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Syntactic frame and verb bias in aphasia: Plausibility judgments of undergoer-subject sentences

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This study investigates three factors that have been argued to define "canonical form" in sentence comprehension: syntactic structure, semantic role, and frequency of usage. We first examine the claim that sentences containing unaccusative verbs present difficulties analogous to those of passive sentences. Using a plausibility judgment task, we show that a mixed group of aphasics performed significantly better on unaccusatives than on passives. We then turn to the observation that passives are generally harder than actives for aphasics. We show that this effect is modulated by lexical bias, i.e. the likelihood that a verb appears in a given syntactic structure: Passives of passive-bias verbs are significantly easier than passives of active-bias verbs. More generally, sentences whose structure matches the lexical bias of the main verb are significantly easier than sentences in which structure and lexical bias do not match. These findings suggest that "canonical form" reflects frequency and lexical biases.

Introduction

The simplicity of "canonical form", or "canonical word order", for normal and aphasic comprehension has often been taken as self-evident in the sentence comprehension literature. However, as has been pointed out by Menn (2000), the privileged status of canonical form itself needs explanation. Different definitions of "canonical form" yield testably different predictions. One approach to the definition of canonical sentence form is that implicit in Bates et al. (1987, *inter alii*). Bates et al. note that sentences with Agent-Action-Object order represent the canonical word order for English. A second approach is based on syntactic "movement" analyses and defines as non-canonical any word order that diverges from the [$_{IP}$NP-[$_{VP}$Verb-NP]] configuration assumed for the deep structure of English sentences. Based on this understanding of canonicity, Kegl (1995) argues that sentences with unaccusative verbs should be difficult to process for aphasic patients, in particular for patients with "agrammatism", for reasons that are analogous to the factors giving rise to the greater difficulty of passives compared to actives. Although the precise definition of unaccusativity is contested (see e.g. Levin and Rappaport Hovav 1995), unaccusative verbs are generally understood to be intransitive verbs whose (surface) subjects represent Undergoer arguments. Examples of unaccusative verbs include verbs like *melt* and *blush*. Under the transformational analysis assumed in Kegl (1995), the surface subjects of unaccusative verbs are linked via movement to direct objects in deep structure. Unaccusatives therefore induce the very same difficulties as passive sentences, according to Kegl's analysis, and should be as hard as passives for aphasic speakers.

A different approach to canonical form has been proposed by Menn et al. (1998) who suggest that canonical form relies on the most frequent syntactic frame *for a given verb*. Under this view, aphasic problems with producing and understanding passives derive from the fact that, for most transitive verbs, passives occur less frequently than actives. One prediction of this approach, also advanced by Gahl (2000), is that comprehension difficulty should vary with the lexical bias of the words in a given sentence, i.e. with the likelihood of a particular word's occurring in a particular type of syntactic frame. For example, active transitive sentences should not be uniformly easy to process. Rather, verbs that are rarely transitive should induce greater comprehension difficulty than verbs that are frequently transitive.

As argued in Menn (2000), the basic assumptions underlying the definition of canonical form have not been seriously tested. Furthermore, most experimental work to date relies on materials in which syntax, semantics, and frequency of usage are confounded: The contrast between actives and passives, for example, has been tested primarily with highly transitive verbs like *kick* and *break*. These verbs are most often used in the active form, so the greater difficulty of their passive counterparts could be due to syntactic, semantic, or frequency factors.

To tease apart the effects of frequency of usage, syntactic structure, and semantic roles, the present paper investigates aphasic comprehension of four types of sentences. In two of the sentence types tested - active transitive, and intransitive with agentive subjects -, the Agent precedes the Undergoer. In the other two sentence types - passive, and intransitive with Undergoer subjects (roughly, unaccusatives) - the Undergoer precedes the Agent. For each of the four types of sentences or syntactic frames, we test verbs that occur frequently in the given frame and verbs that occur infrequently in the frame in question. We are particularly interested in the extent to which matches or mismatches between lexical bias and syntactic structure may be responsible for the observed difficulty of passives, and of unaccusatives compared to passives on the one hand, and to intransitive verbs with agentive subjects on the other.

Materials and Methods

To explore the role of lexical bias in sentence comprehension, we tested four types of syntactic frames: active transitive (T), passive (P), intransitive-undergoer subject (IU; roughly, unaccusative) and intransitive-agentive subject (IA). The method used was judging the plausibility of sentences using verbs with different preferred syntactic frames. We needed several verbs favoring each of the four syntactic frames. As part of a related project reported in Roland et al. (2000), we determined the preferred frames of about 80 verbs from the British National Corpus. This was done by hand-classifying 100 randomly-chosen occurrences of each verb by syntactic frame. Not every verb appeared in all four frames, since not all English verbs alternate between transitive and intransitive forms. We identified those verbs which appeared in at least two of the four frames and showed over 50% preference for one of the four frames. These verbs were considered to have a lexical bias for that frame. About 150 plausible 3-NP sentences were created by combining each verb with one or two noun phrases and at least one prepositional phrase; all of these sentences were 'real-world' irreversible in the sense that interchanging the NPs would result in an implausible sentence. We used each verb in all the frames for which grammatical sentences could be created; a few verbs could be used in all four frames, but most were usable in only two or three. For example, for the verb *slip*, our sentences included *The thief slipped the jewelry into the pocket* and *The jewelry slipped out of the thief's pocket*. An equal number of implausible sentences was created from the same verbs and NPs (with minor modifications in functors, where needed, to avoid having such locally implausible sub-sequences as 'in the table'), e. g. *The jewelry slipped the thief into the pocket*.

A written list of the full set of plausible and implausible sentences was presented in two pseudo-random orders to a pool of undergraduate normal subjects for rating on a scale of 1 to 7; the 149 sentences with extreme ratings (average above 5.6 or below 2.3) – about half of the original set - were then presented to subjects with aphasia for their judgments. There were thirty-two combinations of the four syntactic frames, the verb biases to each of the four frames, and the two levels of plausibility (plausible and implausible). However, seven of the thirty-two cells were empty after the sentences with equivocal plausibility ratings were removed. This necessarily limited the statistical analyses that could be performed.

Each subject with aphasia then individually heard the list of sentences in the same pseudo-random order and was asked to say if each sentence made sense or not. Each sentence was read aloud, and repeated upon request. Actual yes-no responses were written down and later evaluated as correct or incorrect. Two subjects who made too few errors for analysis and one subject who said that all but 5 of the sentences were plausible were excluded from analysis. The remaining eight subjects provide the data analyzed below.

Subjects

The subjects were eight aphasic patients. Testing took place at the University of Arizona and the University of Colorado, Boulder. Background information on the eight aphasic patients is given in Table 2 below.

Results

Analysis of group data

The three questions posed in this study are (1) whether sentences with unaccusative verbs and passive sentences indeed present similar difficulties as predicted by Kegl (1995), (2) whether sentences with Undergoer subjects are generally more difficult than sentences with agentive subjects, and (3) whether comprehension difficulty is influenced by the match or mismatch between syntactic structure and the lexical bias of the verb, as predicted by Menn (2000) and Gahl (2000).

If, as postulated by Kegl (1995), aphasic patients experience difficulties with sentences containing unaccusative verbs that are analogous to those encountered with passives, then these patients should perform equally poorly on the two sentence types. That this is not the case can be seen from Table 1, which presents the total number of correct and incorrect responses from the group of eight aphasic subjects in each condition. A chi-square analysis shows that performance on intransitive-undergoer subject (IU) sentences was significantly better than on passive (P) sentences (χ^2 (187,320) = 21.398, $p < 0.00001$). (In this and all other comparisons, the degrees of freedom for the chi-square tests were one, and the number of trials entering each comparison is presented in parentheses). It might be objected that this finding could simply be due to the fact that intransitive sentences contain only one syntactic argument, whereas passives contain two. To rule out this possibility, we compared performance on IU and intransitive-agentive subject (IA) sentences: If the movement account of unaccusatives is correct, then intransitive sentences with unaccusative verbs should be harder than intransitive sentences with agentive subjects, i.e. sentences that are not subject to any movement operation. That this is not the case can again be seen from a chi-square test comparing the error rates on IU and IA sentences, which are virtually identical (χ^2 (187, 181) = 0.158, $p = 0.691$, n.s.). The fact that performance on intransitive-agent (IA) and intransitive-undergoer (IU) sentences did not differ significantly also fails to support the claim that Undergoer-first sentences should necessarily be more difficult for aphasic patients than Agent-first sentences, as predicted by an approach to canonical form purely based on semantic roles. This answers the second of our three questions.

To check whether the plausibility judgment task is in fact capable of detecting relevant differences in processing difficulty, we also compared patients' performance on active transitive sentences and passives. As was to be expected, active transitive sentences in fact elicited significantly better performance than passives (χ^2 (510, 320) = 23.615, $p < 0.00001$).

	Sentence frame					
Verb bias	**T** (agent subject)	**P** (undergoer subject)	**IA** (agent subject)	**IU** (undergoer subject)	**total**	**sample verbs**
T						
correct	81 (55)	22 (51)	0 (24)	7 (12)	139 (229)	disturb
error	15 (24)	10 (45)	0 (8)	1 (4)	37 (138)	pour
P						
correct	62 (10)	43 (8)	0 (0)	0 (0)	148 (26)	elect
error	10 (14)	5 (16)	0 (0)	0 (0)	20 (46)	injure
IA						
correct	43 (30)	0 (15)	52 (49)	0 (0)	147 (158)	lean
error	5 (9)	0 (9)	4 (13)	0 (0)	13 (53)	walk
IU						
correct	64 (49)	20 (38)	19 (6)	90 (43)	322 (223)	burst
error	8 (31)	4 (34)	3 (3)	9 (21)	40 (147)	float
total correct	250 (144)	85 (112)	71 (79)	97 (55)	756 (636)	
total errors	38 (78)	19 (104)	7 (24)	10 (25)	110 (384)	

Table 1: Total number of correct and incorrect responses from eight aphasic subjects on the plausibility judgment task. The first number in each cell shows the number of correct or incorrect responses on plausible stimuli. The second number (in parentheses) shows the number of correct or incorrect responses on implausible sentences. Highlighted cells represent "concordant" conditions, i.e. ones in which sentence frame and verb bias match.

Turning to our third question, concerning the effect of match between lexical bias and syntactic frame, we find that performance on "matching" (concordant) sentences was significantly better than on nonmatching sentences: (χ^2 (528, 670) = 13.421, $p < 0.001$). This suggests that comprehension difficulty is indeed influenced by match between lexical bias and syntactic structure.

Analysis of data from individual subjects

As is usually the case with data from aphasic patients, there is a considerable amount of between-subject variability. In Table 2 below, we show the results for each individual patient. Several of our subjects showed a tendency towards accepting all sentences as plausible. What is needed is a statistical measure that takes this type of response bias into account in assessing subjects' sensitivity to sentence plausibility. Therefore, in the analysis of individual patients' responses, we adopt the logic and notation of signal detection analysis. Specifically, we use A', a non-parametric index of sensitivity, (Pollack & Norman 1964, Grier 1971), for this purpose.[1] The values of A' range from 0 to 1. A value of 0.5 indicates complete inability to discriminate between two types of events (in our case, plausible and implausible sentences). A value of 1 indicates perfect discrimination of the two types of events. In determining the values for A', we made use of the formula reported in Grier (1971).

[1] Another commonly used statistic for this type of task is d', which we rejected because of the assumptions it requires about the probability distributions underlying subjects' performance (cf. Swets 1973).

For each combination of sentence type and lexical bias, we compare the proportion of plausible sentences which the subject correctly accepts as plausible to the proportion of implausible sentences which the subject falsely accepts. Note that the value of A' is undefined when a subject accepts all stimuli in a set (in our case, when a subject accepts all sentences in a particular condition as plausible).
Two important features of the data can be gleaned from Table 2. First, there is clear evidence of good discrimination ability in all eight subjects, i.e. plausible sentences elicit different responses from implausible ones. Second, the data from individual subjects tend to be consistent with the findings based on pooled group data. Specifically, performance on passive sentences is worse than on intransitive-undergoer subject (IU) sentences. In addition, "concordant" sentences, i.e. sentences whose structure matches the bias of the main verb, tend to elicit better performance than "discordant" sentences, i.e. ones in which there is a mismatch between syntactic structure and lexical bias.

Table 2: Plausibility judgments by eight aphasic subjects, with background information on each patient. The table shows each subject's A', a non-parametric index of sensitivity (see text) in each condition.

		Subject							
Sentence frame	Match	AZ2	AZ5	AZ6	JS	KJ	LM	SK	WK
T	concordant	0.9	0.856	0.716	0.9	0.917	0.855	1	0.655
	discordant	0.75	0.838	0.633	0.849	0.933	0.963	0.933	0.781
IA	concordant	0.857	1	0.917	0.875	0.964	1	0.964	0.909
	discordant	0.9	0.9	0.897	0.85	1	0.767	1	0.9
IU	concordant	0.844	0.784	0.938	0.875	0.879	0.982	0.964	0.795
	discordant	0.875	0.875	-	0.875	1	1	1	0.875
P	concordant	-	-	0.833	0.833	0.75	0.838	-	0.838
	discordant	0.823	0.38	0.624	0.875	0.774	0.894	0.893	0.317
all	concordant	0.857	0.865	0.841	0.879	0.899	0.933	0.941	0.792
	discordant	0.796	0.719	0.708	0.853	0.903	0.926	0.935	0.692

Patient background information:

Patient	Sex	Age[a]	Post-onset[b]	Aphasia diagnosis	Aphasia Severity	Etiology
WK	Female	58	40	Conduction	103[c]	Left CVA
KJ	Female	33	131	Conduction	98[c]	Left CVA
LM	Male	37	6	Broca's	103[c]	Left CVA
JS	Female	54	21	Conduction	103[c]	Left CVA
AZ-2	Male	45	40	Anomic	92.2[d]	Head injury
AZ-5	Female	45	unknown	Anomic	82.1[d]	Gunshot wound
AZ-6	Male	70	37	Broca's	15.7[d]	Left CVA
SK	Female	78	168	Broca's	3 BDAE	Left CVA

[a]Years
[b]Months
[c]As measured by the aphasia diagnostic profiles (ADP; Helm-Estabrooks, 1992)
[d]As measured by the Western Aphasia Battery (WAB, Kertesz 1982)

General Discussion

The three questions posed in this study were whether sentences with unaccusative verbs and passive sentences indeed present similar difficulties, whether sentences with Undergoer subjects are generally more difficult than sentences with agentive subjects, and whether comprehension difficulty was influenced by the match or mismatch between syntactic structure and the lexical bias of the verb. We discuss these three questions in turn.

Kegl (1995) found that story narratives by several agrammatic speakers contained fewer unaccusatives than similar narratives by normal speakers. Since unaccusatives are transformationally derived in the syntactic framework assumed in Kegl (1995) (and other transformational theories), Kegl hypothesized that agrammatic aphasics should have problems with unaccusatives that paralleled their difficulties with passives, and interpreted the near-absence of unaccusative verbs in their narratives as confirming this hypothesis. We found that performance on unaccusatives was significantly better than performance on passives, and that performance on unaccusatives was not significantly different from performance on intransitive sentences with agentive subjects. These findings constitute a challenge for Kegl's account, and more generally for purely syntactic approaches to explaining patterns of aphasic miscomprehension. Similarly, Gottfried et al. (1997) showed that aphasic speakers had equal difficulty in repeating sentences whose subjects were Agents and sentences whose subjects were Undergoers, again challenging the claim that the derivation of unaccusatives poses particular problems for aphasics.

It might be objected that Kegl's claim pertained specifically to agrammatic patients with Broca's aphasia, and that our data from a mixed patient group therefore do not constitute a direct challenge. Indeed, it is theoretically possible that agrammatic patients with Broca's aphasia have difficulties with unaccusatives and passives for reasons that do not apply to other patient groups. However, we do not think that the comprehension patterns that have been observed for aphasic patients in general offer sufficient motivation for setting "agrammatic" patients with Broca's aphasia apart from all other patients (see e.g. Goodglass & Menn 1985, Berndt et al. 1996).

An alternative explanation for the near-absence of unaccusative verbs in Kegl's data suggests itself: In general, narratives from speakers with aphasia encode considerably less information than those from unimpaired speakers. At the same time, aphasic speakers do have an accurate sense of what the key elements of a story are; thus, these speakers tend to encode the main line of action in a story, leaving out the background and less important items (Menn et al. 1998, 1999). For most stories, this entails reporting the actions of a small set of agonists, which tend to get encoded as agentive subjects or, in the case of Undergoers, as objects. Hence, we would expect verbs with Undergoer subjects to be proportionately less frequent in aphasic narratives, unless the plot has been chosen to highlight events that are not under the protagonist’s control.

With regard to our second question, while our approach has much in common with the semantic-role based account of canonical form, our findings do not support the hypothesis that sentences with undergoer subjects are uniformly more difficult than sentences with agentive subjects. Semantic roles are indeed important predictors of sentence comprehension difficulty, as long as lexical bias is also taken into account.

With regard to our third question, we found that performance on "matching" (concordant) sentences was significantly better than on nonmatching sentences. We conclude from this that syntactic structure alone does not adequately account for comprehension difficulty: the match between syntactic structure and verb bias needs to be taken into account. Our findings confirm those of Gahl (2000). This earlier study tested three sentence types (active transitive, passive, and intransitive-undergoer subject), with similar results as the present study. Thus, the results of the present study add to a growing body of evidence that aphasic sentence comprehension reflects usage-based and exposure-based factors also known to influence normal comprehension. In the future, we plan to examine the effect of lexical bias in aphasic patients' speech, using elicited speech. We believe that, despite the care taken in this study to include only 'natural-sounding' sentences in the experiment, patients' speech affords a look at more natural data.

As stated earlier, the notion of 'canonical form' has variously been defined in purely syntactic or purely semantic terms. Kegl (1995) is consistent with a purely syntactic approach to defining canonical form, whereas the work of Bates et al. (1987) represents an approach to canonical form that is based on semantic roles. Our findings support an alternative approach to the definition of canonical word order, one that takes syntactic, semantic, and frequency-based factors into account.

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