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Nielsen, Sarah Rosenbech; Boye, Kasper; Bastiaanse, Roelien; Lange, Violaine Michel

Published in:
Language, Cognition and Neuroscience

DOI:
[10.1080/23273798.2019.1616104](https://doi.org/10.1080/23273798.2019.1616104)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2019

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Nielsen, S. R., Boye, K., Bastiaanse, R., & Lange, V. M. (2019). The production of grammatical and lexical determiners in Broca's aphasia. *Language, Cognition and Neuroscience*, 34(8), 1027-1040.
<https://doi.org/10.1080/23273798.2019.1616104>

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To cite this article: Sarah Rosenbech Nielsen, Kasper Boye, Roelien Bastiaanse & Violaine Michel Lange (2019) The production of grammatical and lexical determiners in Broca's aphasia, *Language, Cognition and Neuroscience*, 34:8, 1027-1040, DOI: [10.1080/23273798.2019.1616104](https://doi.org/10.1080/23273798.2019.1616104)

To link to this article: <https://doi.org/10.1080/23273798.2019.1616104>

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REGULAR ARTICLE

The production of grammatical and lexical determiners in Broca's aphasia

Sarah Rosenbech Nielsen^a, Kasper Boye^a, Roelien Bastiaanse^{b,c} and Violaine Michel Lange^{a,d}

^aDepartment of Nordic Studies and Linguistics (NorS), University of Copenhagen, Copenhagen, Denmark; ^bCenter for Language and Cognition (CLCG), University of Groningen, Groningen, Netherlands; ^cNational Research University Higher School of Economics, Moscow, Russian Federation; ^dDanish Research Centre for Magnetic Resonance, Hvidovre, Denmark

ABSTRACT

Determiner production is a testing ground for theories of Broca's aphasia and agrammatic speech. On one type of theory, determiner production is impaired in so far as determiners are grammatical items. On another type of theory, determiner production is impaired because determiners depend on verbs for case-assignment. These two types of theories are mutually compatible, but in recent years, research on determiner production has focused on the second type. In order to test the first type, an experiment was carried out which contrasted the production of Danish grammatical determiners (indefinite articles) and lexical ones (numerals) in five speakers diagnosed with Broca's aphasia and four non-brain-damaged controls. The results strongly support the first type of theories: (1) in agrammatic speech, only grammatical determiners were omitted to an extent which differs from omission rates in the speech of the controls; (2) substitutions of grammatical agreement markers were found only in agrammatic speech.

ARTICLE HISTORY

Received 12 June 2018
Accepted 30 April 2019

KEYWORDS

Agrammatism; language production; determiners; articles; numerals

1. Introduction

A central characteristic of agrammatic speech is that grammatical (or “function”) words and morphemes tend to be omitted or substituted, whereas lexical (or “content”) words and morphemes are relatively unaffected (e.g. Bates, Wulfeck, & MacWhinney, 1991; Menn, Obler, & Miceli, 1990; Saffran, Berndt, & Schwartz, 1989). Articles provide an often-discussed example of this: in spontaneous speech, agrammatic speakers tend to omit or substitute articles (e.g. Månsson & Ahlsén, 2001).

1.1. Agrammatism as a problem with grammatical items

The most simple account of this tendency is that agrammatic speakers have problems with grammatical items. We will refer to this type of account as “grammatical-item-centred”. As one example of such an account, some researchers have proposed a dual-route processing system, in which the route for grammatical items is said to be impaired for individuals with agrammatic aphasia, while the route for lexical ones is assumed to be spared (e.g. Biassou, Obler, Nespoulous, Dordain, & Harris, 1997; Rosenberg, Zurif, Brownell, Garrett, & Bradley, 1985).

Another example is adaptation theory (e.g. Hofstede & Kolk, 1994; Kolk, 1995; Kolk & Heeschen, 1990; Kolk & Van

Grunsvén, 1985). According to this theory, agrammatic speech is the result of an adaptation to a processing impairment in which lexical items are prioritised above grammatical ones.

Adaptation theory is arguably better than a dual-route model at capturing the fact that agrammatic speakers are able to produce and comprehend grammatical words under some circumstances (e.g. Hofstede & Kolk, 1994). Thus, in a study dealing specifically with determiners, Stavrakaki and Kouvava (2003) found that in spontaneous speech, Greek agrammatic speakers omitted definite articles in contexts where an article was obligatory, but “completely redundant and without communicative use” (Stavrakaki & Kouvava, 2003, p. 134). The same participants were able to produce definite articles in a picture description task – a task which is more constrained than spontaneous speech, and in which agrammatic speakers have previously been found to perform better (Sahraoui & Nespoulous, 2012; Salis & Edwards, 2004).

1.2. Agrammatism as a problem with verbs

As an alternative to these simple accounts, it has been argued that it is not the grammatical items in themselves that are problematic for agrammatic speakers, but that the problem is syntactic in nature (e.g. Bastiaanse, Jonkers, & Moltmaker-Osinga, 1996; cf. Saffran et al.,

CONTACT Kasper Boye boyek@hum.ku.dk

Supplemental data for this article can be accessed at <https://doi.org/10.1080/23273798.2019.1616104>.

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1989). We will refer to this type of account as “verb-centred”.

Again, key arguments come from studies of determiner production. De Bleser, Bayer, and Luzzatti (1996) originally found that German agrammatic speakers were able to produce the correct article when inserting it into an isolated noun phrase, but when the article had to be inserted in a noun phrase to complete a sentence, they were less accurate. The authors argued that the difficulties of the agrammatic speakers must be due to case, since case is not relevant in an isolated noun phrase, but becomes obligatory when the noun phrase occurs in a sentence.

Later studies are based on a theory which claims that the basic problem in agrammatism concerns verbs, and that grammatical items are affected to the extent that they relate to verbs (Bastiaanse, Jonkers, Ruigendijk, & Van Zonneveld, 2003; Ruigendijk & Baauw, 2007). Accordingly, it has been argued (*pace* De Bleser et al., 1996) that it is not case as such which is the problem in agrammatic determiner production, but verbs. And as will be discussed below, it has been demonstrated that determiner production is conditioned by verb production: when agrammatic speakers produce an utterance with a verb in it, it is more likely that the noun phrase in the utterance contains a determiner, than when no verb is produced. These studies assume with Chomskyan theory (e.g. Chomsky, 1986) that case-assigning elements, such as verbs, always assign case to any syntactically related NP, even in languages where case is not expressed morphologically,¹ and that NPs receive case from case-assigning elements such as verbs.

Ruigendijk, Van Zonneveld, and Bastiaanse (1999) investigated the spontaneous speech and picture descriptions of six Dutch and six German agrammatic speakers. They reported that the Dutch speakers omitted significantly more determiners than they produced in sentences where no verb was realised, while there was no significant difference between the numbers of determiners omitted and produced in sentences with a verb. The German speakers produced as many determiners as they omitted in sentences without a verb, but in sentences with a verb they generally produced the determiner with the correct case inflection – only 7% out of 270 nouns with determiners were produced with a case error. Based on this low number of case errors, the authors suggested that case was not the central difficulty for the agrammatic speakers, but that verbs and the relation between verbs and case morphemes are at the root of the problem. In a study of language production in German agrammatic speakers, Ruigendijk and Bastiaanse (2002) reported a

higher number of determiners when a case-assigning verb was present than when it was absent. The authors' account was that determiners and pronouns tend to be omitted in agrammatic speech not because the production of these kinds of items is impaired as such, but because agrammatic speakers have difficulties producing the verbs that assign case to these determiners. Bastiaanse et al. (2003) observed that case errors give rise to a higher number of article substitutions than gender errors do. Focusing on substituted articles in Dutch and German agrammatism, they reported that gender errors on articles constituted only 0.9% in the Dutch group and 1.8% in the German group. In the same task, the German speakers produced 12.8% case errors on articles.

Ruigendijk and Friedmann (2008) put forth the Preserved Case Hypothesis, in which they argue that case-assignment and morphemes that depend on case are preserved in agrammatism, and that difficulties related to case are a by-product of an impairment in case-assigning elements: agrammatic speakers have an impairment in their syntactic structure building, which causes difficulties in producing and inflecting verbs. When the verbs are not produced or not inflected, they cannot assign case to their arguments, which are noun phrases. When noun phrases do not receive case, the determiner which carries case cannot be produced. This leads to determiner omission. Ruigendijk and Friedmann (2008) found support for this hypothesis in Hebrew and Dutch elicited speech as both Hebrew and Dutch agrammatic speakers in general produce case-marked morphemes correctly. In addition, Ruigendijk (2010) found that Dutch and English agrammatic speakers patterned together regarding determiner omissions, while German agrammatic speakers omitted significantly more determiners than the English and Dutch speakers. German determiners carry both case and gender information, while Dutch determiners carry only gender information and English determiners carry neither – therefore, gender information cannot be the problem. Ruigendijk (2010) argued that overt case morphology must cause extra difficulties for agrammatic speakers, since the German speakers omitted the most determiners – if the difficulties were only due to the syntactic relation between verbs and the elements that depend on (abstract) case, then the speakers of the three languages would not differ in their determiner omission. However, the agrammatic speakers studied were not matched on degree severity of their grammatical impairment, which makes Ruigendijk's (2010) interpretation of the data rather speculative.

As mentioned, the studies described above have demonstrated that determiner production is conditioned

by verb production. An additional study, Ruigendijk and Baauw (2007), demonstrated the opposite relationship, however: verb production is conditioned by determiner production. In a study of the spontaneous speech of Dutch agrammatic speakers Ruigendijk and Baauw found that in utterances where a determiner was produced, a verb was generally also produced (85% of the time), whereas in utterances where a determiner was not produced, there was an equal number of times where a verb was produced or omitted. Thus, there was a higher number of case-assigning verbs when a determiner was present than in the absence of a determiner.

It seems then that just as verb problems lead to determiner problems, determiner problems lead to verb problems. This means that there may be no unequivocal causal relationship between verb and determiner problems. In fact, one might envisage a third problem as the causer of both verb and determiner problems.

1.3. The present study

The studies supporting the verb-centred account all focus on grammatical determiners, especially articles. They do not contrast grammatical determiners with lexical counterparts. While these studies represent an alternative to simple accounts that see agrammatism as centred on problems with grammatical items, it thus cannot be excluded that both kinds of accounts are on the right track. That is, agrammatic speakers may have problems both with verbs and with grammatical items – or they may have problems with verbs that affect only grammatical items. Ruigendijk and Baauw (2007) distinguished two groups of determiners: one consisting of articles, demonstratives and possessives, and a second consisting of numerals and quantifiers. They found that only the first group was affected in agrammatic speech. While it is unclear how their distinction relates to the grammatical vs. lexical distinction, the findings suggest a picture that is too complex to be captured by the verb-centred account on its own.

The aim of the present study is to test the grammatical-item-centred account. In other words, the aim is to investigate whether the contrast between grammatical and lexical items plays a role in agrammatic determiner production. To this end we carried out an NP production experiment with five participants diagnosed with Broca's aphasia in which we compared the production of grammatical and lexical determiners. More specifically, we compared the Danish indefinite articles *en* and *et* with the production of the adnominal numerals *en* and *ét* ("one") in entirely identical surroundings, as in (1) and (2).

- (1) a. *Jeg har en grøn firkant.* (*en* = common gender article = grammatical)

- "I have a green square."
b. *Jeg har én grøn firkant.* (*én* = common gender numeral = lexical)
"I have one green square."
(2) a. *Jeg har et grønt brev.* (*et* = neuter gender article = grammatical)
"I have a green letter."
b. *Jeg har ét grønt brev.* (*ét* = neuter gender numeral = lexical)
"I have one green letter."

The classification of both the articles (1a, 2a) and numerals (1b, 2b) as determiners is in line with Ruigendijk and Baauw (2007). Whether they are determiners or not, is however not important. What is important is that the articles and numerals behave in exactly the same way with respect to case: neither show any case marking, but squinting to the related language German, both may be assumed to show hidden case in the Chomskyan sense. Thus, in German the corresponding numeral as well as the corresponding indefinite article are marked for case – in (3), the accusative-marked word *einen* can be read both as a numeral and as an article.

- (3) *Ich habe ein-en Wagen.*
"I have one-M.ACC/a-M.ACC car."

The conception of the contrast between articles (1a, 2a) and numerals (1b, 2b) as a contrast between respectively grammatical and lexical elements is based on a recent theory of grammatical status and grammaticalisation (Boye & Harder, 2012). According to this theory, grammatical items are defined as items that by convention carry secondary (or background) information and are dependent on a host item, whereas lexical items are defined as items that by convention have the potential to carry primary (or foreground) information and can sometimes stand alone. A series of studies have found psycholinguistic support for this theory (cf. Section 4.1). For instance, the definition of grammatical items as secondary entails the hypothesis that they attract less attention than lexical items. This hypothesis was confirmed in letter detection and change blindness experiments (Christensen, Kristensen, Vinther, & Boye, 2019; Vinther, Boye, & Kristensen, 2014; see also Rosenberg et al., 1985). The definition of grammatical items as dependent on a host item entails the hypothesis that the production of these items is more complicated than the production of lexical items, as reflected in response times and accuracy measures. This hypothesis was confirmed in studies of the production of verbs and determiners (Ishkhanyan, Boye, & Mogensen, 2019; Lange, Messerschmidt, & Boye, 2018; Lange, Messerschmidt, Harder, Siebner, & Boye, 2017; cf. Section 4.1).

It also follows from the above definitions that only lexical items can be focalised (as long as conventions are not overridden in corrective contexts). In accordance with this criterion, the numerals *en* (1b) and *et* (2b) are lexical in that they can be focalised (for instance, they can receive emphatic stress), whereas the articles *en* (1a) and *et* (2a) are grammatical in that they cannot be focalised (they cannot receive stress outside corrective contexts).

Thus, the present study contrasts grammatical items and lexical ones that behave in exactly the same way with respect to case. Moreover, it contrasts grammatical and lexical items that are morphologically, syntactically, phonologically and diachronically closely related. As for morphology, both sets of words show a contrast between common gender (*en*) and neuter (*et*), but no other contrast. As for syntax, both sets of items agree with their head noun for gender, and both sets of items take a prenominal position preceding that of an attributive AP (which also agrees with the head noun for gender; see Section 2.2.1). Definite articles occur in a position distinct from that of the numerals, but the indefinite articles under scrutiny here cannot be distinguished from numerals in terms of position, as the two kinds of words are mutually exclusive. Phonologically, the two sets of items differ only in terms of stress and distinctness, the articles being typically less stressed and less distinct than the numerals. Diachronically, the articles developed from the numerals through grammaticalisation, just as the English indefinite article *a(n)* developed from the numeral *one*.

In testing the grammatical-item-centred account, we eliminate variation central to the verb-centred account. That is, we investigate whether there is an effect of the grammatical vs. lexical contrast when case and verb properties are constant. Based on the grammatical-item-centred account, we hypothesise that in agrammatic speech the production of grammatical articles is more compromised than the production of lexical numerals, whereas in a non-brain-damaged control group (henceforth NBDs) neither the production of grammatical articles nor that of lexical numerals is compromised (in contrast, based on the verb-centred account we would expect no differences between agrammatic production of grammatical articles and lexical numerals as both kinds of determiners have the same case properties). In order to test this hypothesis we use item omissions as a measure of the degree to which production is compromised. That is, we make the following prediction:

Omission prediction based on a grammatical-item-centred account of agrammatism:

Agrammatic speakers omit more grammatical articles than lexical numerals, whereas NBDs omit similar (and very low) numbers of grammatical articles and lexical numerals.

In addition to omissions, we look at substitutions in which a neuter form (*et*) of the article or numeral is replaced by a common gender form (*en*), or vice versa. These substitutions are grammatical errors; in fact, they can be seen as morphological substitutions in which a neuter suffix (-t) is replaced by a common gender suffix (-n), or vice versa. This means that they can be seen as applying to a common grammatical element (gender-agreement, marked by a suffix) in both the lexical condition (numerals) and the grammatical one (articles). On a grammatical-item-centred account, we would therefore expect that such substitutions are more pronounced in agrammatic speech than in the speech of NBDs, whereas within groups (agrammatic or NBD), substitutions are equally frequent in the lexical condition (numeral) and in the grammatical one (article) (in contrast, based on a verb-centred account we would expect no differences between agrammatic speakers and NBD substitutions). In other words, we make the following prediction:

Morphological substitution prediction based on a grammatical-item-centred account of agrammatism:

Agrammatic speakers produce more morphological substitutions than NBDs, but neither agrammatic speakers nor NBDs produce more morphological substitutions in grammatical articles than in lexical numerals.

2. Method

2.1. Participants

Five individuals with Broca's aphasia participated in the study, along with a control group of four NBD individuals. All aphasic participants were classified as suffering from Broca's aphasia using the Western Aphasia Battery (translated to Danish by Pedersen & Vinter, 2001). The Western Aphasia Battery Aphasia Quotient (WAB-AQ) was given by a speech therapist for P1, P2 and P3, while P4 and P5 were tested in the WAB by the experimenter. All participants were guaranteed anonymity and have signed an informed consent according to the Declaration of Helsinki under a procedure approved by The Research Ethics Committee at the Faculty of Humanities, University of Copenhagen. Further information about the participants can be seen in Table 1. Importantly, on the WAB none of the participants showed signs of colour-blindness.

2.2. Materials

The materials are designed to contrast grammatical articles and lexical numerals in the production of NPs.

Table 1. Information about agrammatic speakers (P1–P5) and NBD speakers (NBD1–NBD4).

Participant	Gender	Age	Prior profession	Time post-onset	Cause	WAB-AQ
P1	F	73	Nurse	1 year; 2 months	Stroke	55.8
P2	M	67	School teacher	9 months	Stroke	43
P3	M	77	Jeweller	15 years	Stroke	53.2
P4	F	61	Nurse	27 years	Stroke	68.6
P5	M	59	Engineer	20 years	Traumatic	52.6
NBD1	F	71	Pedagogue	–	–	–
NBD2	M	79	School teacher	–	–	–
NBD3	M	62	Manual worker	–	–	–
NBD4	F	62	Secretary	–	–	–

The stimuli in the experiment consist of simple line drawings of 16 objects. For each object eight pictures were created. Each picture contained either one or two of the same type of objects in the same colour, either green, blue, red or yellow. Half of the words for the objects were monosyllabic and half were disyllabic. Moreover, half of the words had common gender and half had neuter gender. The voice of a female native Danish speaker was recorded for each picture naming the number, colour and type of item in the picture prefixed by *jeg har* “I have” (e.g. sentence 4). The same voice was also recorded asking two questions (5–6).

- (4) *Jeg har to røde breve.*
“I have two red letters.”
(5) *Hvor mange har du?*
“How many do you have?”
(6) *Hvad har du?*
“What do you have?”

There were 2 conditions (lexical and grammatical) for each of 64 items. Figure 1 illustrates these two conditions. In the lexical condition, participants saw a picture with two identical objects for three seconds and heard the matching sentence. They were then presented with a blank screen for two seconds, while hearing the question in (5) above. Next, a picture of a single object of the same type and colour was presented. This created a contrast in number, which was designed to elicit a noun phrase consisting of a numeral (lexical), an adjective and a noun. In the grammatical condition, participants first saw a picture of a single object for three seconds. They were then presented with a blank screen for two seconds, while hearing the question in (6), followed by a picture of the same object in a different colour. In this condition, there was a colour contrast but no number contrast. The colour contrast was designed to elicit a noun phrase consisting of an article (grammatical), an adjective and a noun. The complete list of stimuli can be seen in Appendix A. The order of the items was fully randomised, meaning that no participants saw the items in the same order.

The design described above was originally developed to test healthy participants (Ishkhanyan et al., 2019; Lange et al., 2018; see Section 4.1 for a summary of the

results of these studies). Some changes have been made to the original experiment to make it more appropriate for brain-damaged speakers. These changes include deleting filler items and lengthening the amount of time each participant is allowed to use when responding.

2.2.1. Differences in the target sentences

The eliciting questions (5 and 6) are not the same for the lexical and grammatical conditions, as the questions were tailored to ensure that the difference between articles and numerals was in fact produced. The lexical numerals are elicited using a numerical contrast which puts linguistic focus on the numeral. Since grammatical items cannot be focused outside of a corrective or meta-linguistic context (Boye & Harder, 2012), we elicited the grammatical articles as a by-product of a focused colour contrast which is expressed by an adjective. To ensure that the lexical and grammatical conditions are as similar as possible, the adjective is included in both conditions (both in the eliciting question and in the target sentence).

The adjective is grammatically congruent with the determiner (whether it is an article or a numeral) for gender, but only the neuter adjective is inflected with a suffix, *-t* (7), while the common adjective is realised as the adjective root (8). However, this difference between common and neuter adjectives is consistent across the grammatical and lexical conditions, so it does not affect the contrast which we are investigating.

- (7) *Et rød-t brev.*
“a.NEUT/one.NEUT red-NEUT letter.”
(8) *En rød-Ø firkant.*
“a.COMM/one.COMM red-COMM square.”

2.2.2. Frequency

As mentioned, the article *en/et* and the numeral *en/et* are morphologically, syntactically and phonologically similar, as well as diachronically related. However, they differ with respect to frequency. Lange et al. (2018) found that the article *en/et* is significantly more frequent than the numeral *en/et* in a large Danish language corpus.²

Figure 1. Illustration of the experimental design. The speech bubbles represent the utterances expected to be produced by the participants. From Lange et al. (2018).

Therefore, if there is any frequency effect, it should be to the advantage of the article, and thus run counter to our hypothesis.

2.3. Procedure

The experiment was run on a computer using PsychoPy (Peirce, 2007). The procedure was identical for the NBD participants and the agrammatic speakers. An experimenter sat next to the participant during the whole experiment, and no other people were in the room. To begin with, participants were presented with black drawings of all 16 objects 2 times: first with their corresponding written noun, where the participant was asked to read or repeat the noun, and then without their written noun, where the participant was again asked to repeat the noun. If the participant could not name the noun, the experimenter would provide the noun and ask the participant to repeat it. This was to ensure that the participant was familiar with all nouns before the experiment started. Subsequently four trials were run to ensure the participant was familiarised with the task, and the experimenter provided clear instructions for how to reply. In these four trials, the participant would

receive help if needed, which was of course mainly relevant for the agrammatic speakers. This was followed by the actual experimental task, in which participants were not given any help. If the agrammatic speakers struggled, they were encouraged to say as much as they could and not to worry if they could not reply. If the participants struggled for more than 10 seconds without providing a reply, they were encouraged to move on to the next item. This was done by pressing the space bar. The participants' replies were recorded via a headset from onset of the eliciting picture. The program was set to record only for 10 seconds. The participants were informed that they could take as many breaks as they needed to, and that they could stop the experiment at any time.

The experiment was stopped after a maximum of 40 minutes, even if the participant had not finished all trials. This means that not all agrammatic speakers completed the same number of trials.

2.4. Scoring

All recorded responses were individually analysed using Praat (Boersma & Weenink, 2017). Each response was

coded for whether the article/numeral and adjective were produced correctly, omitted or produced with a gender error, i.e. a morphological substitution. In trials where the participant made several attempts at the same word, the word was categorised as correct if any of the attempts were correct. As the program was set to record only for 10 seconds, replies given later than 10 seconds after onset of the second picture were categorised as omissions.

2.5. Statistical analysis

To test our hypothesis, we compared both the agrammatic speakers' mean to the NBDs' mean and the individual scores of agrammatic speakers to the NBDs' mean. For each participant, individual scores were calculated by counting the number of omitted and morphologically substituted articles and numerals, and the means for the agrammatic speakers and the NBDs were calculated from the individual scores. We used Fisher's exact test to investigate potential differences between groups, between conditions, and between individual agrammatic speakers. All p -values given are one-tailed. All significant results remain highly significant also if a two-tailed test is employed, with one exception: the difference between article and numeral omissions for P5 (see Table 2).

In a post-hoc qualitative analysis, we also investigated individual variation in the agrammatic speakers, as we expect to find some between-subject variation which might reflect individual strategies.

3. Results

3.1. Omission of articles and numerals

The NBD speakers did not omit any articles or numerals. Fisher's exact test showed that the group mean for omitted articles was significantly higher for the agrammatic speakers (mean = 13.6 omitted articles out of 45 completed grammatical trials) than for the NBDs (mean = 0 omitted articles out of 64 completed

grammatical trials), $p < .0001$. The two group means were not significantly different regarding the omission of numerals (agrammatic group mean = 2.4 omitted numerals out of 45.4 completed lexical trials, NBDs mean = 0 omitted numerals out of 64 completed lexical trials). Within the agrammatic group, the mean number of omitted articles was significantly higher than the mean number of omitted numerals $p < .001$. The proportion of omitted articles and numerals for the two groups are shown in Figure 2.

Table 2 shows the proportions of omitted articles and numerals for the individual agrammatic speakers and for the NBDs as a group. The proportions of omissions were calculated by dividing the numbers of omitted articles and numerals with the number of grammatical and lexical trials completed. The p -values in Table 2 reflect that P1, P2, P3 and P5 had significantly higher proportions of omitted articles than the NBDs did. In addition, the same four participants omitted significantly more articles than numerals. Only one agrammatic speaker (P3) had a significantly higher proportion of omitted numerals than the NBDs did.

Figure 2. Group mean ratios for omitted articles (gram) and numerals (lex). The agrammatic group omitted significantly more articles (gram) than numerals (lex), and also significantly more articles (gram) than the NBD group omitted. The agrammatic group did not omit significantly more numerals (lex) than the NBD group, and the NBD group did not omit significantly more articles (gram) than numerals (lex).

Table 2. The number of omitted articles and numerals out of the number of grammatical and lexical trials that each participant completed.

Participant	Articles		Numerals		Significance of article–numeral difference
	<i>n</i> omitted of <i>n</i> trials	Significance of difference between patient and NBD group	<i>n</i> omitted of <i>n</i> trials	Significance of difference between patient and NBD group	
P1	29 of 38 (76%)	$p < .0001$	1 of 36 (3%)	$p > .05$	$p < .0001$
P2	12 of 35 (34%)	$p < .0001$	2 of 34 (6%)	$p > .05$	$p < .01$
P3	16 of 24 (66%)	$p < .0001$	7 of 29 (24%)	$p < .001$	$p < .01$
P4	2 of 64 (3%)	$p > .05$	0 of 64	$p > .05$	$p > .05$
P5	9 of 64 (14%)	$p < .01$	2 of 64 (3%)	$p > .05$	$p < .05$
NBDs	0	–	0	–	$p > .05$

Note: The control group value is an average of each NBD participant. Significant p -values are bolded.

3.2. Morphological substitutions in articles and numerals

Agrammatic speakers substituted both articles and numerals more often than the NBDs. Fisher's exact test showed that the agrammatic group mean for morphologically substituted articles (mean = 12.2/31.4 non-omitted articles) was significantly higher than the NBDs mean for morphologically substituted articles (mean = 0.5/64 non-omitted articles), $p < .0001$. The agrammatic group mean for morphologically substituted numerals (mean = 15.4/43 non-omitted numerals) was also significantly higher than the NBDs mean for substituted numerals (mean = 1/64 non-omitted numerals), $p < .0001$. Within the group of agrammatic speakers, there was no significant difference between proportions of morphologically substituted articles and numerals ($p > .05$). The same is true for the NBDs. The proportions for the two groups are shown in Figure 3.

Table 3 shows the proportions of morphologically substituted articles and numerals out of all non-omitted articles and numerals for the individual

Figure 3. Group mean ratios for morphologically substituted articles (gram) and numerals (lex) out of all non-omitted determiners. The agrammatic group substituted both articles (gram) and numerals (lex) significantly more than the NBD group did. Neither within the agrammatic group nor within the NBD group was there any significant difference between the number of substituted articles (gram) and the number of substituted numerals (lex).

agrammatic speakers and for the NBDs as a group. The significance levels in the table show that four (P2, P3, P4 and P5) out of five agrammatic speakers had a significantly higher proportion of morphological substitutions in articles than the NBDs did, and the same four agrammatic speakers had a significantly higher proportion of morphological substitutions in numerals than the NBDs. None of the agrammatic speakers or NBD speakers had a significant difference between proportions of morphological substitutions in articles and in numerals.

3.3. Post-hoc qualitative analysis – individual variation

To summarise, we have shown that the group of agrammatic speakers omit significantly more articles than numerals compared to NBDs, and that they do not omit significantly more numerals than the NBDs. We have also shown that the group of agrammatic speakers had significantly more morphological substitutions in both articles and numerals than the NBDs, and that both the NBDs and the agrammatic group did not morphologically substitute significantly more articles than numerals. Furthermore, upon inspecting Tables 2 and 3, it is obvious that there is a great variation between the agrammatic speakers. Particularly, P1, P2 and P3 have high ratios of omissions of articles, while P4 and P5 have lower ratios. Conversely, it seems P4 and P5 have much higher ratios of morphological substitutions in both articles and numerals than the other agrammatic speakers. In this section, we will discuss potential individual adaptive strategies of the agrammatic speakers.

For the grammatical condition, the two agrammatic speakers who have the lowest omission ratios (P4 and P5), are also the ones who have the highest ratios of morphological substitutions, while P1, P2 and P3 have higher omission ratios and a lower number of morphological substitutions. Interestingly, for the lexical condition all participants, except P3, have low omission ratios that are close to 0, while P4 and P5 still have relatively

Table 3. The number of morphologically substituted articles and numerals out of the number articles and numerals each participant produced (i.e. did not omit).

Participant	Articles		Numerals		Significance of article–numeral difference
	<i>n</i> morph. substituted of <i>n</i> produced articles	Significance of difference between patient and NBD group	<i>n</i> morph. substituted of <i>n</i> produced numerals	Significance of difference between patient and NBD group	
P1	0 of 9	$p > .05$	4 of 35 (11%)	$p > .05$	$p > .05$
P2	8 of 23 (35%)	$p < .0001$	10 of 32 (31%)	$p < .001$	$p > .05$
P3	4 of 8 (50%)	$p < .0001$	7 of 22 (32%)	$p < .001$	$p > .05$
P4	29 of 62 (47%)	$p < .0001$	31 of 64 (48%)	$p < .0001$	$p > .05$
P5	20 of 55 (36%)	$p < .0001$	25 of 62 (40%)	$p < .0001$	$p > .05$
NBDs	0.5 of 64 (1%)	–	1 of 64 (2%)	–	$p > .05$

Note: The control group value is an average of each NBD participant. Significant p -values are bolded.

higher ratios for morphological substitutions than P1, P2 and P3. When investigating the replies from P4 and P5, it is evident that they both produce only articles and numerals in one gender, no matter the gender of the noun. P4 does the same for adjectives. Specifically, P4 produces only a single word in neuter gender (an article), and generally produces articles, numerals and adjectives in common gender even when the noun is neuter gender, as in (9):

- (9) **en rød hus*
 "a.COMM red.COMM house.NEUT"

Similarly, P5 produces only four words in common gender (all articles) and the rest of the articles and numerals in neuter gender even when the noun is common gender. However, P5 does not to the same degree produce adjectives in neuter gender, but interchangeably uses neuter and common gender for adjectives, as in (10):

- (10) **et gul firkant*
 "a.NEUT yellow.COMM square.COMM"

Since the experiment was designed to have 50% neuter gender nouns and 50% common gender nouns, P4 and P5 have determiner correctness ratios very close to 50%.

We also investigated the production of adjectives and nouns in the grammatical and lexical condition for the group of agrammatic speakers. The information in the adjective was primary (foreground) information in the grammatical condition (elicited by a colour contrast), while it was secondary (background) information in the lexical condition (elicited by a number contrast). The adjective may therefore be expected to be more often omitted in the lexical condition than in the grammatical one. P1 omitted significantly more adjectives in the lexical condition (75%) than in the grammatical condition (37%), which reflects this contrast in discourse prominence. (11) shows a response from P1 for the grammatical condition, where P1 has omitted the article, but produced the adjective. An example of a response from P1 in the lexical condition is given in (12), in which P1 has omitted the adjective, but not the numeral.

- (11) *blå glas*
 "blue glass"
 (12) *en trekant*
 "one triangle"

Similarly, P2 and P3 showed a tendency to produce more correct adjectives in the grammatical condition (66% and 50%) than in the lexical condition (38% and 31%). The remaining participants showed no difference between the production of adjectives in the grammatical and lexical condition.

As for nouns, no participants showed any differences in the production of nouns in the grammatical and lexical conditions.

4. Discussion

4.1. The grammatical-lexical contrast

The following two predictions were made based on a grammatical-item-centred account of agrammatism:

Omission prediction based on a grammatical-item-centred account of agrammatism:

Agrammatic speakers omit more grammatical articles than lexical numerals, whereas NBDs omit similar (and very low) numbers of grammatical articles and lexical numerals.

Morphological substitution prediction based on a grammatical-item-centred account of agrammatism:

Agrammatic speakers produce more morphological substitutions than NBDs, but neither agrammatic speakers nor NBDs produce more morphological substitutions in grammatical articles than in lexical numerals.

Both predictions were confirmed at group level. As for the first prediction, within the agrammatic group, the mean number of omitted grammatical articles was higher than the mean number of omitted lexical numerals, whereas the NBDs omitted neither articles nor numerals. As for the second prediction, the agrammatic group mean for morphologically substituted determiners was higher than the NBD mean, whereas no difference was found between types of determiners: neither agrammatic speakers nor the NBDs substituted more articles than numerals.

These results are in line with two recent studies of agrammatic spontaneous speech in which grammatical and lexical items were also contrasted based on Boye and Harder (2012). Ishkhanyan, Sahraoui, Harder, Mogenssen, and Boye (2017) observed that French pronouns classified as grammatical are significantly more affected in agrammatic speech than pronouns classified as lexical. Boye and Bastiaanse (2018) found that Dutch verbs classified as grammatical are significantly more affected in non-fluent aphasic speech, but significantly less affected in fluent aphasic speech, than verbs classified as lexical. In addition, Bastiaanse and Bennis (2018) reported similar findings for prepositions: prepositions with a lexical function (*the cat jumps on the table*) are used to a normal extent by agrammatic speakers, whereas the use of prepositions with a grammatical function (*he gives flowers to the girl*) is very limited.

Thus, our study supports accounts of agrammatism centred on grammatical items and their contrast to

lexical items. For instance, it supports the adaptation theory (e.g. Hofstede & Kolk, 1994; Kolk, 1995; Kolk & Heesch, 1990; Kolk & Van Grunsven, 1985) according to which agrammatic speech is seen as the result of an adaptation to a processing impairment. The theory in Boye and Harder (2012), which formed the basis of our classification of Danish numerals and indefinite articles as respectively lexical and grammatical, provides a motivation why such a processing impairment would lead to omissions and substitutions of exactly grammatical items. According to this theory, grammatical items have two defining properties (see Section 1.3): (1) they are by convention secondary (backgrounded); (2) they depend on a host item. Due to the first property they are better candidates for omission than lexical (hence potentially primary, foregrounded) items in order to accommodate to and economise with limited resources. Due to the second property, they are associated with an extra processing load and thus harder to produce: since they are dependent on a host, the production of grammatical items requires combining them with this host.

The studies from which the production test of the present study was adopted and adjusted provide independent evidence for an extra processing load of grammatical items. Lange et al. (2018) applied the test to NBD persons. They found that in the fastest half of the participants,³ production of grammatical indefinite articles was associated with longer reaction times and lower accuracy rates than production of lexical numerals. Ishkhanyan et al. (2019) also applied the test to NBD persons, but added a complex span task to the test in order to investigate the role of working memory. They found that production of the grammatical indefinite articles was associated with lower accuracy rates than production of the lexical numerals. Importantly, in a parallel study of the production of lexical vs. grammatical verbs in NBD persons, Lange et al. (2017) found that the production of grammatical verbs (auxiliaries) was associated with longer reaction times and lower accuracy rates than the production of lexical verbs (full verbs).

A detailed look at the results of the present study point to a role of prioritisation. Firstly, the numerals employed in the lexical condition were not only lexical items, but also contextually focalised: they constituted the main point in the elicited answers to the elicitation question. The elicitation question was “how many do you have?”; an example of an answer is “I have one green letter”. Secondly, the role of prioritisation can be observed in P1, who produced more colour adjectives in the grammatical condition, where exactly colour was important in the answer to the elicitation question. Here, the elicitation question was “what do you have?”; an example of an answer is “I have a green letter”.

4.2. The role of verbs and case-assignment

Our results cannot be explained based on accounts of agrammatic aphasia that see case problems or verb problems as basic. Consider first case. While the participants in our study did not produce a verb, and thus not a case-assigning element, case and case-assignment may still be assumed to play a role. A verb was in fact present in the elicitation questions: “what do you have?” (grammatical condition), “how many do you have?” (lexical condition), and it is beyond doubt that case-assignment transcends the utterance border between questions and answers: Danish nouns have no case marking (or no explicit case marking) apart from genitive marking, but personal pronouns do, and a personal pronominal answer to the question “what do you have” is required to be in the accusative (e.g. accusative *dem* “them” vs. nominative *de* “they”). However, case or case-assignment problems cannot explain our results. Firstly, if such problems were the driving force behind agrammatic determiner omissions, we would expect (on the assumption that lexical numerals are case marked; see Section 1.3) lexical numeral production to be more compromised in agrammatic speakers than in NBDs. However, agrammatic speakers did not omit more lexical numerals than NBDs (agrammatic group mean = 2.4 omitted numerals out of 45.4 completed lexical trials; NBD group mean = 0 omitted numerals out of 64 completed lexical trials). Secondly, neither the fact that grammatical article production was more compromised than lexical numeral production in agrammatic speech, nor the fact that agrammatic speakers produced more morphological substitutions than NBDs can be straightforwardly explained with reference to case or case-assignment problems. As for the former of these two facts, it might be speculated, of course, that the lexical numeral is not even invisibly marked for case, but only the grammatical article is. For us, however, such a distinction between absence and presence of invisible case would seem far-fetched, not least when compared to German, where both the corresponding numeral and article have (visible) case. If the Danish numeral does not have case, then neither does the indefinite article.

Consider now verbs. Our experiment did not contrast presence and absence of verbs, and therefore we cannot say anything about any possible effect of this contrast. However, we can say with certainty that the differences we found had nothing to do with verbs. Thus, verb problems cannot explain, for instance, that agrammatic speakers omitted more grammatical articles than lexical numerals, or that they produced more morphological substitutions than the NBDs.

For a usage-based approach to language, invisible case is unthinkable, and it is obvious that case-assignment is not a precise way of capturing what is going on. However, case is basically a relation, and case-marking basically an expression of a dependency, and it may be fruitful to think about determiner production in terms of dependency. As discussed in Section 1.3, grammatical items are dependent on (combination with) a host item, and due to this dependency, they are harder to produce than lexical items (everything else being equal). As discussed in Section 4.1, this motivates that agrammatic speakers have problems with grammatical article production. In addition, an account of agrammatism in terms of problems with dependencies or problems combining dependent items with host items would provide a unified understanding of verb problems and problems with grammatical items: whereas grammatical items depend on host items, verbs depend on their arguments for specification, and arguments depend on verbs for being assigned semantic roles and possibly case.

4.3. Individual adaptive strategies

An analysis of individual performance revealed that not all agrammatic speakers show a dissociation between articles and numerals: some participants had little or no difference between the grammatical and lexical condition. The relevant participants had high ratios of morphological substitutions, however, while the remaining participants had large differences between the grammatical and lexical conditions and low ratios of morphological substitutions.

The participant who had been living with aphasia for the longest time (P4), had omission ratios for both articles and numerals which were close to the NBD group, but produced articles, numerals and adjectives in only one gender, common gender. We suggest that P4 has developed an adaptation strategy in which the gender of the noun is ignored, which in turn reduced the processing load for the speaker, enabling her to produce all words that the task demanded of her, whether they were grammatical or lexical. This is in line with a processing approach to agrammatism, in which it is argued that agrammatic performance goes up when the processing load is reduced (e.g. Sahraoui & Nespoulous, 2012). Grammatical gender in Danish is generally not semantically meaningful, and producing it erroneously does not have communicative consequences. Therefore, there is a positive trade-off for a speaker with limited resources: if she ignores the correctness of the bound morpheme in order to focus her resources on producing the words that she is instructed

to produce, the expected result will be the one we found: no difference between production of determiners in the grammatical and lexical condition. Ignoring gender results in a paragrammatic output which, according to Kolk and Heeschen (1990) and Kolk (1995), some speakers are able to produce when refraining from using the elliptical style.

Semi-spontaneous speech samples obtained from P4 support the claim that her strong preference for common gender is indeed a strategy – in fact, a task-specific strategy – and not due to a gender-selective impairments of the sort reported by Seyboth, Blanken, Ehmann, Schwarz, and Bormann (2011). In these samples, P4 produced only few determiners (9 in a free narrative and 1 in a picture description; a NBD speaker produced 18 and 7, respectively, in samples of comparable length). However, she produced both common gender and neuter determiners, and she always produced the correct gender.

In Danish, common gender determiners are more than twice as frequent as neuter gender determiners.⁴ It can be speculated that the higher frequency of common gender articles motivates P4's preference for common gender. However, it cannot motivate P5's preference for neuter gender.

Participant P5 has a time post-onset which is close to P4's and has a similar pattern regarding articles and numerals, in that he also has a low omission ratio for both articles and numerals, which he then produces with only neuter gender, regardless of the gender of the noun. As in the case of P4, semi-spontaneous speech suggests that P5's strong preference for one gender is a task-specific strategy. In a picture description, P5 did not produce any determiners at all, but he did produce two definite inflections in common gender, which was in both cases the correct gender – and different from the gender preferred in the experiment reported here. It should be noted, however, that P5 did omit significantly more articles than numerals, so there is reason to believe that he has not been able to implement the one-gender strategy to the same extent that P4 has.

P1, P2 and P3 omit the most articles and also have the lowest ratios of morphological substitutions in the study. This seems to suggest that they are employing the elliptical style that Kolk (1995) argues is a type of preventive adaptation, in that the message simplification prevents a capacity overload in the speaker. The benefit of simplifying the message by omitting grammatical elements, which are by convention background information, seems to be that the speakers are able to produce the correct grammatical gender. This means that there is again a trade-off between producing grammatical

words and producing the correct gender inflection – however, for P1, P2 and P3, the trade-off goes in the opposite direction of P4 and P5.

The elliptical style is most obvious in the performance of P1, who had the largest difference between omitted articles and numerals. Interestingly, P1 also seems to employ the same elliptical style with lexical words when they are not part of the main point of the message: in the current task, she generally omits the adjective in the lexical condition, where it expresses secondary (background) information, while she generally produces the adjective in the grammatical condition, where it expresses primary (foreground) information. She is also the agrammatic speaker who has the overall lowest ratios of morphological substitutions in determiners and adjectives in the study. This supports a trade-off hypothesis: agrammatic speakers focus their limited resources either on producing correct morphological inflections or on producing grammatical words.

It seems, therefore, that ignoring grammatical gender and sticking with one default gender facilitates the production of the words that are required in the task. However, we do not mean to suggest that the only problem with determiners is the grammatical gender, because both the Danish article and numeral carry gender inflections. Instead, we suggest that the gender inflections cause extra difficulties for the agrammatic speaker, and when choosing a default gender, extra resources are available for the speaker to focus on producing both grammatical and lexical words.

The tendencies for individual variability are in line with previous studies that have shown that some participants rely more on substitution of grammatical elements, while other participants rely more on omission. Sanchez-Alonso, Martínez-Ferreiro, and Bastiaanse (2011) and Månsson and Ahlsén (2001) found a tendency for substitution to be more frequent in individuals with milder agrammatism or a longer time post-onset (as P4 and P5 in the current study), while individuals with severe agrammatism or a shorter time post-onset (as at least P1 and P2 in the current study) were more likely to omit grammatical elements. This supports the idea that individuals with more processing capacity can produce more words by implementing a strategy resulting in paragrammatic output. However, patients are found who have stretches of spontaneous speech with primarily substitutions followed by stretches with omissions, dependent on the topic of conversation (Bastiaanse, 1995). This suggests that omissions and substitutions are the result of different strategies rather than of different underlying disorders.

In the present study, however, omissions cannot be directly compared with substitutions. Omission of

determiners depends on the status of the determiner as grammatical (article) or lexical (numeral). In contrast, substitution of common gender determiners with neuter gender ones, or vice versa, is in all cases a grammatical phenomenon and is thus found to the same degree in grammatical and lexical determiners, but to a higher extent in agrammatic speakers than in NBDs.

4.4. Methodological issues

As discussed in Lange et al. (2018), the tasks employed to elicit articles and numerals are not completely identical with regards to semantic processing, and this might be a confounding variable. In the grammatical condition, the task revolves around the contrast in colour, while the task in the lexical condition is centred around a number contrast. It is possible that the reason why speakers with agrammatic aphasia omit significantly more articles than numerals is this difference in semantic tasks: one of the semantic tasks may be more difficult than the other one. If processing a contrast in colour is more difficult than processing a contrast in number for a person with limited resources, that may result in more omitted words or erroneously produced words in the colour contrasting task than in the number contrasting task. This would partially explain why participants with agrammatic aphasia omit more articles than numerals. However, if this were the only reason, then we also expect more adjectives and nouns to be omitted or erroneously produced in the colour contrasting task (the grammatical condition), which is not the case (see Section 3.3). It is therefore unlikely that the omission of articles is only due to a potentially heavier semantic processing load, and we argue that our results can only be explained when taking into account the grammar–lexicon distinction.

The two tasks also differ with respect to which word classes are central (adjectives in the grammatical condition and numerals in the lexical), and this focus on different word classes might also be a potential confound. If agrammatic speakers have specific difficulties producing adjectives, then that might also account for their added difficulties in the grammatical condition where adjectives constitute the main point of the message. However, Meltzer-Asscher and Thompson (2014) found that a group of English speakers with agrammatic aphasia did not differ from NBDs with respect to their overall proportions of adjectives in a narrative task.

Lastly, frequency of the articles and numerals might play a role. However, as mentioned (Section 2.2.2), Lange et al. (2018) found that the Danish article *en/et* is

significantly more frequent than the numeral *en/et*. Based on frequency one would thus expect the grammatical article to be more spared than the lexical numeral in agrammatic speech. Since the article is in fact more impaired than the numeral for the agrammatic speakers in the current study, we argue that frequency is not a confound here.

Notes

1. A central argument for this view of case comes from languages in which nouns have lost case, but pronouns retain it. The argument goes like this: since, for instance, the verb *kiss* assigns case to the pronouns in *She kissed him*, it must assign case also to the NPs in *The girl kissed the boy*.
2. For *en*, 94% of the relevant occurrences are articles, while 6% are numerals. For *et*, 93% of the relevant occurrences are articles, while 7% are numerals.
3. The fastest half of the participants are the participants who had the shortest reaction times. The authors argue that the effect of grammatical vs. lexical status found in the fastest participants was counterbalanced by a frequency effect in the slowest group: grammatical determiners are harder to produce than lexical determiners, but infrequent items are harder to produce than frequent ones, and the lexical determiners studied were much less frequent than the grammatical determiners studied.
4. In a large corpus of Danish, KorpusDK (accessed 2014), approximately 991,000 determiner occurrences of *en* were found (6% numerals, 94% articles), and approximately 463,000 determiner occurrences of *et* (7% numerals, 93% articles).

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors Violaine Michel Lange and Kasper Boye were partially supported by the University of Copenhagen Excellence Programme for Interdisciplinary Research (Project title: PROGRAM: Information PROminence and GRAMmar in mind and brain). The author Roelien Bastiaanse is partially supported by the Center for Language and Brain NRU Higher School of Economics, RF Government grant, ag. № 14.641.31.0004.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, SRN. The data are not publicly available due to the fact that they contain information that could compromise the privacy of research participants.

References

- Bastiaanse, R. (1995). Broca's aphasia: A syntactic and/or a morphological disorder? A case study. *Brain and Language*, 48(1), 1–32.
- Bastiaanse, R., & Bennis, H. (2018). Productie en begrip van voorzetsels bij sprekers met agrammatische en vloeiende afasie [Production and comprehension of prepositions in speakers with agrammatic and fluent aphasia]. *Nederlandse Taalkunde*, 23(1), 3–22.
- Bastiaanse, R., Jonkers, R., & Moltmaker-Osinga, U. (1996). Aspects of lexical verbs in the spontaneous speech of agrammatic and anomic patients. In R. Jonkers, E. Kaan, & A. Wiegel (Eds.), *Language and cognition* (Vol. 5, pp. 13–26). Groningen: University of Groningen.
- Bastiaanse, R., Jonkers, R., Ruigendijk, E., & Van Zonneveld, R. (2003). Gender and case in agrammatic production. *Cortex*, 39(3), 405–417.
- Bates, E., Wulfeck, B., & MacWhinney, B. (1991). Cross-linguistic research in aphasia: An overview. *Brain and Language*, 41(2), 123–148.
- Biassou, N., Obler, L. K., Nespoulous, J. L., Dordain, M., & Harris, K. S. (1997). Dual processing of open- and closed-class words. *Brain and Language*, 57(3), 360–373.
- Boersma, P., & Weenink, D. (2017). *Praat: Doing phonetics by computer* [Computer program, Version 6.0.36]. Retrieved from <http://www.praat.org/>
- Boye, K., & Bastiaanse, R. (2018). Grammatical versus lexical words in theory and aphasia: Integrating linguistics and neurolinguistics. *Glossa: A Journal of General Linguistics*, 3(1), 29. doi:10.5334/gjgl.436
- Boye, K., & Harder, P. (2012). A usage-based theory of grammatical status and grammaticalization. *Language*, 88(1), 1–44.
- Chomsky, N. (1986). *Knowledge of language: Its nature, origin, and use*. Westport, CT: Greenwood.
- Christensen, M. H., Kristensen, L. B., Vinther, N. M., & Boye, K. (2019). *Grammar is background in sentence processing*. Manuscript submitted for publication.
- De Bleser, R., Bayer, J., & Luzzatti, C. (1996). Linguistic theory and morphosyntactic impairments in German and Italian aphasics. *Journal of Neurolinguistics*, 9(3), 175–185.
- Hofstede, B. T., & Kolk, H. H. (1994). The effects of task variation on the production of grammatical morphology in Broca's aphasia: A multiple case study. *Brain and Language*, 46(2), 278–328.
- Ishkhanyan, B., Boye, K., & Mogensen, J. (2019). The meeting point: Where language production and working memory share resources. *Journal of Psycholinguistic Research*, 48(1), 61–79. doi:10.1007/s10936-018-9589-0
- Ishkhanyan, B., Sahraoui, H., Harder, P., Mogensen, J., & Boye, K. (2017). Grammatical and lexical pronoun dissociation in French speakers with agrammatic aphasia: A usage-based account and REF-based hypothesis. *Journal of Neurolinguistics*, 44, 1–16.
- Kolk, H. (1995). A time-based approach to agrammatic production. *Brain and Language*, 50(3), 282–303.
- Kolk, H., & Heeschen, C. (1990). Adaptation symptoms and impairment symptoms in Broca's aphasia. *Aphasiology*, 4(3), 221–231.
- Kolk, H. H., & Van Grunsven, M. M. (1985). Agrammatism as a variable phenomenon. *Cognitive Neuropsychology*, 2(4), 347–384.

- Lange, V. M., Messerschmidt, M., & Boye, K. (2018). Contrasting grammatical and lexical determiners. *Journal of Psycholinguistic Research*, 47(3), 467–482. doi:10.1007/s10936-017-9531-x
- Lange, V. M., Messerschmidt, M., Harder, P., Siebner, H. R., & Boye, K. (2017). Planning and production of grammatical and lexical verbs in multi-word messages. *PLoS One*, 12(11). doi:10.1371/journal.pone.0186685
- Månsson, A. C., & Ahlsén, E. (2001). Grammatical features of aphasia in Swedish. *Journal of Neurolinguistics*, 14(2), 365–380.
- Meltzer-Asscher, A., & Thompson, C. K. (2014). The forgotten grammatical category: Adjective use in agrammatic aphasia. *Journal of Neurolinguistics*, 30, 48–68.
- Menn, L., Obler, L. K., & Miceli, G. (Eds.). (1990). *Agrammatic aphasia: A cross-language narrative sourcebook* (Vol. 2). Amsterdam: John Benjamins.
- Pedersen, P. M., & Vinter, K. (2001). *Western aphasia Battery – WAB* [Danish translation, Adjustment and standardisation]. Copenhagen: Dansk Psykologisk Forlag.
- Peirce, J. W. (2007). Psychopy—Psychophysics software in Python. *Journal of Neuroscience Methods*, 162(1), 8–13.
- Rosenberg, B., Zurif, E., Brownell, H., Garrett, M., & Bradley, D. (1985). Grammatical class effects in relation to normal and aphasic sentence processing. *Brain and Language*, 26(2), 287–303.
- Ruigendijk, E. (2010). Determiner omission in Dutch agrammatic aphasia: Different from German, similar to English? *Journal of Germanic Linguistics*, 22(4), 445–459.
- Ruigendijk, E., & Baauw, S. (2007). Syntactic and pragmatic aspects of determiner and pronoun production in Dutch agrammatic Broca's aphasia. *Aphasiology*, 21(6–8), 535–547.
- Ruigendijk, E., & Bastiaanse, R. (2002). Two characteristics of agrammatic speech: Omission of verbs and omission of determiners, is there a relation? *Aphasiology*, 16(4–6), 383–395.
- Ruigendijk, E., & Friedmann, N. (2008). On the relation between structural case, determiners, and verbs in agrammatism: A study of Hebrew and Dutch. *Aphasiology*, 22(9), 948–969.
- Ruigendijk, E., Van Zonneveld, R., & Bastiaanse, R. (1999). Case assignment in agrammatism. *Journal of Speech, Language, and Hearing Research*, 42(4), 962–971.
- Saffran, E. M., Berndt, R. S., & Schwartz, M. F. (1989). The quantitative analysis of agrammatic production: Procedure and data. *Brain and Language*, 37(3), 440–479.
- Sahraoui, H., & Nespoulous, J. (2012). Across-task variability in agrammatic performance. *Aphasiology*, 26(6), 785–810.
- Salis, C., & Edwards, S. (2004). Adaptation theory and non-fluent aphasia in English. *Aphasiology*, 18(12), 1103–1120.
- Sanchez-Alonso, S., Martínez-Ferreiro, S., & Bastiaanse, R. (2011). Clitics in Spanish agrammatic aphasia: A study of the production of unaccusative, reflexive and object clitics. In S. L. Devi, R. Mitkov, I. Hendrick, & A. Branco (Eds.), *Anaphora processing and applications* (pp. 184–197). Berlin: Springer.
- Seyboth, M., Blanken, G., Ehmann, D., Schwarz, F., & Bormann, T. (2011). Selective impairment of masculine gender processing: Evidence from a German aphasic. *Cognitive Neuropsychology*, 28(8), 564–588.
- Stavrakaki, S., & Kouvava, S. (2003). Functional categories in agrammatism: Evidence from Greek. *Brain and Language*, 86(1), 129–141.
- Vinther, N. M., Boye, K., & Kristensen, L. B. (2014). Grammatikken i baggrunden: Opmærksomhed under læsning [Grammar in the background: Attention in reading]. *NyS*, 47, 99–139.