Functional Categories in English and German Broca's Aphasia Production

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I. Introduction

In this paper, functional features from the production of 14 agrammatic German and English speaking Broca's aphasics were examined. It was found that determiners, verb morphology and German case were all impaired. Thus, the results serve as a criticism of the tree-pruning hypothesis (TPH), which solely predicts a differential deficit between the nodes of the subdivided IP (Friedman, 1997, 2002). According to the TPH, the hierarchical nature of these nodes results in predicable deficits in Broca's, with the CP node showing the first sign of impairment followed by the tense, then agreement, and so on, as the degree of impairment increases. The the TPH predicts that all production above the AgP node will be impaired, it does not predict generalized problems with determiner and case production.. Thus, the findings in this paper show the tree-pruning hypothesis insufficient as a description of the impairment of Broca's aphasia.

By criticizing the TPH, this paper raises the question of the grounds on which that hypothesis may be criticized. There are two possible directions of objection. One possibility is that the predictions of the hypothesis simply prove incorrect. This would result in a direct problem with the Friedmann and Grodzinksy's proposal. However, it is also possible that the TPH holds true as far as its predictions, but is incomplete. This paper criticizes the TPH on the both grounds; the strong predictions that all data above the AgP node is damaged do not bear out because this study demonstrates determiners and objects below the AgP node are impaired to the same degree as those below. Furthermore, the . However, if the hypothesis is simply incomplete, it is possible that it could be considered an adequate approach when combined with a series of descriptions. If the TPH were combined with a set of other effective descriptions to explain Broca's aphasia, and these set of descriptions were not in themselves contradictory, then we might have an effective description agrammatic production.

The criticism of the TPH invites a larger inquiry into the goal of neurolinguistics. It is possible that a modified TPH combined with other theories could effectively describe the data. However, a series of unrelated descriptions would not allow us to generalize about the role of Broca's area in language processing and production. Based on current ideas of neurological function, a given area of the brain would have a designated function in language. A description of several theories that were not fundamentally related would not effectively describe the functioning of the brain unless Broca's area indeed participated in several distinct, unrelated functions. Thus, when a greater understanding of language organization in the physical brain is the goal, a theory which explains only one structural element, makes predictions in those lines, but has nothing to say about other deficits is fundamentally inadequate from a neurolinguistic perspective. The motivation for looking at varied functional categories stems from the desire to describe the Broca's area as a unified functional entity. If the shared features of the impairment could be described, these shared features could illuminate the role of Broca's area in language function. In endeavoring to describe, effectively, completely and without bias, the set of data, neurolinguistics may run afoul of accepted syntactic theory. While it is well beyond the scope of this project, neurolinguistics would aim to find accord with linguistic structure. Ultimately, any theory of language might hope to describe both the events on the brain and events on paper. Given the success of many syntactic ideas, it is likely that many syntactic notions are reflective of neurolinguistic ideas.

In the following sections, this paper describes existing knowledge on the anatomy of Broca's area, descriptive generalizations about the data, and existing information on functional elements in agrammatic aphasia. Then the results from the 7 German and 7 English speakers are provided. Finally, the last chapter discusses the implications for these results with respect to the TPH and the slow syntax hypothesis

II. Background

Defining Broca's Aphasia

Broca's aphasia occurs from damage to the inferior left frontal gyrus in a region known as Broca's area. This area may be described according to Broadmann's areas 44 and 45. Casual observers of this aphasia would note its slow, labored speech in which smaller words seem to be forgotten. Oftentimes, comprehension appears intact. Linguistically rigorous examinations, however, demonstrate that comprehension of non-canonical sentences like passives or certain relative clauses are impaired, and the subject's verb selection is restricted (Caramazza 1976, Caramazza 1991). The telegraphic quality of the speech stems from the omission of function words and elements such as determiners and prepositions

Because Broca's subjects tend to have no difficulty repeating or even reading language, the labored speech cannot be attributed to motor-related production problems in the throat, tongue or lips. Nonlinguistic cognitive impairments do not appear in Broca's aphasia unless combined with damage to other regions (Fadiga 2006). As a result, Broca's aphasia may be understood, at the most basic level, as a damage occurring in an area of the brain that is explicitly connected to language function (Grodzinsky & Amunts, 2006). Ultimately, the goal of any study of Broca's aphasia should be to describe the role of that area of the brain in language function.

Diagnosing Broca's Aphasia

Most linguistics research in Broca's aphasia relies on aphasics diagnosed by the medical community. The Boston Diagnostic Aphasia Examination is a comprehensive medical assessment of an aphasic's linguistic abilities and diagnoses a variety of aphasias on both the comprehension and the production aspects including Wernicke's and Broca's aphasia. The exam tests ability to repeat phrases, name nouns and verbs and perform a variety of tasks at which a

linguistically competent person would be perfect or near perfect. In addition, motor skills were tested so that the problem was known to be linguistic .

The boston assessment is not directly a test of linguistic ability in a theoretical sense, however. Instead, the test was created by normalizing the subject's responses against prototypical manifestations of the types of aphasia. The subject is diagnosed with a syndrome when he falls within the same statistical region as the prototypical cases. These cases were all males, all right-handed, and all taken in the 1970s (Goodglass 1980). Because of this, the test may not accurately diagnose women or left-handed people in a predictable way. The test does not examine the subject for specific sentence construction types and what amounts in a syndrome that can predict the location of brain damage, but may not behave in a linguistic way.

The consequences of using a phenomenon which is diagnosed in a medical model is that the phenomena may not be theoretically cohesive at all. It may be that everyone diagnosed with Broca's aphasia actually possesses a set of linguistically different traits (for instance, Broca's aphasia may be made up of three theoretically separate aphasias just as dementia may consist of Alzheimer's as well as others). In this case, the best approach for neurolinguistics would be to abandon the medical idea of medical aphasia in favor grouping aphasics based on isolated theoretical criteria. For instance, linguists might study a group of subjects who produce determiners at a significantly diminished rate. By studying subjects that share this linguistic feature, others characteristic deficits may emerge.

Another option for neurolinguistics, should the medical/statistical model of diagnosis prove untenable is the use of physical diagnoses in aphasia. In other words, the question could become the question of what linguistic difficulties correlate with very specific areas of damage. To some degree, the current tests do offer this type of certainty. However, the location of damage is so crudely determined given the current capabilities of MRI and PET that regions which

appear to be identical using this method might prove to be quite varied should the level of precision increase. Indeed, some studies indicated that the classic geographic markers of neurology like gyri and sulci (the folds and chasms on the surface of the brain) are not good predictors of the locations of specific neurons (Amunts 1999, Grodzinsky 2000, Dronkers 1992).

Descriptive Generalizations of Broca's Production

The production difficulties in Broca's aphasia have been summarized in three major influential theories. According to Kean (1977), the omitted elements could be united in their lack of phonological prominence. Functional words missing stress, including question words and determines would be omitted (Shelstad, 1991). This line of inquiry is not explored in this paper and these ideas made strong predictions which have since been disregarded (Shelstad 1991).

One of the most investigated syntactic theories of Broca's aphasia production addresses the problem of movement in Broca's speech. Bastiaanse (2002, 2004, 2007) have demonstrated that Broca's patients have greater difficulty supplying argument when verbs are in the verb second position of Dutch matrix clauses compared to the base position in embedded clauses. Similarly, patients have a greater difficulty with unaccusative subjects than with unergative ones (Bastiaanse 2005). "The boy laughs," an unergative sentence, was less problematic than "the ship sinks" an unaccusative one. This led to the theory that Broca's aphasia is a problem with movement of verbs (in the case of V2), and movement of arguments in the case of unaccusatives. The problem of this theory stems from the fact that the VP internal subject hypothesis proposes that all subjects movement from a base position within the VP (Poole 2002). If movement is truly the problem, then all subjects might prove problematic. Furthermore, as with the tree-pruning hypothesis discussed in the introduction, this movement approach does not address morphological deficits or those seen in verb production.

The most prominent current theory to explain the impairment of functional elements is tree pruning hypothesis offered by Friedmann and Grodzinsky which suggests the precise nature of functional impairments in Broca's using the syntactic tree structure. The tree-pruning hypothesis relies by the theoretical syntax of Pollock 1989 that suggested the functional projection of IP would be split into a multitude of hierarchically ordered functional projections including tense, agreement. This hypothesis suggests that the subjects lose functional projections. With increasing severity, more projections are lost from the tree, moving from top to bottom. Thus, tense projection is lost before agreement projections, and onwards.

As evidence of this theory, Friedmann and Grodzinsky afforded several case studies that native Hebrew speakers with Broca's aphasia. The Hebrew language offers a particularly good testing ground for this idea because verbs contain not only tense and person and number agreement, but gender agreement as well. Furthermore, it is impossible for speakers to produce the bare stem with no morphology, so all verbs produced have some degree of morphology. The case studies demonstrated that subjects produced near-perfect agreement in sentence completion tasks, but performed at random when producing tense. Thus, Friedman suggests that the tense functional projection had been "pruned," or was otherwise inaccessible, but the agreement node had been preserved. In more severe cases, Friedman hypothesized that agreement would also be lost. Importantly, agreement would never be lost before tense, because it was a higher projection (Friedmann 1997). A follow-up study showed problems with question production, suggesting that the CP node was also impaired (Friedmann 2002).

Friedmann's hypothesis offers a tremendous amount to Broca's research by distinguishing between functional elements and using existing theory, as well as explaining degrees of severity in Broca's aphasia, but falls short on other counts. Because tense is lost

before agreement, the hypothesis places the tense node above the agreement node, contrary to Pollock's original hypothesis, as well as evidence from German and Dutch (Wenzlaaf 2004).

Though this paper does not address comprehension and processing in Broca's Aphasia, the Slow Syntax Hypothesis of Broca's comprehension may be of value in analyzing the results. The slow syntax hypothesis suggests that Broca's syntax is slowed down significantly. Evidence stems from studies that demonstrate delayed trace activation in EEGs (Friederici 1989). As a result of the slow syntax, linguistic elements that might be achieved by semantics (eg tense has a semantic component) are impaired as the semantic system proffers shoddy alternative repairs, but structures which rely purely on syntax are intact because there is no faulty semantic repair mechanism. Proponents of the slow syntax hypothesis suggest that anaphors remain intact because they are completely structurally dependent on syntax, whereas pronouns rely very little on syntax and more on semantic referents. Thus, the preservation of anaphors seems to suggest that syntactic system is operating on some level, but the problem is manifested in the connection between syntax and semantics.

At this point, none of the theories anticipate all of the production deficits found in Broca's aphasia. What follows is a description of these deficits from a more theory neutral perspective. The ideal theory might be able to encompass all of these concerns.

Verb Morphology

Studies by Wenzlaff (2004) and Burchert (2005) in German suggest, in these languages, agreement disappears before tense. Given these results, one might believe that agreement and tense projection is ordered differently in each language, and the predictions for aphasics should be reversed according to the behavior of each language. However, Hagiwara (2005) found that Japanese-speaking Broca's subjects treated tense and agreement differentially, but the direction

of the impairment was different in each individual. Lee (2003) demonstrated a similar phenomena for native Korean-speaking Broca's subjects. These results might suggest that functional elements are indeed impaired differently, but these subjects had different lesions or the arrangement of the projections is somewhat idiosyncratic. Whatever the conclusion, arguments about agreement being more salient, and thus better preserved, cannot withstand this data. Burchert (2005) goes even further into dismantling the distinction by suggesting that most subjects do not distinguish between tense and agreement at all.

Studies taking a less theoretical bent examine regular and irregular verbs. Despite one study indicating a greater impairment of irregular verbs (Penke 1999), larger scale studies indicate no difference (Faroqi-Shah, 2007). The absence of such a distinction indicates that frequency of forms as well as the phonological characteristic of verbs forms are not significant predictors of impairment. This would suggest that the semanto-syntactic processes or morphology are more significant than the frequency of forms.

Determiners

There is frequent mention in the literature of Broca's patients' impaired determiner production. However, despite the dogma that subjects produce consistently fewer determiners than normal speakers, the nature of the phenomenon had not been explicitly described and the degree of the impairment and its correlates have not been investigated.

In agrammatism, the absence of determiners has be explained by the inability to assign syntactic case, by generalized processing difficulties listed above and by difficulties making morphological distinctions, as determiners are, in a sense, pure morphology. Ruigendijk (1999, 2002, 2006) suggest that production of determiners is related to case assignment and the omission of case assigning verbs will also cause the omission While many phonological and

morphological features of the determiner are impaired, gender does not seem to be one of them. Studies in Dutch and German have found that gender remains relatively intact (Ruigendik 2007). This observation is in keeping with Friedmann's observation that gender agreement is preserved on verbs. Despite evidence that case was a major impairment in determiner production Ruigendijk 2007 found no significance regarding the case position of the noun and the production of determiners; determiners were just as likely to be omitted in a case-free position as in a case position. Nonetheless, there is some evidence that determiner production is improved in the presence of a finite verb for German speaking aphasics (Ruigendijk 2002).

Prepositions

Because Broca's was assumed to be a syntactic deficit, Grodzinsky proposed that syntactic prepositions such as those required by the subcategorization of the verb would be omitted more frequently than those in adjuncts or optional locatives. While at least one study bears this out (Grodzinsky 1988), others indicate inconclusive results where Broca's patients demonstrate little or no difference in their comprehension or production of the two classes of prepositions (Freiderici 1982, Tesak 1994).

Pronouns

Work in pronoun impairment in Broca's aphasia has focused primarily in comprehension rather than production. Nontheless, studies note two important distinctions. There is data to suggest that Broca's aphasics are more impaired in the comprehension of pronounds that in that of anaphors (Burkhardt 2005, Edwards 2007). This data has been used to defend the notion of Broca's aphasia as the results of a slow syntax discussed earlier in the paper.

Phonology

Some investigations of Broca's aphasia do consider phonological impairments as the source of comprehension problems and agrammatism. These studies suggest that stress or phonological intensity affects the salience of morphemes and predicts the degree of their impact. Because syntax affects prosody, seemingly syntactic deficits could be explained by stress distribution (Blumstein 1994, Kean 1977, Obler 1999). These hypothesis are not considered in this study.

III. Methods

Two sources of pre-existing data were examined quantitatively for the occurrence of functional elements. Five English speaking subjects and seven German speaking subjects from the AphasiaBank corpus were included. Using Menn and Obler's Agrammatic aphasia, the number of subjects was rounded out to include two more English speaking aphasics, and two more subjects from each of the languages described.

The TalkBank data was collected exclusively from male speakers who had a single native language. All these subjects had been diagnosed with Broca's aphasia according to the guidelines offered in the Boston Diagnostic Aphasia examination. The data taking from the subjects was elicited with different examiners, but always used the Northwestern Verb-Naming task where subjects were shown a simple picture containing a single action and asked to produce a sentence describing the action of the picture. The pictures included a variety of common verbs, from single-argument verbs such as ski or swim, to transitive verbs such as hug and the ditransitive verb give. Subjects who participated in this task were given as much time as necessary with each picture, and occasionally offered encouragement by the examiner, but not offered other clues. Their data was transcribed using traditional English orthography. The data from German languages was translated literally by Ann Dahl, a native German speaker, in word by word style and then smooth style.

The subjects from Menn and Obler were also officially diagnosed as aphasics using the Boston Aphasia Diagnostic Examination. These subjects were also monolingual males, with varying levels of education and varying degrees of severity in aphasia. Unlike the subjects in the AphasiaBank study, these subjects were given prompts which would create more spontaneous speech. The subjects were asked to describe their stroke experience and tell the story of little red riding hood. They were asked to describe three complex pictures where many events taking place

including the cookie theft story and a picnic. Because the subjects produced a lot of uninterrupted speech with only occasional comments from the examiner, the speech was more reflective of natural aphasic speech.

The difference between the corpora's data collection styles will not come into scrutiny in this essay, but it is not necessarily insignificant. Hofstede (1994) demonstrated a lower rate of functional element omission in picture matching tasks such as those of the AphasiaBank than in free narrative elicitation such as that found in Menn and Obler. However, because the patients aren't being compared on individual lines, but as aggregates, the impact on this study should be minimal. Nonetheless, the reader may keep this information in mind should corpora-specific anomales in the data be observed.

To analyze the AphasiaBank data, each response to a prompt was separated and coded for a variety of features. Each utterance was linked to the subject, the prompt, the verb, and the verb type. Each sentence was marked for determiners, prepositions and whether each required argument of the verb was present. In German, determiners were marked for a match in case and gender. Often, the subjects produced multiple determiners, but the best production (which matched for the most features of gender and case) was on the response counted in the coding. Each verb was analysed for any morphology that may have appeared. In English, this was limited in scope, particularly with regard to agreement. Tense was marked, but, because there were not obvious tense requirements there was no "correct" tense.

When the sentence was ambiguous with regard to a certain parameter, that parameter was disgarded from the analysis. For instance, if it was unclear whether the subjects correctly produced a subject, than that item was left out entirely when the percentage of utterances containing subjects was included. When words or phrases were repeated several times, one after the other, any determiners or prepositions in those phrases were counted only once. On occasions

when entire sentences were repeated with only slight modification, only the best attempt was used for analysis of verb morphology of the correctness of arguments. However, every novel determiner phrase was counted separately in any number of repetitions because each assigment of determiner to noun is a novel event. Deictics and possessives were not counted as determiners.

The analysis of the Menn and Obler data was almost identical to the AphasiaBank analysis with a few important exceptions. Because the speech was spontaneous, the data was divided into utterances based on sentence units. These units consisted either of clear sentences with subjects verbs and objects, or partial sentences where one or more arguments were missing, or of groupings of associated arguments where no verb was present. The speech had been marked for all pauses, so these groupings were unambiguously determined by the subject's own cadence and were usually clear in regard to their related content as well. The counting was done based on these utterance groupings because it is important to get not simply the number of finite verbs, but the number of finite verbs with respect to each phrase that might theoretically contain a verb. The advantage of such a technique was that the rate of various utterances could be compared in an intra-subject method and did not necessarily rely on pure comparison.

All comparisons were made on the basis of percentage correct in the case of obligatory items (the argument or subcategorization structure required for a verb, for example) or percentage produced in the case of non-obligatory. The purpose of using percentage production was the result of having an unequal number of examples in categories it was desirable to compare. Those categories with so few examples as to legitimize the percentage-style analysis were excluded from comparative analyses. When comparing the performance of the groups of subjects, the subjects with the fewest data points were discarded from the average (subjects more than one standard deviation below the average number of data points).

Verb tense and aspect were grouped into larger categories which must be defined. Verbs in English were classified according to tense and aspect, but not agreement, because agreement errors were arguably absent. The category of present indicated a simple present form and the category of progressive indicated a present progressive form. Similarly, the category of past referred the simple past as not other category was present. The distinction of "stem" indicated that the bare stem was all that was produced. The bare stem corresponds to the third person plural present form, so the error could be interpreted as agreement error. The distinction of "x progressive" referring to the gerund form without an auxiliary verb. The categories of "stem" and "x progressive" were also classified as "nonfinite" when broader categories of analysis applied.

The prepositions were also grouped into the categories of obligatory and non-obligatory. If the preposition was required because of the subcategorization of the verb or if is was required for a non-optional locative (as was the case for copula verbs). Idioms, genitive and instrumental prepositions were classified as optional.

IV. Results

English

Subjects and Lexical Items

The following table summarizes the lexical item production of the patients. The first line of each row gives the percentage of arguments, or verbs supplied out of the required number and the second line gives the number of produced over the number required (assuming a normal speaker would produce all required arguments in English).

Table 1: Patients and Lexical Items

Feature\Subject	b01	b03	b04	b05	b06	m01	m02	Total
% subjects	75.0	92.0	82.4	78.6	22.2	90.6	44.4	70.8
produced/required	21/28	23/25	14/17	22/28	2/9	58/64	32/72	172/243
% Direct Object	62.5	100	76.9	81.3	0.0	84.4	82.1	78.9
produced/required	10/16	14/14	10/13	13/16	0/4	27/32	23/28	97/123
% Indirect Object	50.0	50.0	33.3	33.3	0.0	33.3	100	38.7
produced/required	3/6	3/6	2/6	2/6	0/3	1/3	1/1	12/31
% Verbs Supplied	67.9	100	64.7	85.7	0.0	95.3	54.2	74.1
produced/required	19/28	25/25	11/17	24/28	0/9	62/64	39/72	180/243
% Locative	75.0	100	100	83.3	80.0	100.0	100.0	90.6
produced/required	3/4	5/5	4/4	5/6	4/5	7/7	1/1	29/32

Verb Morphology by Subject

Table 2. Occurrence of Verb by Tense and Aspect

	b01	b03	b04	b05	m01	m02	Total
% infinitive	0	4	0	0	1.64	0	
n=	0	0	0	0	1	0	1
% Present passive	0	0	0	0	1.64	2.56	
n=	0	0	0	0	1	1	2
% past	0	0	0	0	27.87	12.82	
n=	0	0	0	0	17	5	22
% present	33.33	20	0	50	31.15	48.72	
n=	6	5	0	12	19	19	61
% present progressive	50	64	18.18	20.83	21.31	0	
n=	9	16	2	5	13	0	45
% stem	0	0	72.73	0	6.56	33.33	
n=	0	0	8	0	4	13	25
% X present	0	0	0	0	1.64	0	
n=	0	0	0	0	1	0	1
% X progressive	16.67	12	9.09	29.17	8.2	2.56	
n=	3	3	1	7	5	1	20

The above table summarizes the percentage of each tense and aspect out of the total number of verbs the subjects produced. These percentages do not include the overall number of verbs produced. The categories are self-explanatory for the most part. Stem refers to the bare infinitive part of the verb and was not used to describe irregular verbs which arguably do not have a single bare stem. The designation "X present" refers to the present plural form which is the same as the stem and cannot necessarily be said to have morphology, despite being correct. There is only one instance of "X present." The designation "X progressive" refers to the "ing" form of a verb without the finite auxiliary. Thus, the form is non-finite but contains morphology nonetheless.

The present and present progressive forms were used by for the most frequently, comprising 34% of all the verbs produced together and an average of 30% of each subjects'

production. Despite this clear plurality, not every subject used the present most frequently and many used the progressive with greater frequency than the present. Subject b01 using the present progressive most frequently, 50% of the time, in 9 cases, followed by the present 33% of the time in 6 cases and the "x progressive" 17% of the time in 3 cases. Subject b03 used the present progressive most frequently in 64% of the cases, 16 times, followed by the present 20% of the time in 5 cases and "X progressive" 12% of the time in 3 cases. Subject b04 used the stem form 72% of the time in 8 cases, followed by the progressive 18% of the time in 2 cases and "x progressive" 9% of the time in a single case. Subject b06 never produced a verb and is thus excluded from this chart. Subject m01 produced presnt verbs with the greatest frequency 31% of the time in 19 cases, followed by past 28 % of the time in 17 cases and progressive 21% of the time in 13 cases. The subject produced 5 cases of the "x progressive" form, accounting for 8% of verb production. The remaining verbs produced were only a handful of one case each of infinitive, present passive and "x present."

It is worthwhile to analysis subjects b01-b05 separately from subjects m01 and m02 because the two sets received different prompts. Subjects b01, b03 both favored, in this order, present progressive, present and "x progressive verb morphology. Subject b04 favorted the bare stem, by a wide margin (72%) followed by progressive. When "progressive" and "x progressive" are measured together as a larger category, Subjects b01, b03 and b05 all favor the progressive form by a wide margin of 67%, 76% and 50% respectively. Thus, of the subjects that used any morphology, (any form which was not the bare stem), favored the progressive form. The pattern between m01 and m01 is less clear and cannot include a broad number of generalizations when past and present are considered separately. However, when verbs are grouped as simple aspect (past, present and passive), progressive and "x progressive" a clearer pattern emerged. The subjects preferred simple aspect by a wide margin, and used it in 61% and 64% of their verb

production respectively. Then the subjects diverge again, with m01 preferring progressive or "x progressive" for 30% of his verb utterances, and m02 using bare stem verbs in 33% of his utterances.

The data may be summarized by lumping the "X progressive" and "stem" category into the unit "non finite" to get a better picture of the prevalence of morphological errors. With the exception of subject b04, who used a bare stem in 72% of his verb utterances, most subjects had a minority of true morphological errors. Subjects b01, b03 and use of non-finite verbs accounted for

Determiners

There were 309 nouns produced which required determiners and 159 determiners were produced. The subjects' determiner ability was widely varied and is summarized in the table below:

Table 3. Overall Percent of Required Determiners Produced

Feature\Subject	b01	b03	b04	b05	b06	m01	m02	Total
% Determiners	0.0	71.7	50.0	39.5	0.0	66.7	56.1	51.5
produced/required	0/38	33/46	15/30	17/43	0/6	62/93	32/57	159/309

Determiners by Noun Argument Position

Table 4. Percent Determiners Broken by the Noun's Position

	b03	b04	b05	m01	m02	Total
Subject	62.5	0	33.3	73.1	58.1	64.8
produced/required	15/24	14/14	7/21	38/52	18/31	92/142
Object	64.3	100	18.2	70.6	36.8	56.3
produced/required	9/14	10/10	2/11	12/17	7/19	40/71
Indirect	66.7	X	50	100	0	57.1
produced/required	2/3	X	1/2	1/1	0/1	4/7
Place	100	50	60	71.4	0	68.2
produced/required	5/5	2/4	3/5	5/7	0/1	15/22

Subject b01 and b06 were left off this table because they produced no determiners. There was no significant difference between determiners produced in the subject or object position, but three patients, b03, b05 and m01 produced the most determiners in the place position One of the subject, m02, who produced no determiners in the place position may be ignored, because he only produced one instance of a place complement. When the analysis includes only the subjects with sufficient production of all of the components, three patients with sufficient determiner production produced substantially higher rate of determiners for the place position as compared to the other positions. Subject b03 produced all determiners for the place complement in 5 out of 5 cases. The subject produced subject determiners at a rate of 63%, in 15 out of 24 cases, 64% of object determiners in 9 out of 14 cases and 67% of Indirect object determiners in 2 of out 3 cases. Subject b04 produced determiners in 100% of object determiners in 10 case ant 50% of place determiners in 2 out of 4 cases.

Determiners and Verb Morphology

In total, 243 sentences were collected, Of these sentences, 65 were missing a verb, 130 contained a verb with the proper morphology and 48 contained a nonfinite verb where a finite verb would be required. Of the three subjects that produced enough determiners to be analyzed, these subjects produced significantly more determiners when a finite verb was present than when a finite verb was not present ($p=0.047$). These subjects produced a determiner 77.5% of the time when a finite verb was present and 30.7% of the time when a finite verb was not present. The subjects whose determiner production was more impaired, and produced fewer overall determiners did not show the same sensitivity to verb finiteness in a significant way.

Analysis of copula, preposition by subject.

The verb is lost before the complement – In no cases was the verb produced, but not the complement. On the other hand, there were 25 instances of the copula and 22 in which the place complement was produced. Of those 22 instances in which the complement was produced, 10 of those instances had a null verb (the verb was not produced). Of the three instances in which a complement was not produced, neither was the verb produced. In addition, the three cases which lacked both verb and complement were produced by three different subjects, and thus, any correlations with other deficits cannot be confirmed in this data. Thus, the complement is preserved even when the verb is not intact.

There were forty instances of the copula. Twenty-five of those instances were intended to include a place complement. There were three cases when no verb or place complement was produced. Of these three cases, there was one case in which a preposition was produced, but no complement or verb was produced. Given the isolation of this instance, not further comment or

analysis is possible. Owing to the small number of cases in which no place complement was produced, these cases will be ignored in the forthcoming analysis.

Of the 10 cases where no verb was produced, 7 or 70% also lacked a proposition which would be the head of the place complement. However, of these 7 missing the place-complement head, three contained the possessive preposition 'of" in the phrase" "top of (the)…" Thus, not all prepositions were impaired. Two differently English speaking subjects, subject b04 and b05 both used this phrase, and this structure cannot be formulated as a fixed phrase in one subject.

There were 10 cases in which the preposition head of the place complement was intact. Of these 10 cases, 8 of them also contained a verb. Of the 12 cases in which a preposition was missing, while there was still a "place" produced, 8 did not contain a verb. Thus, there is a strong correlation between the verb being produced and the preposition being produced. However, which feature is lost first is unclear because the correlation is so tight.

B01

For subject b01, there was not correlation between whether the verb was produced and whether the preposition was produced. For two of the three cases, the subject produced the verb, and for two of the three cases the subjects produced the proposition, but the overlap of these two scenarios appeared random and could be contributed to chance.

B03

Subject b03 produced both a verb and preposition in all cases. However, one instance of the production included the verb "look" instead of the elicited copula.

B04

This subject produced neither a verb nor a preposition in any of the cases where such a form was elicited.

B05

This subject produced a verb, but not a preposition in two cases, both a verb and a preposition in two cases, and a preposition, but no verb in one case. As was the case with subject b01, the copula, PP complement structure was impaired, but which functional feature was impaired appeared to be random. This may be attributed to a relatively small data set.

B06

This subject never produced either the verb or the preposition, despite producing the subject and "place" in almost every trial.

Summary

For the two subjects who never produced the copula or the preposition complement, b04 and b06, these subjects were not close in the rate at which they produced subjects, determiners or prepositions. However, the subjects b03, who consistently produced both the copula and the PP showed the least degree of impairment on the metrics of determiners and subjects produced.

Prepositions by category

Prepositions were divided into three categories: Syntactic (indirect object, infinitive, partitive, possessive), semantic (goal, instrumental, place) and other (which influced undefined and idiomatic prepositions).

Table 5: Prepositions Suplied by Category

	b01	b03	b04	b05	b06	m01	m02	TOTAL
% Obligatory	70	100	37.5	33.3	0	87.5	50	57.7
Produced/Required	7/10	9/9	3/8	3/9	0/6	7/8	1/2	30/52
% Optional	100	100	60	X	X	100	66.7	85.2
Produced/Required	4/44	2/22	3/5	0/0	0/0	10/10	4/6	23/27

Pronominals

Table 8: Pronominal Production by Type

Type of Pronoun	b01	b03	b04	b05	m01	m02	**Total**
Subject					10	4	**14**
Indirect Object				3			**3**
Expletive					3		**3**
Fixed Phrase	3	1		1			**5**
PP Complement			1				**1**
Copula Complement					1		**1**
Other	1						**1**
Total	**4**	**1**	**1**	**4**	**14**	**4**	**28**

The patients produced 28 pronominals altogether with the plurality of 14 in the subject position. Three pronominals were in the indirect object position, 3 were expletives, 5 were in fixed phrases, 1 was in a prepositional complement, 1 was in the copula complement, 1 was in an unknown context. Patient b01 produced 3 fixed phrase pronouns and 1 "other." Patient b03 produced 1 fixed phrase pronoun. Patient b04 produced 1 prepositional phrase complement. Patient b05 produced 3 indirect object pronouns. Patient m01 produced 10 subject pronouns, 3 expletives and 1 copula complement. Patient m02 produced 3 subject pronouns.

Correlation

Table 6. Summary of Lexical and Functional Features by Person

Feature Type	Feature\Subject	b01	b03	b04	b05	b06	m01	m02
Lexical Argument	% subjects	75.0	92.0	82.4	78.6	22.2	90.6	44.4
	% Direct Object	62.5	100	76.9	81.3	0.0	84.4	82.1
	% Indirect Object	50.0	50.0	33.3	33.3	0.0	33.3	100
	% Verbs Supplied	67.9	100	64.7	85.7	0.0	95.3	54.2
	% Place Compl.	75.0	100	100	83.3	80.0	100.0	100.0
Functional Item	% of Verbs Finite	67.9	100	64.7	85.7	0.0	67.9	100
	% Determiners	0.0	71.7	50.0	39.5	0.0	66.7	56.1
	% Prepositions	78.6	100	46.2	30.0	0.0	95.2	62.5

Determiner production is directly correlated with subject production. The greater degree of impairment in determiners predicts a greater degree of impairment in subjects. There is some correlation between these metrics and direct objects but the correlation is imperfect and two of the subjects were reversed with respect to subject and direct object. Furthermore, some subjects were more impaired with respect to direct objects, while other subjects were more impaired with respect to subjects. This suggests that there is no argument that is preserved more than other arguments. The same holds true for indirect objects; there is no correlation between the degree of impairment in subjects and the impairment in direct and indirect objects. However, it is also possible, given the small data sample that a correlation could emerge with a greater number of people.

There was a correlation between all functional features with each other. Thus, the relative degree of subjects' impairment on one feature could predict the relative degree of impairment a subject had on another feature – the most impaired in determiners was also the most impaired on finite verbs. There was a 0.69 correlation between % of finite verbs produced and % determiners. There was a 0.67 correction between finite verbs and prepositions, and a 0.59 correlation between determiners and prepositions. Prepositions had the weakest correlations because half the subjects (b01, b03, m01 and m02) produced prepositions at a higher rate than they did determiners, while the rest of the patients produced determiners at a lower rate. Thus, the rate of determines or finite verbs was not a good predictor of the performance on prepositions. On average, finite verbs were produced at a higher rate than determiners. Not definitive statements may be made about prepositions.

On average, the functional elements were produced at a lower rate than the lexical elements (56% functional, 68% lexical), but this difference was not significant (P=0.21 for a t-test paired assuming unequal variance). Even when the widely varying cateogires of preposition

and place complement were excluded, significance did not emerge. This lack of significance may be the result of a the small sample size.

Table 7: Rate of Production for Prepositions in Obligatory and Non Obligatory Phrases.

There was not significant difference between the rate of obligatory production and optional production of determiners.

German

Lexical Items

The following table summarizes the rate at which the subjects supplied required lexical items (arguments and verbs). The first row indicates the percentage of required subjects supplied and the next row the actual numbers. The same pattern applies to each row.

Table 9: Rate of Production of Lexical Items

Subject	g01	g02	g03	g04	g05	g06	g07
% Subjects	96.2	92.3	100.0	100.0	100.0	100.0	88.5
Produced/required	25/26	23/26	26/26	26/26	26/26	2/6	23/26
% Objects	93.3	93.3	92.9	100.0	92.3	93.3	86.7
Produce/required	14/15	14/15	14/14	14/14	12/13	14/15	13/15
% Indirect	16.7	50.0	20.0	0.0	0.0	100.0	16.7
Produced/required	1/6	3/6	1/6	0/5	0/4	6/6	1/6
% Place	66.7	66.7	100.0	50.0	85.7	100.0	66.7
Produced/required	4/6	4/6	6/6	3/6	6/7	4/4	4/6
% Verb	96.2	100.0	96.0	84.6	80.8	100.0	57.7
Produced/required	25/26	26/25	24/25	22/26	21/26	25/25	15/26

The patients varied in their ability to supply subjects from 86% to 100%. All patients were considered for 26 total utterances. Patient g07 produced the lowest number of subjects, only 23 out of the required 26, or 87%. The patients g03, b04 and g05 produced 26, 100% of the required subjects. Five of the patients omitted 1 direct object, 1 patient omitted none and patient g07 omitted two. Patients produced from 0% to 100% of indirect objects. Patients g01 and g07 produced 1 out of 6 indirect objects, or 17%. Patient g02 produced 3 out of 6 or 50%. . Patient

g03 produced 1 out of 5 indirect objects, or 20%. Patients g04 and g05 produced 0% out of 4 and 5 required indirect objects respectively. Patient g06 produced 6 out of 6 objects, or 100%. Patients produced from 50% to 100% of place complements. Patients produced from 58% to 100% of required verbs

Verbs Morphology

Table 10: Verb Morphology by Type out of Total Verbs Produced

	b01	b02	b03	b04	b05	b06	b07	Total
nfinitive	8.0	15.4	4.2	0.0	0.0	0.0	0.0	7.0
nfinitive/verbs produced	2/25	4/26	1/24	4/22	0/21	0/25	0/15	11/158
erfect	0.0	3.8	4.2	0.0	0.0		0.0	1.9
erfect/verbs produced	0/25	1/26	1/24	0/22	0/21	1/25	0/15	3/158
resent	92.0	80.8	87.5	77.3	100.0	96.0	100.0	89.9
resent/verbs produced	23/25	21/26	21/24	17/22	21/21	24/25	15/15	142/158
tem	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.6
tems/verbs produced	0	0	0	1/22	0	0	0	1/158
inite verbs	92	84.6	95.8	77.3	100	100	100	92.4
inite/verbs produced	23/23	22/26	23/24	17/22	21/21	25/25	15/15	146/158
otal (excluding finite reduncy)	25	26	24	22	21	25	15	158

Overall, 158 verb forms were produced. Of these, 90% were in the present tense, which accounted for the majority of verbs produced by every patient. The next most common form, accounting for 11 instances, was the infinitive form. In all cases, this form appeared when a finite form was grammatically appropriate. There were three examples of the perfect form. And only 1 example of a bare stem produced by g04.

Determiners

There were 310 nouns required determiners for which the patients produced 244 determiners, or 79%

Table 11: Overall Production of Determines

Subject	g01	g02	g03	g04	g05	g06	g07	Total
% Determiners	76.2	71.1	97.8	73.2	97.7	89.8	44.4	
produced/required	32/42	32/45	44/45	30/41	42/43	44/49	20/45	244/310

The patients produced between 44% and 98% of determiners. Patient g01 produced 32 out of 42 required determiners, or 76%. Patient g02 produced 32 out of 45 or 71%. Patient g03 produced 44 out of 45, or 98%. Patient g04 produced 30 out of 41 or 73%. Patient g05 produced 42 out of 43 or 98%. Patient g06 produced 44 out of 49 or 90%. Patient g07 produced 20 our of 45 or 44%.

Determiners by Position

Table 12. Percent Determiners Broken by the Noun's Position

Patient	g01	g02	g03	g04	g05	g06	g07	Total
Subject	84	84.6	100	92.3	100	100	23.1	83.3
Produced/required	21/25	22/26	26/26	24/26	26/26	25/25	6/26	150/180
Object	71.4	58.3	92.3	42.9	92.9	71.4	64.3	70.5
Produced/required	10/14	7/12	12/13	6/14	13/14	10/14	9/14	67/95
Indirect	100	33.3	100	X	X	100	100	88.2
Produced/required	1/1	1/3	1/1	0/0	0/0	6/6	6/6	15/17
Place	0	50	100	0	100	75	100	73.9
Produced/required	0/2	2/4	5/5	0/1	3/3	3/4	4/4	17/23

The patients produced a significantly greater number of determiners for nouns in the subject position as compared to the object positions (P = 0.037). The patients produced a mean of 93# of Subject determiners and 72% of object derminers. Three patients, g03, g05 and g06 produced

100% of the determiners for the subject position, 26 determiners out of 26 required. Patient g01 produced 21 out of 26, patient g02 produced 22 out of 26, patient g04 produced 24 out of 26 and patient g07 produced 6 out of a required 26. With the exception of patient g07, who made 20 errors in determiners for subject, all patients omitted 0 to 4 of the required determiners. The patients produced a lower range of object determiners from 64 – 93 % of required determiners for nouns in the object position. Patient g01 produced 10 out of 14 required determiners for nouns in the object position. Patient g02 produced 7 out of 12. Patient g03 produced 12 out of 13. Patient g04 produced 6 out of 14. Patient b05 produced 13 out of 14. Patient g06 produced 9 out of 14 and patient g07 produced 9 out of 14. Questions over indirect object determiners are less interesting because patiebts g01, g03 and b07 were asked to produce only 1 instance of a ditransitive verb while patients g04 and g05 were asked to produced none at all. Simliarly, there were

Determiners by Gender

Table 13: Supply of Correct Case out of Total Determiners

Patient	g01	g02	g03	g04	g05	g06	g07	Total
% Correct Gender	87.5	94.1	88.6	90.3	95.2	84.1	65	92.7
Correct/Total	19/21	21/22	25/26	23/24	25/26	21/25	5/6	139/150

The patients produced the correct gender determiner between 65% and 95% of the time. There were more mistakes over gender than overall omissions of the determiners. Patient g01 produced a correct gender for his determiners in 28 out of 32 instances. Patient g02 produced a correct gender in 32 out of 34 instances. Patient g03 produced a correct gender in 39 out of 44 instances. Patient g04 produced a correct gender in 40 out of 42. Patient g05 produced a correct gender in

40 out of 42 instances. Patient g06 produced a correct gender in 37 out of 44 instances. Patient b07 produced a correct gender in 13 out of 20 instances.

Determiners were analyzed for whether they matched the gender of the noun for nouns in each argument position. There was no significant difference across patients between correct gender in the subject and noun position ($p = 0.14$). There was insufficient examples in the locative and indirect argument positions to include them in these comparisons.

Case in Determiners

Table 14: Percent Correct Case Supplied Correctly

Subject	g01	g02	g03	g04	g05	g06	g07	Total
% Nominative Case	100	100	100	100	96.2	100	83.3	98.7
Correct/Total	21/21	22/22	26/26	24/24	25/26	25/25	5/6	148/150
% Accusative Case	70	71.4	100	50	100	80	55.6	79.1ß
Correct/Total	7/10	5/7	12/12	3/6	13/13	8/10	5/9	53/67

Whether the case of the determiner was correct was found to differ significantly between the subject and object position ($p=0.013$). Patients provided the nominative case for the determiner when the nominative case was required an average of 97% of the time and the correct accusative case 75% of the time. For the nominative case, five patient (g01, g02, g02, g04 and g06), produced the determiners all in the correct case. These patients produced 21, 22, 26, 24 and 25 determiners in the nominative case respectively. Patient g05 produced 25 out of 26. Patient g07 produced 5 out of 6 determiners in the correct nominative case. All patients save g03 and g05 produced fewer correctly cased determiners in the direct object position. Patient g01 produced 7 determiners in the accusative case for 10 determiners produced which should have been in the accusative case. Patient g02 produced 5 out of 7. Patient g03 produced 12 out of 12.

Patient g04 produced 3 out of 6. Patient g05 produced 13 out of 13. Patient g06 produced 8 out of 10. Patient g07 produced 5 out of 9.

Comparing Case and Gender in Determiners

Table 15: Percent Determiners with Correct Gender and Correct Case

Subject	b01	b02	b03	b04	b05	b06	b07	Total
% Correct Gender	87.5	94.1	88.6	90.3	95.2	84.1	65.0	87.9
Correct/Total	28/32	32/34	39/44	28/31	40/42	37/44	14/20	217/247
% Correct Case	54.7	54.7	67.7	50.0	63.1	63.6	54.5	80.6
Correct/Total	29/53	29/53	44/65	27/54	41/65	42/66	12/22	224/278

Overall, the patients produced the correct case at a significantly lower rate than the correct gender ($p = 0.00011$). The patients produced the correct gender and average of 86% of the time while the patients produced the correct case an average of 58% of the time. No patient produced case correctly 100% o the time. The patients ranged in their correct production of case from 50% to 68% of the time.

Determiners and Verbs

Table 16: Percent Determiners Supplied by Verb Type

	g01	g02	g03	g04	g05	g06	g07
% determiners for finite verbs	68.2	68.2	68.2	64.7	57.1	64	73.3
Produced/Required	15/22	15/22	15/22	11/17	12/21	16/25	11/15
% determiners for nonfinite verbs	0	0	0	80	X	X	X
Produced/Required	0/2	0/4	0/1	4/5	0/0	0/0	0/0
% determiners for omitted verbs	100	X	0	50	100	X	27.3
Produced/Required	1/1	0/0	0/1	2/4	5/5	0/0	3/11

There was no significant difference in the production of determiners for utterances with finite or nonfinite verbs or with null verbs.

Pronominals

Table 17: Determiners Supplied by Type

Type of Pronoun	g01	g02	g03	g04	g05	g06	g07	**Total**
Reflexive		1		1				**2**
Expletive		1						**1**
PP Complement	2							**2**
Subject	4		1			2		**7**
Ungrammatical							1	**1**
Fixed Phrase						1		**1**
Other						1		**1**
Total	**6**	**2**	**1**	**1**	**0**	**4**	**1**	**15**

Pronouns appeared the most frequently in the subject position. All other positions for pronouns or types of pronouns possessed only one or two examples in the corpus.

Correlation

Table 18: Overall Production by Element

Subject	b01	b02	b03	b04	b05	b06	b07
% Subjects	96.2	92.3	100.0	100.0	100.0	100.0	88.5
% Objects	93.3	93.3	92.9	100.0	92.3	93.3	86.7
% Indirect	16.7	50.0	20.0	0.0	0.0	100.0	16.7
% Place	66.7	66.7	100.0	50.0	85.7	100.0	66.7
% Verb	96.2	100.0	96.0	84.6	80.8	100.0	57.7
% Determiners	76.2	71.1	97.8	73.2	97.7	89.8	44.4
% Correct Gender	87.5	94.1	88.6	90.3	95.2	84.1	65.0
% Correct Case	54.7	54.7	67.7	50	63.1	63.6	54.5

Looking at overall production, the ability to produce nouns in the subjects positions correlated positively ($r>0.5$) with the ability to produce any of the other forms counted (other arguments, verbs, determiners, case and gender), except for indirect objects. There was no significant trend between the production of subjects and the production of indirect objects. The ability to produce nouns in the object position correlated positively with the ability to produce subjects, verbs,

determiners and the correct case and gender. The was no significant correlation between object production and indirect objects, locatives or correct case. Indirect objects correlated positively with the abilty to produce place, verbs. Locatives correlated with the ability to produce determiners and case. Verbs correlated positively with subjects, objects and indirect objects. Determiners correlated positively with all measured elements save indirect objects. The greatest predictors of overall ability were subjects and determiners were both correlated with all other entities save indirect objects.

Comparing German and English

Overall, significantly fewer omissions were made in the German determiner system as compared to the English system ($p=0.02$). Germans also produced significantly more subjects than English patients. There were no other significant differences between German and English in metrics which could be measured in both languages. Case and gender could not be compared in the languages because they do not exist in English. Prepositions could not be compared effectively because German uses dative case for indirect objects whereas English uses prepositions. Thus, the contexts in which prepositions appear in the language diverge too greatly to effectively compare. While German patients used more infinitive forms and English patients used more nonfinite progressive forms, these differences did not elicit a statistically significant difference because there were too few examples.

V. Discussion

The results may serve as a critique of the tree pruning hypothesis (Friedmann & Grodzinsky 1999). Lexical arguments are omitted in all parts of the sentence, a result not predicted by any of the existing theories. The data indicate that determiners are impaired in virtually every patient, to varying degrees. In addition, case is impaired while gender remains intact. There are important differences in German and English production. Because these impairments are not predicted directly by the tree pruning hypothesis, that theory cannot effectively describe Broca's aphasia .

Lexical Items

One of the most surprising results in the data was sporadic omission of lexical arguments in the Broca's production. While observers have long noted the omission of functional elements, subjects, objects, indirect objects and locatives are also left out. There was no significant difference between the rate of omission of any given lexical item, so Bastiaanse's movement hypothesis cannot explain the date. Furthermore, no particular argument was completely impaired in any of the patients, so the production seems random. With a larger data set, patterns might emerge. As it stands, any theory of Broca's aphasia should be able to explain a small degree of impairment in argument production. The lexical items were produced at a greater rate than determiners, however, which could explain the perception that functional items, but not lexical items are impaired.

Determiners

The impairment of determiners is not as simple as complete and consistent omission, nor was it purely random. Furthermore, the rates of omission differed distinctly across languages, with a significantly higher rate of omission among the English speaking patients. The omission was dependent on whether the verb produced was finite, in accordance with Ruigendijk's predictions (1999) and there was some trend towards a greater supply of determiners in obligatory locatives. The presence of the prepositions in obligatory locatives did not impact whether or not a determiner was produced. The need for finite verbs would suggest that determiners rely on Case-assigning verbs, as suggested by Ruigendijk. However, there was no significant difference between subjects and direct objects, which might also show a distinction were case-assignment at place. Futhermore, the presence of a preposition, another case-assigning feature, had no predictive value as to the production of a determiner. Thus, despite the prevalence of determiners in the noun phrases of obligatory locatives, the key case-assigning feature does not seem important. Nonetheless, the linking between prepositions and determiners deserves more attention, because there were an insufficient number of obligatory locatives to have a true statistical significance.

The difference between German and English determiner production deserves some attention. Despite the fact that German determiners encode tense, gender, and definiteness, and English determiners encode only definiteness, English determiners were omitted at a far higher rate than German determiners. One hypothesis might be that the semantic value of German determiners is higher, because they encode more information, and thus is more salient. However, the notion of semantic salience could not be supported by the observation that agreement in the verb is preserved beyond tense. While tense has arguably greater semantic value than agreement, agreement is nonetheless preserved, as demonstrated elegantly in Friedman 1997, 2002. Another

possibility is that German determiners are more lexically ingrained. Such a hypothesis might be tested in normal native German speakers. Finally, it may be that a larger data set might allow the effect to disappear, in which case, the difference between English and German need not be described.

Verb Production

The pattern of verb usage confirms existing knowledge about Broca's patients' preference for the for the progressive form of the verb (Menn & Obler 1990), which was widely preferred by virtually all English speaking patients when it's finite (auxiliary + progressive) and it's nonfinite (gerund) form were produced. The fact that patients produced ungrammatical gerundives without an auxiliary verb for finiteness indicates that verb morphology beyond agreement is intact. From the perspective of the slow syntax hypothesis, which asserts that purely grammatically structures are preserved, Broca's use of the nonfinite gerundive may be a way to supply the verb morphology, without committing to semantically laden tense and finiteness. In other words, the absolute syntactic requirement that a verb possess morphology is fulfilled, but the semantic tag of tense is not. This analysis is admittedly imperfect because the semantically vacuous trait of agreement is not preserved in the use of a nonfinite progessive form. Furthermore, the sentence without a finite verb is ultimately ungrammatical.

An interesting distinction emerges between German and English verb production. While the most common ungrammatical nonfinite form in English was the progressive, the most common ungrammatical form in German was the infinitive. This might be the result of the English infinitive consisting of two separable morphemes. Thus, the patients may be selecting the simplest nonfinite form that consists of a single word. This question could be tested easily by

examining and comparing nonfinite verb production in languages with different infinitive structures.

Case and Gender

The greater impairment of case than gender is in accordance with the slow syntax idea that syntactic-semantic features are more impaired than pure syntactic features. The gender in the determiner is a pure syntactic feature relating the determiner to the noun without adding syntactic value. Case, on the other hand, is linked to thematic role assignment, albeit imperfectly. Nonetheless, patients with slowed syntax might eschew proper case assignment in favor of other semantic clues such as positioning in the sentence.

The gender errors that were made were done so to avoid case-assignment decisions: all gender errors were a switch from masculine to feminine determiners. The feminine determiner is the same in both the nominative and accusative case. Thus, the gender switch may have been a strategy to avoid selecting between nominative and accusative case. Why the switch would be made to feminine, instead of neuter, which shares the same property of nominative and accusative matching is unclear. It may be that accusative case is marked or dispreferred, or because the feminine retains some degree of animacy when most of the subjects and objects were animate. This last argument is imperfect because animate nouns such as "madchen" (young girl) are occasionally neuter.

The data of the corpora in this experiment were not conducted in such a way that enabled comparisons between anaphors and pronouns. However, certain features of the production are of note; pronouns appeared more frequently in the subject position, and the most commonly used pronoun was the first person singular, in both German and English. In the subject position, the pronoun is closest to its conversation referent, and is least likely to rely on case markings to

distinguish which argument it fills because the subject appears first in both English and German. The first person pronoun always has an unambiguous antecedent in conversation. Thus, like preferring the subject position, the use of the first person encounters fewer problems for assigning referentiality. This analysis of pronouns must be tempered with the understanding that there are very few examples at all. Furthermore, the usage of different positions was most strongly predicted by the identity of the patient; different patients preferred different pronoun positions. For many of the positions, there was only one example in the corpus, so any type of extrapolation or generalization would be very difficult.

Correlations

The evidence for correlation from German and English is inconclusive. Overall, subjects and determiner production in both languages is the strongest predictor overall ability to produce lexical and functional items. Distinct groupings of correlation that operated independently did not emerge. This is a good initial indication that the problems in Broca's are not independent constellations of symptoms which have been incorrectly grouped together. Nonetheless, more sophisticated regressions could prove otherwise, as could a larger data set.

The items that have the weakest correlation between other elements included indirect objects in both German and English, prepositions in English and locatives in both German English may have shown this pattern for two reasons. There may simply be an insufficient number of examples in the data to achieve strong correlation. Or, these items could be impaired in the more severe cases of Broca's. Thus, a wider spectrum or larger number of patients would be needed to demonstrate the effect. In other words, the impairment of these features might appear in the more severe cases not well represented by this data.

The breadth of the data examined, and the relatively small scale of the study are both factors which limit the scale of the conclusions which might be drawn. Nonetheless, the study hints at some important areas of study for future Broca's researchers. First, the study confirms areas of production that are impaired, but not predicted from within the tree pruning hypothesis. The results did not contradict the predictions of the hypothesis, but proved them to be incomplete. The results showing impairment in determiners, as well as the omission of certain arguments, particularly subjects in English is not effectively examined. The contribution Broca's area thus continues to be opaque to a unifying feature of theory.

Methodology and Future Directions

Next, a model of language production that accounted for time dependence would enable these results to be compared more effectively from within the slow-syntax perspective. As of now, no model exists which indicates time-sensitive aspects of production, although such as system would not be improbable. The examination of Broca's production within such a theoretically constrained system deserves attention.

Another encouraging result is the relative interdependence of various elements of production. Such a result suggests that Broca's aphasia is indeed a unified syndrome, not a collection of loosely associated deficits. Given the style of diagnosis, it is possible that Broca's aphasics could have been considered a false group. This does not seem to be the case.

The differences between Broca's aphasia production in German and English suggest two important lines of inquiry. If there exist theoretical differences between how different languages are described (for instance, a widely accepted difference in the ranking of constraints in OT phonology), then these languages might be compared to shed light on the deficits expressed by Broca's. Conversely, differences in Broca's production in different languages could be used to

uncover anomaly that were previously not considered. Thus, a unified theory about Broca's aphasia is helpful from a syntactic as well as a neurological perspective. In neurology, such a unifying theory would give a clue as to the specific contribution of a physical region in the brain. On the other hand, this unifying theory could be used to adjust the descriptions of the syntactic system to better reflect physical realities in the brain.

VI. References

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