Broca’s aphasia, verbs and the mental lexicon

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Abstract

Verb production is notoriously difficult for individuals with Broca’s aphasia, both at the word and at the sentence level. An intriguing question is at which level in the speech production these problems arise. The aim of the present study is to identify the functional locus of the impairment that results in verb production deficits in Broca’s aphasia. Levelt’s (1989) model is used as a theoretical framework for this study. Two experiments have been conducted, one on verb movement and one on verbs with alternating transitivity. The results suggest that the functional impairment in Broca’s aphasia should be located in Levelt’s “grammatical encoder.”

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1. Introduction

Several studies have shown that in Broca’s aphasia the production of verbs is more impaired than the production of nouns [Jonkers (1998) for Dutch; Kim and Thompson (2000) for English; Luzzatti, Zonca, Pistarini, Contardi, and Pinna (2002) for Italian, to name a few recent studies]. These studies also demonstrate that it is not just the categorical property of the verb or noun that determines availability. Rather, it is a matter of grammatical complexity: within the category of verbs, grammatically more complex items are harder to produce than simpler ones.

Considering speech production models, such as Levelt’s (1989), which is given in Fig. 1 in a slightly adapted version, the question can be asked where in the speech production process the verb problems of individuals with Broca’s aphasia arise. According to Levelt (1989), concepts activate the lemmas in the lexicon. The lemmas contain information about word meaning, word class, and, in case of verbs, about thematic roles, argument structure, and subcategorisation frame. The lemmas are used for encoding the message grammatically, and, at the same time, activate the spoken word forms or lexemes. During phonological encoding, the lexemes are inserted into the structure that has been generated by the grammatical encoder, after which the sentence can be produced.

As said above, several researchers have demonstrated that grammatical factors like complexity of argument structure and transitivity influence the production of verbs, both in isolation and in sentences. This suggests that the locus of the deficit is somewhere around the lemmas, because only here grammatical information is stored or used. There are three possible loci of the deficit: (1) the lemma representations themselves may be affected; (2) the retrieval of lemmas may be diminished; and (3) grammatical encoding may be impaired.

The central question of the present paper focuses on determining the exact locus of the deficit that results in poor verb production in Broca’s aphasia. Results of several studies, both from our own research group and from other groups, will be used to evaluate the functioning of the lemma representations, lemma selection, and grammatical encoding.

1.1. Lemma representations

If the representations of the lemmas are completely or partially affected, then one expects to find compre-
hension problems that parallel the production deficit, since there is only one set of lemmas. There is ample
evidence that this is not the case in Broca’s aphasia.
Jonkers (1998) found that Dutch individuals with
Broca’s aphasia are seriously impaired in naming ac-
tions, whereas comprehension of the same action verbs
is virtually perfect. Since closely related verb and noun
distractors were used in this matching spoken-word-to-
picture task, it is quite safe to conclude that the lemma
representations themselves are not affected. The same
has been reported for English in a study from Kim and
Thompson (2000). An earlier study by Shapiro and
Levine (1990) also suggests intact lemma processing.
They used an on-line sentence processing task and in-
dividuals with Broca’s aphasia showed normal sensi-
tivity to the argument structural properties of verbs:
verbs with more complex argument structures (e.g., to
give) take longer to process than verbs with simple
argument structures (e.g., to fix). Kim and Thompson
(2000) used a task similar to the one used by Jonkers
(1998), but they controlled argument structure in the
same way as Shapiro and Levine. Again, they did not
find any evidence for a disorder in the comprehension
of single verbs. Taken together, these three studies
suggest that the lemma representations in Broca’s
aphasia are intact.

1.2. Lemma access versus grammatical encoding

For the present report, two experiments have been
conducted in order to find out whether the deficit
causing the verb production problems in Broca’s aphasia
is due to an impairment to lemma selection or to
grammatical encoding. In both experiments, the same
verbs have been used in two different conditions, one
condition being linguistically more complex than the
other. In experiment 1, production of finite verb + object
strings have been tested in Dutch matrix and embedded
clauses. In experiment 2, the production of verbs with
alternating transitivity has been analyzed. In the next
section, the linguistic background of these two exper-
iments will be discussed.

1.3. Finite verbs in dutch

Dutch has been analyzed as an SOV-language, meaning that the base-generated position of the verb is
after the object (Koster, 1975). In the Dutch matrix
sentence, the finite verb has to be moved to second
position. This movement is known as Verb Second. In
embedded clauses, the finite verb remains in its base-
generated position. This is illustrated in (1) and (2),
where \( t \) designates the canonical verb position, which is
called Verb Second position.

\[
\text{(1) \qquad \text{embedded clause}} \\
(ik \text{ denk}) \quad \text{dat \quad de jongen \quad een fiets \quad koopt} \\
(I \text{ think}) \quad \text{that \quad the boy \quad a bike \quad buys} \\
(I \text{ think that the boy buys a bike})
\]

\[
\text{(2) \qquad \text{matrix sentence}} \\
\text{de jongen \quad koopt}_t \quad \text{een fiets \quad t; \quad the \quad boy \quad buys \quad a bike}
\]

This means that, according to Koster’s theory on
Dutch, the order of the embedded clause is less complex
than that of the matrix clause. In Broca’s aphasia, this
complexity difference might be reflected in the produc-
tion of finite verb–object strings.

1.4. Verbs with alternating transitivity

As mentioned above, there is a difference in produc-
tion performance between transitive and intransitive
verbs in Broca’s aphasia (Jonkers, 1998; Kim &
Thompson, 2000; Luzzatti et al., 2002). A special group
of verbs, that have not been tested at the sentence level,
are verbs with ‘alternating transitivity’ (Levin, 1993).
These verbs can be used with either the agent or the
theme in subject position. When the agent is in subject
position, the result is a transitive sentence, as in (3).
When the theme is in subject position, this results in an
intransitive sentence, as in (4).

\[
\text{(3) \qquad the woman breaks the glass} \\
(4) \quad \text{the glass \quad breaks} \quad t_i
\]

In (4) the theme is supposed to have been moved from
an underlying object position. So, although (4) is
superficially seen less complex than (3), in terms of linguistic theory, (4) is more complex because the argument is not in its base position.

1.5. Expectations

The goal of the experiments is to establish whether lemma selection or grammatical encoding is impaired in Broca’s aphasia. If lemma selection is the crucial process, then one expects that verb production is equally impaired in both conditions, irrespective of grammatical complexity. If, however, grammatical encoding is the affected level, then verb production is supposed to be more problematic in the grammatically more complex condition, which is the finite verb in the matrix clause in the first experiment and the intransitive construction in the second experiment.

2. Experiment 1

2.1. Subjects

Nine individuals with agrammatic Broca’s aphasia participated in this study. All patients were right-handed and aphasic due to a single stroke in the left hemisphere. They were diagnosed with the Dutch version of the Aachen Aphasia Test (AAT; Graetz, De Bleser, & Willmes, 1992) and classified as having Broca’s aphasia, which was confirmed by both the speech therapist and the experimenter. All of them spoke in so-called telegraphic speech, no one suffered from apraxia of speech to an extent that it influenced the test results.

2.2. Materials

The patients were presented with two pictures (see Fig. 2). They were asked to complete a sentence. There were two conditions: (1) a matrix clause that should be completed with a finite verb–object; (2) an embedded clause with the intended answer object–finite verb. There were 15 sentences in each condition. Two examples are:

Condition 1: target = finite verb–object (with verb movement)
Tester: Dit is de man die de tomaat snijdt en dit is de man die het brood snijdt. Dus dit is de man die de tomaat snijdt en dit is de man die het brood snijdt. Dus deze man snijdt de tomaat en deze man.......

Condition 2: target = object–finite verb (without verb movement)
Tester: Deze man snijdt de tomaat en deze man snijdt het brood. Dus dit is de man die de tomaat snijdt en dit is de man die het brood snijdt. Dus, dit is de man die de tomaat snijdt en dit is de man die het brood snijdt. Dus deze man snijdt de tomaat en deze man.......

Fig. 2. An example of a test item of experiment 1.

2.3. Scoring

A simple correct/incorrect scoring system was used, in which determiner omission was ignored.

2.4. Results

The results of the experiment are given in Table 1. Completing a matrix clause was more difficult than completing an embedded clause (Wilcoxon, $z = -2.37$, $p = .018$), meaning that verb–object production diminishes in a linguistically more complex construction. What is intriguing, is that the object–finite verb string in embedded clauses is produced very well by these agrammatic speakers, while they hardly ever produce embedded clauses spontaneously. This rises the question whether other contrasting structures that are superficially less, but syntactically more complex elicit the same pattern. Therefore, a second experiment has been designed on verbs with alternating transitivity.

3. Experiment 2

3.1. Subjects

Eight patients with a Broca’s aphasia were tested (these were different from the patients in experiment 1).
All subjects were right-handed and aphasic due to a single stroke in the left hemisphere. As in experiment 1, the aphasia type was established with the Dutch version of the Aachen Aphasia Test (AAT; Graetz et al., 1992) and confirmed by both the speech therapist and the examiner.

3.2. Materials

Only verbs with alternating transitivity were used. Pictures were drawn to elicit either a transitive or an intransitive sentence. To elicit sentences with verbs in the transitive and intransitive reading, a picture was presented to the patient, with the intended verb (infinitive) underneath. An example is given in Fig. 3.

The task consisted of 14 verbs, each used twice, once in the transitive and once in the intransitive condition (total 28 items).

3.3. Procedure and scoring

A simple correct/incorrect system was used. A sentence was supposed to be correct if it contained the required verb and thematic role(s) and if the thematic roles were in the required position.

3.4. Results

In Table 2, the results are given.

Sentence construction in the intransitive condition is significantly more difficult than in the transitive condition (Wilcoxon, $z = -2.12$, $p = .034$), meaning that the intransitive condition, although superficially less complex, is more difficult than the transitive condition.

4. Discussion

The central question of the present paper was whether we could establish which level is responsible for the often reported poor verb production in Broca’s aphasia.

Before we answer this question, we would like to discuss a methodological issue. One may wonder to which extent the results of two tests at the sentence level can account for the verb production problems at the word level, even more when in both conditions the verb is provided. Maybe other tests, such as sentence production tests in which the verb is not given, are more informative in this respect. In a previous study, Bastiaanse and Jonkers (1998) compared the production of verbs at the word and sentence level, but the results are hard to analyze and even harder to interpret. First of all, the patterns of performance differ greatly among the aphasic speakers, even within one aphasia type. For some individuals with Broca’s aphasia, producing verbs in sentences is easier than producing verbs as single words, whereas for others it is the other way around or there is no difference. Apart from that, it is difficult to develop a reliable and sensible analysis system, since there is a considerable amount of freedom in sentence production. This was why we used the two reported tests to establish the level of the deficit. By varying the degree of grammatical complexity in relation to information contained in the verb (sentence position in experiment 1; transitivity in experiment 2), while keeping the verb lemmas fixed, we aim to show that certain properties of verbs limit the production of grammatical constructions in Broca’s aphasia.

4.1. The locus of the deficit

On the basis of the influence of grammatical complexity in single verb production experiments, it was concluded that the locus of the deficit should be located in or around the lemma representations. Comprehension and language processing studies have revealed that the lemmas themselves are not affected. The next question was whether lemma selection or grammatical encoding is the critical level.

Both experiments show that when the same set of verbs is used in two grammatically different constructions, performance diminishes in the grammatically most complex condition. Performance is worse when the verb has to be moved to second position and when the theme has to move to subject position, although the
verbs that have to be produced are similar. Notice that the sentence structures that are most difficult to produce are superficially the simpler constructions: completion of matrix clauses is more difficult than completion of embedded clauses and intransitive sentences (subject–verb) are more difficult to construct than transitive sentences (subject–verb–object). The conclusion must then be that it is not lemma selection as such, but grammatical encoding that is the affected level.

When grammatical encoding is impaired, how can that account for the problems at the word level? Verbs are more difficult than nouns on a single-word production task and verbs that are more complex with respect to their argument structure are harder to produce than simpler verbs. We think that this can be explained by the fact that even single words need grammatical encoding. As a metaphor, a tree-like construction can be used. When the trees in Fig. 4 are compared, one can see why a transitive verb is more difficult than an intransitive verb [as suggested by Kim and Thompson (2000)] and why, in case of a verb with alternating transitivity, the intransitive verb is more difficult than a transitive verb. Luzzatti et al. (2002) showed that this is not only the case at the sentence level: in their study, significant differences were observed between the production of intransitive unergatives (verbs that have an agent in subject position, like to sleep) and intransitive ergatives (verbs that have the theme in subject position, such as to fall).

All in all, verbs are more difficult to produce than nouns for individuals with Broca’s aphasia, because verb lemmas contain more grammatical information than noun lemmas. This information needs to be grammatically encoded, both in single word and in sentence production. An impairment in grammatical encoding can account for the following findings: (1) verb production is more impaired than noun production (e.g., Jonkers, 1998); (2) verbs with complex argument structure are more difficult to retrieve than verbs with simple argument structure (e.g., Kim & Thompson, 2000; Luzzatti et al., 2002); (3) sentences with finite verbs are more difficult to produce when the verbs have to be moved to V2 position (Bastiaanse, Rispens, Ruigendijk, Juncos Rabádan, & Thompson, 2002); (4) sentences with verbs that have the theme in subject position are more difficult to produce than sentences with (the same) verbs with an agent in subject position.

Fig. 4. Mental representations of different kinds of verbs.