Breakdown at the morphological level in agrammatism

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In this study, we intend to take a closer look at the morphological deficit observed in agrammatism from the two perspectives of language production and language comprehension. In order to be able to assess the influence of the syntactic context on the patients' ability to correctly produce and comprehend morphological material, we administered several tests to a group of German-speaking agrammatic patients. Some of these tests aimed at assessing the agrammatic subjects' morphological abilities in production and comprehension in morpholexical tasks (such as structural analysis of compounds and nominal plural formation), whereas others were intended to provide information on the patients' capacity to make use of morphology in syntactic contexts of differing degrees of complexity (case assignment in prepositional phrases, noun phrases, canonical and non-canonical sentences; interpretation of ambiguously and unambiguously case-marked constituents in canonical and non-canonical position). The results show that the agrammatic patients were generally able to exploit morphology in both production and comprehension in the morpholexical tasks and in local or canonical syntactic structures. Performance deteriorated, however, when the production or interpretation of morphological markers depended on more complex syntactic configurations. We argue that the breakdown of morphology in agrammatism must thus be considered as the consequence of an underlying syntactic deficit and that the results further provide neurolinguistic evidence for theories of Lexical Morphology.

Introduction

Agrammatism has traditionally been defined as a morphosyntactic impairment with loss of bound and free functional elements and simplified syntactic structures. Although the impairment was originally described for production, a number of studies have shown similar difficulties in morphosyntactic comprehension. In their now classical study, Heilman and Scholes (1976) concluded that agrammatics are not only

unable to produce closed-class morphemes such as definite articles, but they cannot comprehend them either. Given sentences like "He showed her baby pictures", the interpretation is ambiguous for controls between the readings in (a) and (b) if sentences are produced with neutral intonation, but the sentence becomes unambiguous as soon as the definite article is inserted as in (a) versus (b).

a. He showed her baby the pictures.
b. He showed her the baby pictures.

However, for agrammatic subjects, the sentences remain ambiguous notwithstanding the presence of the disambiguating article and sentences are interpreted as though words like "the" were not there. Recently, two different classes of theories have been proposed to account for agrammatic performance in comprehension and production: processing theories on the one hand and representational theories on the other.

An example of a processing account is Kolk's adaptation assumption (1985), which states that agrammatism is not a direct consequence of the deficit but mirrors a conscious strategy implemented by the patient in order to improve communication. The three crucial assumptions of the adaptation theory are that (i) the morphosyntactic system itself is not damaged and that omissions are hence not a direct result of the damage but reflect the patient's strategy, (ii) linguistic abilities are not lost but the deficit arises as a consequence of pathological temporal factors with slowing down of processing and (iii) patients can decide for or against adaptation. If the patients relinquish the strategy, the result is substitution of functional elements, i.e. paragrammatism. Alternative processing accounts are given by De Roo (1999) and Baauw et al. (2002).

All processing theories have in common that they consider agrammatism to be a consequence of reduced processing resources, whereas grammar is basically preserved and linguistic knowledge unimpaired. In contrast, representational approaches assume the basic impairment causing agrammatism to be a partial loss of the grammatical structures or processes underlying language production and/or comprehension. With respect to agrammatic production, several authors have proposed that a process or structure will be more difficult for agrammatics if it is higher up in the syntactic tree (McEntee, 1993; Hagiwara, 1995; Friedmann & Grodzinsky, 1997; Platzack, 2001). In their so-called 'Tree Pruning Hypothesis' (TPH), which was originally proposed to account for production patterns of Hebrew- and Arabic- speaking agrammatic aphasics, Friedmann & Grodzinsky (1997) set out to explain dissociations between preserved verbal agreement inflection (mediated by the lower 'AGR' node of the syntactic tree), impaired tense inflection (located in the higher 'T' node) and the inability to produce constructions such as clauses introduced by subordinators or questions with a *wh*-word in first position, which both depend on the highest node of the tree, 'C' (for 'Complementizer'). They propose that C, T or Agr are underspe-

cified in agrammatics and that an underspecified node cannot project any further up the tree. Thus, the TPH predicts an agrammatic pattern in which Agr can be preserved and Tense impaired, but not the reverse, and – being the highest node – C is most vulnerable to damage. As it concerns functional nodes in the syntactic tree, the deficit is structural, and as it does not affect syntax as a whole, it is selective. Furthermore, the direction of impairment is from bottom to top. In this view, agrammatism does not result from a strategy triggered by reduced processing resources but is a direct consequence of the underlying structural deficit.

The studies reported in the literature on agrammatism, which have lead to theoretical accounts, have predominantly been conducted with patients from morphologically poor languages such as English or Dutch. In this paper, we summarize a number of studies concerned with agrammatic processing of morphology in German, a morphologically rich language. Seven agrammatic German-speaking subjects were examined in morphological production and comprehension tasks at the lexical and sentence level. The main question underlying these studies was what morphology can tell us about the impaired language processing of agrammatic patients, whether the descriptive definition of agrammatism as an impairment of closed class elements is valid, what the status of the morphological lexicon is and how the morphology-syntax interface operates in agrammatism. The subjects of the studies were seven patients with classical agrammatic speech production, i.e. utterances consisting of one or two words with frequent omission of function words and often incorrect inflectional endings. They were compared to 15 normal controls, matched for age and education.

Morpholexical tasks: are closed class elements specifically affected in the agrammatic lexicon?

The lexicon of a language contains the phonological, semantic and grammatical information of simple lexical items. For morphologically complex items, there are additional morpholexical composition rules specifying legal and illegal combinations of single morphemes. In all of the following morpholexical tasks, performance of controls was errorless, so we will only report patient data.

Comprehension tasks:

Patients were given an auditory discrimination task with the case-marked definite articles '*DER*' (nominative), '*DES*' (genitive), '*DEM*' (dative), '*DEN*' (accusative). Each article form was presented five times and the patient was to point to the written equivalent of the spoken article. None of the patients had problems with this task either (range: 99%-100%).

A second task consisted of the auditory judgment of the gender-appropriate article in noun phrases (NPs). The material consisted of articles and simple nouns (n=120, 40 x 3 genders: masculine, feminine, neuter) and of articles and compounds in which the head and the non-head differed in gender (n=180, 60 x 3 genders). Compounds in German have the gender of their (rightmost) head morpheme. Examples are given below:

Examples:
Articles and simple nouns:

Masc.	*Fem.*	*Neuter*	
Der Tisch	*Die Tisch	*Das Tisch	(the table)
*Der Tür	**Die Tür**	*Das Tür	(the door)
*Der Bett	*Die Bett	**Das Bett**	(the bed)

Articles and compounds:

Masc.	*Fem.*	*Neuter*	
Der$_M$ Hand$_F$schuh$_M$	*Die$_F$ Hand$_F$Schuh$_M$	*Das$_N$ Hand$_F$Schuh$_M$	(the glove)
*Der$_M$ Sand$_M$Uhr$_F$	**Die$_F$ Sand$_M$Uhr$_F$**	*Das$_N$ Sand$_M$Uhr$_F$	(the hourglass)
*Der$_M$ Kopf$_M$Tuch$_N$	*Die$_F$ Kopf$_M$Tuch$_N$	**Das$_N$ Kopf$_M$tuch$_N$**	(the headscarf)

The group result showed an overall correctness of 89% (range: 79%-95%), with 94% correct for simple nouns (range: 91%-98%) and 82% for compound nouns (range: 75%-92%). Thus, the group and individual performance is well above chance.

Production tasks:

For closed-class production, gender assignment and number realization were tested. The gender task consisted of asking the patient to repeat a noun while adding the (gender appropriate) definite article. There were 120 derived nouns for which gender is determined by the suffix, and 60 compound nouns in which the morphological head determines the gender. In the number task, patients were asked to repeat a noun while pluralizing it. This task comprised 20 nouns with regular and 70 with irregular plural formation.

For the group, overall correctness was 75% and there was no significant difference between the categories (compounds: 70%, derivations: 71%, regular inflection: 74% and irregular inflection: 84%). On an individual level, this result holds for four of the seven agrammatic patients (MH, HR, RM, JW), but three subjects showed evidence for word-building specific dissociations within the lexicon (impaired derivation in CB, compounds and regular inflection in RM, compounds, derivation and regular inflection in KL).

It may thus be concluded that both types of closed-class items, free functional morphemes and bound affixes are in principle available for comprehension and production in agrammatic subjects, although selective impairments within the morpholexicon have been attested for three of the seven patients tested.

Morphosyntax: can relatively preserved morphological abilities be implemented in agrammatic sentence processing?

Comprehension:

To address the question whether overt case morphology beneficially influences agrammatic sentence comprehension, we compared n=22 ambiguously case-marked sentences, which can have a canonical as well as a non-canonical interpretation if they are pronounced with neutral prosody, to n=22 overtly case-marked sentences, which only have one interpretation, corresponding to the morphology. The task used was a sentence-picture verification task. Subjects were to decide whether a sentence matched the picture. Half of the pictures represented actions corresponding to the canonical interpretation of a sentence, the other half actions depicting non-canonical interpretations. Both of them could be accepted as correct for case-ambiguous sentences. An example of an ambiguously case-marked sentence is "Das$_{Nom/Acc}$ Baby liebkost die$_{Nom/Acc}$ Frau", which in its canonical version can mean *"the baby is caressing the woman"* and in its non-canonical version *"the woman is caressing the baby",* i.e. presentation with each of the two pictures could lead to a "yes"-response in this verification task. Morphologically overt sentences like the canonical "D*er* Junge liebkost die Frau" (*theboy*$_{Nom}$*iscaressingthewoman*$_{ACC}$)orthenon-canonical"D*en*JungenliebkostdieFrau" (*the boy*$_{ACC}$ *is caressing the woman*$_{Nom}$) can only be interpreted in one way. Consequently, only one of the two pictures associated with a sentence should lead to a 'yes'-response, while presentation of the other picture should evoke a 'no'-response.

The group of normal controls showed a clear difference between case-ambiguous and case-marked sentences. For the morphologically marked non-canonical as well as canonical sentences, responses were 98% and 100% correct, respectively. In the case of ambiguous sentences, the non-canonical interpretation was accepted in only 63% of cases, whereas the canonical interpretation was accepted in 96% of cases. This pattern occurred in 10/15 individual controls, whose performance was at chance (9/10) or below chance (1/5) on the non-canonical interpretation of ambiguous sentences. The five remaining subjects were above chance overall. Thus, unimpaired German speakers do not generally obtain the non-canonical interpretation of morphologically ambiguous sentences and they obviously benefit from Case-morphology on closed class items for sentence interpretation, as is shown in the case of morphologically marked sentences. The situation was different for the agrammatic subjects, who as a group showed no difference between morphologically marked and unmarked senten-

ces. They scored similarly for the canonical interpretation of morphologically ambi-guous (81%, range: 41%-100%) and marked sentences (84%, range: 64%-100%), and for the non-canonical interpretations in each case (69%, range: 41%-86% for ambiguous, 66%, range: 50%-95% for case-marked sentences).

Thus, even though lexical morphology of closed class items is relatively preserved, German agrammatics do not benefit from the information given by case morphology in sentence comprehension. This, however, does not mean that all agrammatic subjects showed the same pattern of performance. There were basically three performance patterns. Irrespective of case-ambiguity or unambiguous morphological marking, some patients (2/7 subjects) generally performed well above chance on all canonical and non-canonical sentences, other patients generally performed at chance (2/7 subjects), and 3/7 followed the classical pattern irrespective of morphological marking, with chance performance on non-canonical sentences and above chance performance on canonical sentences.

Production:

To test morphology in agrammatic sentence production, a case insertion task involving prepositional phrases (n=10), genitive phrases (n=10), canonical sentences (n=30) and non-canonical sentences (n=30) was used.

Examples:
Prepositional phrases, genitives:
- Acc.: Ein neues Auto fährt gegen ein... morsch... Zaun.
  - a new car drives against a rotten fence
- Dat.: Ein rüstiger Rentner segelt zu ein... einsam... Strand.
  - a brisk retiree sails to a lonely beach
- Gen.: Der Bischof ein... berühmt... Dom... begrüßt den Papst.
  - the bishop of a famous cathedral greets the pope

Canonical sentences:
- Nom.: Ein... hungrig... Bettler trifft einen$_{Acc}$ reichen Mann.
  - a hungry beggar meets a rich man
- Acc.: Ein$_{Nom}$ fähiger Seemann braucht ein... streng... Kapitän.
  - an able sailor needs a severe captain
- Dat.: Ein$_{Nom}$ alter Gärtner droht ein... jung... Koch.
  - an old gardener threatens a young cook

Non-canonical sentences:
- Nom.: Einen$_{Acc}$ hungrigen Bettler trifft ein... reich... Mann.
  - a rich man meets a hungry beggar

- Acc.: Ein... fähig... Seemann braucht ein$_{Nom}$ strenger Kapitän.
  – a severe captain needs an able sailor
- Dat.: Ein... alt... Gärtner droht ein$_{Nom}$ junger Koch.
  – a young cook threatens an old gardener

The 15 control subjects made no errors in inserting case in prepositional phrases and genitives. Performance on case-marking arguments in canonical and non-canonical sentences, however, was not errorless and results were worse on dative case (canonical: 67%, noncanonical: 55%) than on nominative and accusative (canonical: Nom. 88%, Acc. 98%; non-canonical sentences: Nom.: 74%, Acc: 78%). Therefore, patient data on dative sentences are not taken into consideration. For nominative and accusative sentences the performance on non-canonical items was significantly worse than on canonical sentences (χ^2, p<.001, 2-tailed).

The seven agrammatic subjects as a group had 73% correct case markings after prepositions (range: 65-100) and 80% correct genitive inflections (range: 70-100). As a group, the agrammatic subjects performed significantly worse than the controls on canonical sentences (χ^2, p=.04, 2-tailed) as well as on non-canonical sentences (χ^2, p=.004, 2-tailed). Furthermore, the agrammatics' performance on non-canonical sentences was significantly worse than on canonical sentences (χ^2, p=.01, 2-tailed). On canonical sentences, nominatives were correct in 79% (range: 0-100) and accusatives in 60% (range: 10-100) of cases. (The span of the range is explained by the responses of one patient (CB), who used accusative as default case, and those of two other patients (MH and RM), who applied nominative as default). Leaving out the default data, the range was 80-100 for canonical nominatives and 70-80 for canonical accusatives). In the case of non-canonical sentences, performance dropped to 33% correct on nominatives (range 0-100) and 29% on accusatives (range: 0-100). Those patients who made use of a default strategy in canonical sentences made recourse to the same strategy in non-canonical sentences, but an additional patient, HR, had a nominative-by-default strategy for non-canonical sentences only. The individual results were thus as follows:

Table 1. Individual results of the canonical/non-canonical case marking production test

Patient	Canonical sentences (n=20)		Non-canonical sentences (n=20)	
	Nominative	Accusative	Nominative	Accusative
CB	Accusative by default		Accusative by default	
MH	Nominative by default		Nominative by default	
RM	Nominative by default		Nominative by default	
HR	100%	80%	Nominative by default	
HT	100%	80%	20%	20%
KL	90%	70%	10%	10%
JW	80%	60%	40%	30%

Thus, even though the performance of the controls was not errorless on this task, agrammatics as group are significantly impaired on canonical and non-canonical sentences when compared to controls. They either use a default case strategy all over (n=3) or they show relatively preserved performance on canonical sentences, while performance breaks down on case assignment in non-canonical sentences. This is shown by a level of performance for canonical sentences which is not significantly different from controls for the individual patients but a significant difference to controls for each patient on non-canonical sentences (HT, KL: χ^2, p<.001, 2-tailed, JW: χ^2, p=.011, 2-tailed).

Discussion

The underlying aim of the study has been to take a closer look at the morphological deficit observed in agrammatism, from the point of view of language production as well as language comprehension. Further, some of the tests intended to tap agrammatic patients' morphological abilities within these two domains in (relative) isolation, whereas others aimed at assessing the patients' capacity to make use of morphology in syntactic contexts of varying degrees of complexity.

The results of the morpholexical production task, in which subjects had to supply gender- appropriate articles for derived nouns and compounds as well as regular and irregular plural inflections, were generally well above chance. The operations required to master these tasks include the retrieval of the gender-matched form of the article for simple nouns and, additionally, a structural analysis at the word level (i.e. assignment of word-internal structure) in the case of derived nouns and compounds. Whereas gender assignment is completely arbitrary in German, derivation and compounding are regular structural processes. Considering that we did not find any dissociations between these two classes, the lexical information and word-level structure required seems to be available to agrammatic patients and enables retrieval of the correct articles. The patterns observed in the inflection task are fully in line with these findings and the findings are further supported by the results obtained in the morpholexical comprehension task.

Similarly, the patients were able to perform case assignment within certain types of syntactic constructions. Thus, case inflection within prepositional phrases (dative and accusative) and within noun phrases (genitive) was relatively preserved, as was nominative and accusative assignment in canonical SVO (Subject-Verb-Object) sentences for those patients who did not make use of a nominative/accusative default strategy. However, case assignment collapsed to below chance in non-canonical OVS (Object-Verb-Subject) sentences. In parallel to the findings of the production task, patients were unable to exploit case markings on articles for the comprehension of non-canonical sentences, contrary to the controls.

Considering that genitive constructions are certainly an 'endangered species' in modern colloquial German and that they are completely absent in agrammatic spontaneous speech, the retention of these structures in controlled tests may help to shed some light on the question of the nature of the deficit underlying agrammatism. Thus, inflectional morphology may still be correctly implemented as long as the syntactic operations required to establish the necessary structural relationships do not exceed a certain level of complexity. In light of the above findings, 'complexity' might be defined as local syntactic relationships, such as case assignment by structurally adjacent elements, as in the case of prepositions (for accusative or dative case) or 'neighbouring' head nouns (genitive), or adjectival agreement, to name another type of local process. More generally, locality can be seen as involving the relationship of a head to its specifier and complement. Depending on the degree of the impairment and the type of the construction involved (cf. the canonical SVO sentences in the production task), more 'distant' calculations may be carried out (see Bayer et al., 1987; De Bleser & Bayer, 1988; De Bleser et al., 1996 for more detailed discussion of these issues).

Confirming the results of the studies with German speaking subjects, De Bleser & Luzzatti (1994) and Luzzatti & De Bleser (1996) found that Italian speaking agrammatic patients were generally quite successful in morpholexical tasks parallel to those presented above. Also, they were able to inflect the past participle in simple sentences, whereas this ability broke down in more complex constructions, such as agreement across a relative clause boundary. Thus, though agrammatic patients generally seem to be able to 'zoom in' on local syntactic sub-structures and correctly perform morphosyntactic computations within these windows, the 'wide-angle view' necessary for establishing more complex relationships (such as antecedent-trace relationships, co-indexing with empty operators etc.) is not available to them.

So far, we have said nothing about the design of the lexicon that we assume, nor about the particular way it interfaces with the syntactic component. Generally, theories of morphology differ with respect to a) the degree to which general syntactic processes and structures (vs. particular morphological operations/structures) are operative at the word level and b) the place of morphology within the grammar (i.e., at which stage of a derivation words are assembled)[1]. Simplifying to a considerable extent, the proposals concerning b) may be grouped into the following three classes:

1. Lexical Morphology (LM): In such models, all morphology (compounding, derivation, inflection) is situated within the lexicon and words enter the syntax as syntactic atoms (unanalyzable units). Features of a word's 'subparts' percolate to the 'surface' of the word and may be used for syntactic purposes (see Di Sciullo and Williams, 1987; Selkirk, 1982; Lieber, 1981).

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[1] For a discussion of these issues we refer the reader to Borer (1998).

2. Syntactic Morphology (SM): Most of morphology (especially inflectional morphology) takes place within syntax proper. Typically, heads (verbs, for example) move up the tree to 'pick up' inflectional morphemes generated under terminal nodes of functional categories (such as AGR or T) (see Baker, 1985, 1988, 2002; Cinque, 1999).

3. 'Mixed' Models: In these models, different types of morphological operations are attributed to different components. In 'Split Morphology' frameworks (cf. Anderson, 1982; Perlmutter, 1988), for example, derivation and compounding take place within the presyntactic lexicon, whereas phonological forms of inflectional affixes are inserted in a postsyntactic component. In 'Distributed Morphology' frameworks (Halle and Marantz, 1993; Marantz, 1997), there is no lexicon in the classical sense. Rather, some processes relevant to morphology take place in syntax (similar to syntactic models), while others are located in a postsyntactic morphological component. Phonological material of any kind is only inserted in this postsyntactic module.

Presuming a certain degree of isomorphism between models of grammar and production/comprehension mechanisms, as well as Grodzinsky's (1990) criterion of 'Breakdown Compatibility' (which states, basically, that theoretical analyses of certain linguistic phenomena should be compatible with aphasic performance patterns), the results obtained in our studies are compatible with models of Lexical Morphology. Whereas lexical representations and word-formation processes per se are largely preserved, performance breaks down as soon as morphology has to be implemented in complex syntactic structures. Both SM and models of the mixed class cannot explain this dissociation found in the studies reviewed above: all of these actually predict a tight connection between the breakdown of syntax and morphology, contrary to our findings which show morphology to be basically intact while the inability to build complex syntactic phrase-structure must be seen as the underlying deficit in agrammatism.

Models of Lexical Morphology are also in line with current Minimalist theories of syntax (see Chomsky, 1995), which are based on the assumption that words enter the syntactic component fully inflected. The only information available to the syntax are a word's features, which project into syntax proper, where they are also 'checked' (i.e., licensed), and thus constitute the interface between the lexical and the syntactic component. Thus, dysmorphological patterns, which are the outcome of a syntax limited to local structures as domains for computations, may best be described as an underspecification of features within syntax (see Burchert et al., 2004; Wenzlaff & Clahsen, 2004).

The view of morphological impairments presented in this paper is in general agreement with those theories postulating a selective syntactic deficit in agrammatism. In contrast to such a dyssyntactic account, neither asyntactic (i.e., a complete loss of

syntax) nor dysmorphological theories (see Bradley et al., 1980) can account for the dissociations observed. However, not even selective syntactic theories such as the TPH (Friedmann and Grodzinsky, 1997) can cope with all the individual performance patterns observed in recent studies of agrammatism. Other studies support the view of agrammatism as a multi-faceted impairment, defying across-the-board definitions and explanations and calling for even more differentiated accounts (cf. Burchert et al., 2004).

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