, location of the brain damage and the different types of combinations (true and false combinations of auditory and visual presented information), a *multiple analysis of variance* can be carried out to see if there are differences in the type of errors.

When all three groups were included, a non-significant p-value of ,558 for the interaction-effect (Group * Combination) was found and a F-value of ,585. For the individual factor Group a significant p-value (,000) and F-value of 15,572 were found and the results for the individual factor Combination are a non-significant p-value (,317) and a F-value of 1,003.

To establish a possible difference in the nature of errors between the two research groups, the controls were excluded.

Even in this case a non-significant p-value of ,505 and F-value of ,446 were found for the interaction between the two independent variables Group and Combination. In this comparison, the p-values of the individual factors are also not significant (Group: , 096 and Combination: ,318). The founded F-value for the factor Group is 2,786 and for the individual factor Combination it is the same as above (1,003).

When the research groups are individually compared to the controls, to conclude which research group differs the most in interpretation of definite expression from the controls, a significant p-value of ,000 was found in both research groups for the individual factor Group. The founded F-value is larger in the comparison Broca's aphasics versus controls (34,272), then at the comparison of lesion in the right hemisphere versus controls (19,758). At the comparison people with a lesion in the right hemisphere versus controls a larger, but not significant (p-value: ,192), variance between the groups is founded for the factor Combination (1,709) and the interaction effect (Combination * Group) (1,709) in comparison with the Broca's aphasics (,047) for both variables.

4.1.3 Analysis III: Gambling chance

Because there are only two possible answers, 'true' or 'false', there exist a chance that the participants guess their answers. Therefore, the *corrected p-value* has been calculated.
"The p-value of an item is the proportion of the number of people that scored well on an item (S) and the total population participants (P), and indicates the level of difficulty of an item. In formula: p-value = S/P.
The p-value of an item varies from 0 to 1. In general thought, an item with a p-value of 0.5 (50% of the persons score this item true) provides a maximum contribution to the summative function of the test. It must be strived to construct items of which the p-value lies between 0.25 and 0.85" (http://www.euronet.nl/users/warnar/itemanalyse.html).
"There is also the possibility to obtain a corrected p-value (P_c) which takes into account the gambling chances. For this the following formula can be applied: $P_c = P + (P - 1)/(K - 1)$ in which P is the original p-value and K the number of alternatives", therefore in this case 2 (possible answers: 'true' and 'false') (Vierbergen, 2005).
In all cases of this study, the number of individual combinations (true and false) is 60 (10 of each type, 6 participants in each group).
The Broca's aphasics got a score of 77% correctly given answers (success of 46) on the false combinations. The corrected p-value is in this case 0.54. Taking into account the gabling chances, 54% of the Broca's aphasics scored this item correctly. They got a score of 78% correctly given answers (success of 47) on the true combinations and taking into account the gambling chances, 56% scored this item correctly.
Patients with a lesion in the right hemisphere got a score of 82% correctly given answers (success of 49) on the false combinations, which counts as a corrected p-value of 64%. On the true combinations, they scored 90% correctly (success of 54). Taking into account the gabling chances, 80% scored this item correctly.
When you want to interpret the values stated above, the fact that there are six test persons in each research group must be taken into account. The p-value is, at less than 20 candidates, not a very reliable standard (Vierbergen, 2005).

4.1.4 Analysis IV: Relation affected brain area and errors

Because the dependent variable, interpretation of definite expressions (given answers), has just two possible values, 'true' or 'false', and we talk about a nominal scale, *logistic regression* (by using SPSS) has also been carried out. Logistic regression is the calculation of chances on an event. By the chances and chance proportions the link between the dependent variable, interpretation of definite expressions and independent variables, type of combination (matching or non-matching) and the location of the lesion in the brain, will be stipulated (De Vocht, 2007). All three groups (controls, Broca's aphasics and patients with a lesion in the right hemisphere) were included.

A value of ,065 has been found for the Nagelkerke R Square. This value is a measure for the quality of the model.

The regression coefficients and their significance, effect of the individual factors Group and Combination on the given answers, were also calculated using logistic regression. The impact of the variable Combination is not significant (p-value: , 328), but the variable Group does (p-value: ,001).

The Wald Statistic is an indicator for the relative importance of the independent variables Combination and Group for the prediction of the logit (and P). The logit is the predicted natural logarithm form the change proportion: In (P/1-P) (De Vocht, 2007) . The variable Group is also in this case more important (Wald = 10.568) compared to the variable Combination (Wald = ,958).

Chance proportions have also been valued (Exp(B)). For the variable Combination a value of 1,381 and a value of 2,022 for the factor Group was found.

Counting interaction terms, by using logistic regression, the possible impact of the brain damage location on a false answer between the different combinations can be established (De Vocht, 2007). The individual variable Group has however the most influence on given answers (p-value of ,081) compared to the combination of presented linguistic and visual information (,755) and interaction between both variables (,518).

4.2 Conclusions

To find an answer on the main questions of this experiment, a few connected hypotheses were formulated and described truth value judgment task has been carried out.

In this chapter the hypotheses are, based on the earlier mentioned results, preserved or rejected.

4.2.1 Conclusion I: Number of errors

It can be conclude that there is a significant difference in the answers between the three groups.

The p-value for Sig. (,000) that was found is, for all combinations (true and false combinations of auditory and visual presented information mixed but also separated), smaller than α (=,05) and as such significant.

At the same time the founded F-values are clearly larger than 1. This restores a larger variance in answers between the groups than within the groups. The largest part of the total variance is caused by differences between the three groups.

It can be said that there are significant differences in the interpretation of definite expressions between Broca's aphasics, patients with a lesion in the right hemisphere and non-stroke individuals, but at this point, nothing can be concluded about how much and which groups differs from each other.

When the controls are excluded, clear differences compared to above conclusion are found.

When only the research groups, Broca's aphasics and patients with a lesion in the right hemisphere, are compared it can be assumed that the average number of errors does not differ significantly and the variance of the answers between the groups is clearly smaller compared to the first calculation. Based on this data, it can be conclude that mistakes in the research groups (Broca's aphasics and patients with a lesion in the right hemisphere) differ significantly from the control group, but not from each other. This holds for the mixed true and false combinations, but also when they are separated.

4.2.2 Conclusion II: Type of errors

When all three groups are included in the analyses, in order to find possible differences between the type of errors, the interaction-effect (Group * Combination) is not significant. This means that the differences in answers between the examined groups cannot be explained by a combination of the variables location of the brain damage (Group) and type (true or false) of presented combinations of auditory and visual information (Combination).

The individual factor 'location of the affected brain area' is significant, the 'type of presented combination' is not. It can be conclude that the average incorrect answers differs because of an affected brain area and not because of the type of presented combination.

At the same time the F-value is larger for the factor Group when compared to the factor

Combination. This reflects a larger variance in answers between the three groups, and for the type of combinations and the interaction-effect, a larger variance in answers within the groups was found.

To establish a possible difference in the nature of errors between the two research groups, the non-stroke individuals are excluded.

The effects of all the individual factors, location of the brain damage, true and false presented combinations and the interaction-effect, are not significant. In this comparison the location of the brain damage no longer has an effect on the given answers. Compared to the results of the comparison of all three groups, a fall in the F-value for the factor Group is also visible, which indicates a smaller variance between the groups in this comparison.

Based on the results stated above it can be concluded that the differences in answers are caused by brain damage, compared to non-stroke individuals. No significant influence of the type of presented combinations on the given answers was found.

To determine which research group differs the most from the control group, the control group was compared with the individual research groups.

The factor Group has significant effects in both comparisons. Therefore, it can be concluded that there are significant problems in the interpretation of definite expressions, caused by brain damage.

The founded F-value is larger at the comparison Broca's aphasics versus controls, compared to the comparison lesion in the right hemisphere versus controls. It is plausible to think that the answers of Broca's aphasics differs more as the answers of people with a lesion in the right hemisphere, compared to non-stroke individuals.

At the comparison of patients with a lesion in the right hemisphere versus controls a larger, but not significant, variance between the answers was found for the factor Combination and the interaction-effect (Combination * Group) in comparison with the Broca's aphasics.

Based on the results stated above, the answers and possible mistakes are caused by brain damage. Nothing can be concluded about the effect of the type of presented combinations on the given answers.

4.2.3 Conclusion III: Gambling chance

All corrected p-values that were found are values above the 50%.

Therefore it is assumable that the people did not gamble, but based their answers on their own knowledge.

4.2.4 Conclusion IV: Relation affected brain area and errors

Logistic regression has been carried out, to see if there was a possible relation between the location of the affected brain area and the errors.
The Nagelkerke R Square is a measure for the quality of the model and indicates in this case a small coherence between the given answers, location of the brain damage and true or false combinations of auditory and visual presented information.
Compared to the analysis of variance, a significant effect of the factor Group on the given answers has also been found by using logistic regression and the collected Wald statistics refer to a more important effect of the variable Group, compared to the variable Combination.
The results of the chance proportions refer to positive effects between the variables Combination and Group, by which the impact of the last variable is the most strongest on the given answers.
No significant influence of the variables was found when interaction terms were counted. The individual variable Group had however the most influence on given answers compared to the variable Combination and interaction between both variables.
It can be conclude that brain damage, also in this case, has influenced the interpretation of definite expressions.

When all above conclusions are compared, it can be concluded that individuals with an affected brain area have significant more problems with the interpretation of definite expressions, when compared to non-stroke individuals.
Nothing can be concluded about the influence of the factor ‘combinations of (non)matching visual and auditory presented information’ and possible differences in answers between the Broca’s aphasics and patients with a lesion in the right hemisphere.

5. Discussion

Based on the calculations stated above, it can be concluded that there are differences in the interpretation of definite expressions, by bridging and/or deixis, between patients with an affected brain area and non-stroke individuals. No significant differences in answers between Broca’s aphasics and patients with a lesion in the right hemisphere have been found.
The differences in answers between the groups became visible when the research groups were compared to the non-stroke individuals and are in that way caused by the affected brain area.

From the results of earlier research the expectation arised that Broca's aphasics have problems with matching the linguistic and visual information. They could have problems with interpreting the presented definite expressions based on linguistic information, because this information is stored in the Broca's area. Therefore it was expected that Broca's aphasics would base their answers more on the visual information and have a higher chance to reject matching conditions and accept non-matching conditions, when compared to patients with a lesion in the right hemisphere and non-stroke individuals.

It can be assumed that Broca's aphasics, compared to patients with a lesion in the right hemisphere, have more problems with the interpretation of definite expressions. The largest differences in answers were found for the factor `location of the brain damage', in the comparison Broca's aphasics versus non-stroke individuals.

With above described results, nothing can be concluded about the expected rejecting of matching conditions and acceptation of non-matching conditions. No significant results have been found for the impact of presented combinations of linguistic and visual information on their answers.

In patients with a lesion in the right hemisphere, the expectations were different. It was expected that patients with a lesion in the right hemisphere could get stuck in their linguistic system and have problems with connecting linguistic and visual information in the context. They would probably base their answers on linguistic information. If this was true, there was a higher chance to accept non-matching conditions, compared to Broca's aphasics and non-stroke individuals, because they do not connect the linguistic information to the picture. Compared to the comparison of Broca's aphasics with non-stroke individuals, the answers of patients with a lesion in the right hemisphere differ less from the answers of non-stroke individuals. It can be assumed that patients with a lesion in the right hemisphere have less problems with the interpretation of definite expressions compared to Broca's aphasics, but it could not be pointed out significantly with the obtained results.

Nothing can be conclude about the expected higher change to accept non-matching conditions. No significant influence of the type of presented combinations of linguistic and visual information on the given answers of the patients with a damaged right hemisphere was found.

In summary, patients with an affected Broca's area and patients with an affected right hemisphere have more problems with the interpretation of definite expressions, by bridging and/or deictic use, compared to non-stroke individuals. Further examination is needed to get more results on possible differences in the interpretation of definite expressions between Broca's aphasics and patients with a lesion in the right hemisphere and possible preferences for bridging or the deictic use.

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http://www.sofiatopia.org/equiaeon/ibrain9.jpg

Appendix A

Sentences

Warming-up

I. Afb.: Hier staan twee kinderen, een jongen en een meisje.
> *Er staan twee kinderen. De jongen kust het meisje.*

II. Afb.: Er zijn een lerares en een meisje in de klas.
> *In deze klas zijn twee mensen. De lerares fietst.*

III. Afb.: We zien hier een oude vrouw en een man.
> *Er zijn twee mensen in de kamer. De vrouw slaapt.*

IV. Afb.: Hier zien we een vrouw en een man.
> *Er zijn twee mensen. De vrouw kookt.*

V. Afb.: In deze slaapkamer zien we een jongen en een meisje.
> *Er zijn twee kinderen in de kamer. De jongen eet.*

Test items

1. Afb.: * Op dit veld zijn twee jongens en er zitten nog meer mensen.
> *Er zijn veel mensen. De sporters spelen.*

2. Afb.: Er ligt een boek op tafel en één in de kast.
> *Er ligt een boek op tafel. De kaft is dicht.*

3. Afb.: In de tuin staat een boom en een tafel met daarop een plant.
> *Er staat een boom in de tuin. De bladeren zijn groen.*

4. Afb.: Er zijn twee kinderen buiten aan het schaatsen, een jongen en een meisje.
> *Er is een jongen aan het schaatsen. De muts is rood.*

5. Afb.: Hier zien we een deel van een tuin, met daarin een boom en planten.
> *Er staat een boom in de tuin. De stam is dun.*

6. Afb.: Er staan twee schoenen in de kamer, één op de tafel en één op de grond.
> *Er staat een schoen op de grond. De veter is los.*

7. Afb.: * In dit circus zijn een aap en een olifant.
> *In het circus zijn twee dieren. De aap zwemt.*

8. Afb.: Er zitten twee kinderen op de bank, een meisje en een jongen.
> *Er zit een meisje op het bankje. De trui heeft stippen.*

9. Afb.: Er zit een vogel op tafel en in de kooi die op tafel staat.
   > *Er zit een vogel op tafel. De kleur is geel.*

10. Afb.: * Hier zien we twee kinderen.
    > *Er zijn twee kinderen in het bos. De jongens rennen.*

11. Afb.: In dit circus zien we een clown en een muis en beide dragen een ballon.
    > *Er staat een clown in het circus. De ballon is klein.*

12. Afb.: Er staan een koe en een schaap in het weiland.
    > *Er staat een koe te drinken. De emmer is ingedeukt.*

13. Afb.: * Hier staan een dokter en een verpleegster.
    > *Er staan twee mensen. De dokter schopt.*

14. Afb.: Hier zien we een keuken, met daarin een koelkast en keukenkastjes.
    > *Er staat een koelkast in de keuken. De deur is open.*

15. Afb.: * Er zitten een vrouw en een man op een bankje.
    > *Er zitten twee mensen. De vrouw rookt.*

16. Afb.: * In deze keuken staan een kok en een meisje.
    > *Er staan twee mensen in de keuken. De kok bakt.*

17. Afb.: Hier zien we een tafel met daarbij een stoel.
    > *Er staat een tafel. De poten zijn breed.*

18. Afb.: Er staat een auto bij een huis geparkeerd.
    > *Er staat een auto. De ramen zijn rond.*

19. Afb.: * Er zit een vrouw in een stoel en bij haar staat een man, de kapper.
    > *Er zijn twee mensen in de kamer. De man knipt.*

20. Afb.: Aan het water staan een kasteel en een huis.
    > *Er staat een kasteel aan het water. De dakpannen zijn rood.*

21. Afb.: * In deze bakkerij staan een bakker en een man.
    > *Er staan twee mannen. De bakker maait het gras.*

22. Afb.: Er vaart een bootje in de vijver bij een huis.
    > *Er vaart een bootje. De vlag is rood.*

23. Afb.: * De man en het meisje zijn in de slagerij.
    > *Er staan twee mensen. De man wast.*

24. Afb.: Hier zien we twee vazen, één op de grond en één op tafel.
    > *Er staat een vaas op de grond. De bloem is rood.*

25. Afb.: Er staan een auto en een bus voor het stoplicht.
    > *Er staat een auto op de weg. De lampen zijn aan.*

26. Afb.: Er rent een hond en er ligt een poes op het gras.
    > *Er rent een hond op het gras. De halsband is oranje.*

27. Afb.: Er staan een vrouw en een man op straat.
    > *Er staat een vrouw. De hakken zijn hoog.*

28. Afb.: * Hier zien we twee mannen, een agent en een boef, op straat.
    > *Er zijn twee mannen. De agent vangt de boef.*

29. Afb.: Op dit bankje zitten een man en een vrouw.
    > *Er zit een man op het bankje. De hoed is laag.*

30. Afb.: Er zit een man in een boot te vissen.
    > *Er zit een man te vissen. De hengel is kort.*

Appendix B

Visual stimuli – Filler (true combination)

10. Afb.: * Hier zien we twee kinderen.
    > *Er zijn twee kinderen in het bos. De jongens rennen.*

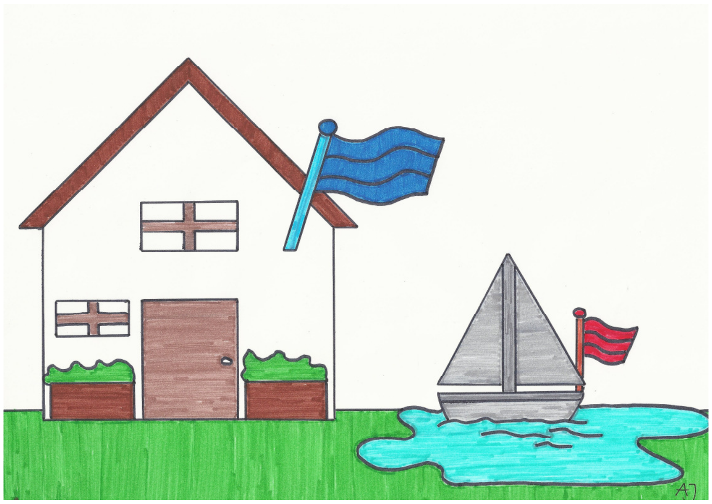
Visual stimuli – Filler (false combination)

21. Afb.: * In deze bakkerij staan een bakker en een man.
    > *Er staan twee mannen. De bakker maait het gras.*

Visual stimuli – Test item (true combination)

22. Afb.: Er vaart een bootje in de vijver bij een huis.

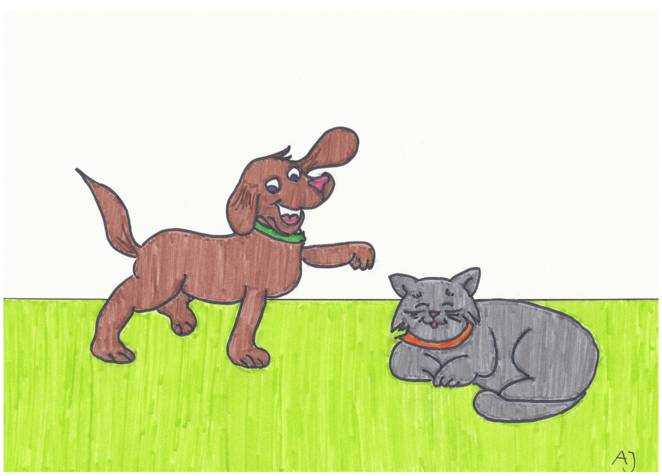
    > *Er vaart een bootje. De vlag is rood.*



Visual stimuli – Test item (false combination)

26. Afb.: Er rent een hond en er ligt een poes op het gras.

    > *Er rent een hond op het gras. De halsband is oranje.*



Appendix C

Results

<u>Broca's aphasia</u>

	Fillers		***Test items***	
	False sentences	*True sentences*	*False sentences*	*True sentences*
1. Female	100%	40% (3 mistakes: no to yes)	60% (4 mistakes: yes to no)	80% (2 mistakes: no to yes)
2. Female	60% (2 mistakes: yes to no)	100%	80% (2 mistakes)	80% (2 mistakes)
3. Female	100%	80% (1 mistake)	80% (2 mistakes)	90% (1 mistake)
4. Male	100%	80 % (1 mistake)	50 % (5 mistakes)	50% (5 mistakes)
5. Male	100%	100%	90% (1 mistake)	80% (2 mistakes)
6. Male	100%	100%	100%	90% (1 mistake)

Lesion right hemisphere

	Fillers		***Test items***	
	False sentences	*True sentences*	*False sentences*	*True sentences*
1. Female	100%	100%	100%	80% (2 mistakes: no to yes)
2. Female	100%	100%	50% (5 mistakes: yes to no)	70% (3 mistakes)
3. Female	100%	100%	90% (1 mistake)	100%
4. Male	100%	100%	100%	90% (1 mistake)
5. Male	60% (2 mistakes: yes to no)	100%	90% (1 mistake)	100%
6. Male	60% (2 mistakes)	100%	60% (4 mistakes)	100%

Total

	Fillers		***Test items***	
	False sentences	*True sentences*	*False sentences*	*True sentences*
Total Broca's aphasia	93.3% (2 mistakes: yes to no)	83.3% (5 mistakes: no to yes)	76.7% (14 mistakes: yes to no)	78.3% (13 mistakes: no to yes)

	Fillers		***Test items***	
	False sentences	*True sentences*	*False sentences*	*True sentences*
Total Lesion right hemisphere	86.7% (4 mistakes)	100%	81.7% (11 mistakes)	90% (6 mistakes)

	Fillers		***Test items***	
	False sentences	*True sentences*	*False sentences*	*True sentences*
Total controls	100%	100%	100%	100%