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Verb preference effects in the sentence comprehension of fluent aphasic individuals

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Abstract

This investigation examined sentence processing of fluent aphasic subjects with varying severity levels. Subjects performed a cross-modal lexical decision task for transitive and intransitive verbs in preferred and non-preferred frameworks. Verb processing was measured by reaction times during on-line sentence comprehension. Reaction times to the cross-modal lexical decision (CMLD) task indicated that the subjects with aphasia were insensitive to preference information associated with the processing of verbs in sentences. Severity level did not alter the pattern observed regarding verb type and preferences.

Introduction

Most accounts of sentence processing include a privileged role for a verb's argument structure. Arguments, briefly, refer to the participants required by the verb; arguments are often associated with noun phrases (NPs) in the sentence. On some accounts argument structure also includes the thematic roles (e.g. Agent, Patient) associated with these arguments. For example, the verb *watched* allows a two-place argument structure, as in 'Scott watched Lola', whereby the NP *Scott* is a subject argument serving the role of Agent and *Lola* is the direct object argument serving the role of Theme. Several psycholinguistic studies have found that as the verb is encountered in a sentence, its argument structure properties are activated (e.g. Shapiro *et al.* 1987, 1991; see also Tanenhaus *et al.* 1989, 1990), and might be used to help determine the grammatical relations (subject, object) in a sentence (McElree 1993).

Argument structure can, in principle, be used for subsequent sentence analysis as well. Indeed, a few studies have shown that verbs appear to have a particular argument structure that is preferred, even though the verb might be compatible with more than one argument structure (Connine *et al.* 1984, McElree 1993, Shapiro *et al.* 1993a). For example, the verb *watched* is more likely to prefer an NP complement than a prepositional phrase (PP) complement (Connine *et al.* 1984,

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McElree 1993); that is, the verb *watched* prefers sentence (1) over sentence (2), with preference determined by off-line judgements:

(1) John watched the man.
(2) John watched with the man.

In studies examining how subjects use such off-line preferences, the most preferred structure appears to take precedence over the other possibilities and is used in the initial stages of sentence processing (Clifton *et al.* 1984, Shapiro *et al.* 1993a, Trueswell *et al.* 1993). That is, given a particular verb, the processor uses preference information to help with subsequent sentence analysis; on one strong account, such preference is used to predict what might come up next in the sentence (MacDonald *et al.* 1994). Using (1) and (2) as examples, if the verb *watched* prefers an NP complement, then when the head of that complement (*the*) is encountered, processing should continue unabated. But, if the head of the prepositional phrase (e.g. *with*) is encountered instead, as in (2), the processor will be 'surprised' and processing load will increase. It is the 'surprise effect' that we intend to exploit in our experiment.

Argument structure information also appears important to aphasic language processing. Shapiro and colleagues (Shapiro and Levine 1990, Shapiro *et al.* 1993b) investigated the influence of argument structure on sentence comprehension of subjects with Broca's aphasia and varieties of fluent aphasia. As with normal subjects, subjects with Broca's aphasia showed sensitivity to the number of different argument structure possibilities a verb allowed, whereas fluent aphasic patients treated verbs with different argument structures similarly, suggesting an insensitivity to this lexical information.

The purpose of the following study, then, was to assess whether or not a fluent aphasic patient's initial insensitivity to argument structure would affect her sensitivity to preference information that refers to argument structure. That is, given that (i) normal listeners appear to use argument structure preference information on-line during sentence comprehension and (ii) fluent aphasic patients are not normally sensitive to the argument structure properties of verbs, do these brain-damaged patients thus show a subsequent insensitivity to preference information? In essence, then, the focus of the present experiment was to assess whether or not there is a difference in the sentence processing of patients with fluent aphasia when the verb appears in either its preferred or non-preferred structure. If these subjects do not show such a difference, then this 'deficit' might ramify throughout the comprehension system, affecting the ultimate interpretation of sentences.

In order to address these issues, a cross-modal lexical decision (CMLD) task was used in this experiment. Subjects were seated in front of a computer monitor and were presented with sentences like the following over headphones:

(1) The ageing pianist taught his * solo with great dignity.
(2) The ageing pianist taught with his * entire family.

Note that in this example, the verb *taught* prefers to be in a transitive slot (based on normative data). That is, the verb prefers (1) where there is a direct object argument (noun phrase; *his solo*) following the verb over (2) where the verb is used intransitively, without such a direct object argument.

During the temporal unfolding of each sentence, a visual probe consisting of a

sequence of letters appeared momentarily on the monitor. The probe either formed an English word or a non-word. Subjects were required to attend to the sentence and to make a lexical decision (Word/Non-word) on the visually presented probe. Reaction times (RTs) to the lexical decision were recorded. In the test sentences, the visual probe was introduced in the immediate temporal vicinity of the item that disambiguates the structure as being a transitive or intransitive sentence (that is, in (1) immediately at the offset of the pronoun signalling a direct object, or immediately after the preposition in (2) signalling an intransitive use of the verb. The placement of the probes above is signified by the * in the examples). The sentence continued to be played over the headphones unabated.

The idea here is that if a listener is sensitive to the argument structure preferences for a verb, then RTs to the visual lexical decision should increase when the verb is placed in its *non-preferred* slot relative to RTs when the verb is placed in a preferred sentence. In essence, processing load will increase (and hence so will RTs to the secondary lexical decision) when the listener encounters the unexpected non-preferred structure.

We therefore predict that if fluent aphasic listeners are not sensitive to the argument structure properties of verbs and, hence, are insensitive to the argument structure preference, then they should not evince an increase in RTs to the lexical decision in the non-preferred structure relative to the preferred, unlike our control subjects who should show the normal pattern exhibited by the subjects in Clifton *et al.* (1984) and Shapiro *et al.* (1993a).

Method

Subjects

Ten subjects participated in this investigation, five subjects with aphasia and five normal controls. The subjects ranged in age from 52 to 82. The group mean age was 66·6 for the subjects with aphasia and 61·2 for the controls. Months post-onset of stroke ranged from 18 to 26 months for the subjects with aphasia. All subjects were native speakers of English. All subjects passed a pure tone hearing screening bilaterally at 40 dB HL. All subjects had use of their preferred right limb. Handedness was confirmed by the administration of the Edinburgh Handedness Inventory. Subject information is presented in table 1.

Each subject with aphasia had experienced a single stroke restricted to the left hemisphere. Subjects with aphasia had no previous history of neurological impairments. Furthermore, subjects with aphasia included in this experiment were not currently receiving any rehabilitation. The controls had no neurological medical history. No subjects demonstrated visuo-perceptual deficits as supported by the administration of the agnosia subtests of the test instrument Examining for Aphasia (Eisenson 1994). No subject demonstrated evidence of a right hemianopsia via informal observations during the administration and completion of tasks.

All aphasic subjects were administered portions of the Boston Diagnostic Aphasia Examination (BDAE). All subjects presented with characteristics consistent with fluent aphasia. Characteristics included fluently articulated speech with inconsistent paraphasias and various levels of impaired auditory comprehension, repetition and naming. Mean scores of the comprehension subtests on the BDAE ranged from the 40th to the 97th percentile. Each subject demonstrated comprehension and repetition impairments of varied severity (see table 2).

Table 1. Subject information

Subjects	Age	Gender	Months post-onset
Aphasia			
1	65	M	18
2	74	F	21
3	52	F	26
4	67	M	19
5	75	F	21
Normal			
6	58	F	
7	82	F	
8	60	F	
9	53	F	
10	53	M	

Table 2. Percentile scores for aphasic subjects on selected Boston Diagnostic Aphasia Examination subtests

Subtest	Subject				
	1	2	3	4	5
Fluency					
Articulatory agility	70	50	70	60	70
Phrase length	70	70	70	70	70
Auditory comprehension					
Word discrimination	100	80	100	90	95
Body part identification	100	90	100	90	100
Commands	90	50	80	65	90
Complex ideational material	100	90	65	80	100
Verbal expression					
Word repetition	100	50	50	90	90
Phrase repetition	100	50	45	77	90

Table 3. Example sentences

Verb preference	Sentence type	Sentence
Transitive	Transitive	The ageing pianist taught his solo with great dignity
Transitive	Intransitive	The ageing pianist taught with his entire family
Intransitive	Intransitive	The ageing pianist performed his solo with great dignity
Intransitive	Transitive	The ageing pianist performed with his entire family

Materials

The sentences for this investigation included optionally transitive verbs (those that allow either a transitive or intransitive reading) in their preferred and non-preferred frameworks. The stimuli were composed of 48 test sentences (12 per framework) and 80 foils, yielding 128 sentences altogether. Table 3 provides examples of each of these sentence types. The sentences were used originally by Clifton, Frazier, and Connine (1984) as well as by Shapiro *et al.* (1993a) in their

studies of verb preferences. Again, the lexical information of a verb may include preferences for certain complements over others. Originally, Connine *et al.* (1984) demonstrated preferences for frameworks associated with verbs in normal subjects. The verb frame preferences were then used to create the materials for experiments considering the effects of verb preferences on comprehension.

Visual probe stimuli for the CMLD task were presented with each sentence and consisted of English words and non-English words. The visual probe stimuli were composed of 68 English words and 60 non-words, yielding a total of 128 visual probes (Shapiro *et al.* 1993a). The stimuli ranged from six to 12 letters in length per word. The non-words were derived by changing a letter or two in an English word. The meaning of the visual probe stimuli did not facilitate or relate to the sentence being processed by the subject. The visual probe was introduced in the vicinity of the verb (see examples in description of CMLD task) during the temporal unfolding of the sentence for all test sentences (Shapiro *et al.* 1993a). The position of the visual probe varied across foil sentences to prevent subject expectations regarding probe position.

Procedure

Reaction times acquired during the cross-modal lexical decision task provided information regarding the processing complexity of the preferred and non-preferred frameworks presented as stimuli. The subjects were initially required to respond to practice visual probe stimuli to ensure comprehension of the lexical decision component of the experiment. The most comfortable loudness level was determined during the practice portion of the experiment. Sentences were presented to the subjects binaurally via headphones at the most comfortable loudness level for each subject. Simultaneously, a visual probe was presented on the computer screen at a particular point chosen in the sentence. The subjects were required to judge whether the 128 visual probes formed a word in English by pressing one of two response keys indicating yes or no. The visual probes were not utilized more than once during the experiment. The subjects were encouraged to respond as rapidly and accurately as possible to the visual stimuli and maintain a consistent hand placement on the response key box. Sentence comprehension was probed by randomly choosing trials for which the subjects were asked simple yes/no questions about the sentence they just heard.

Analysis

Reaction times (RTs) were organized into preferred and non-preferred sentence frames for each verb based on preferences demonstrated by Clifton *et al.* (1984). RTs associated with incorrect lexical decisions to visual probes or sentences that were comprehended incorrectly using the yes/no questions were excluded from further analyses. That is, correct responses to the lexical decision and correct answers to the yes/no question asked on randomly selected sentences were included in subsequent analyses. Approximately 36% of the responses produced by aphasic subjects were errors; these were distributed nearly evenly across the subjects. Thirteen per cent of normal subjects' responses contained errors. The RTs which exceeded 2000 ms also were excluded from the analyses because RTs of this magnitude were thought no longer to reflect sentence processing at the point

Table 4. Mean reaction times (ms) to CMLD task for preferred and non-preferred sentence frameworks

Subject group	Preferred	Non-preferred
Aphasia		
1	1015·46	947·23
3	996·13	1107·67
4	1359	1239·75
5	1256·13	1108·38
Mean	1156·68	1100·76
SD	179·39	119·72
Normal		
6	857·74	979
7	1177·75	1383
8	1194·6	1314·1
9	770·24	800·14
10	967	933·74
Mean	993·47	1082
SD	189·32	253·23

of the visual probe. Subject No 2 was excluded from further analysis because all of her RTs exceeded 2000 ms. For each of the remaining subjects, data points that were more than two standard deviations above the mean for a particular variable (preferred, non-preferred) were replaced by the overall subject mean. About 2% of the data were eliminated based on this criterion. These responses generally were evenly distributed across both sentence types.

Because of our specific interest in paired comparisons, that is, verbs in their preferred versus their non-preferred sentence frameworks, only those verbs for which both the preferred and non-preferred cells were filled were entered into the statistical analysis. For example, if subject 1 had an 1100 ms RT for a verb in its preferred context but made an error on its non-preferred counterpart, that comparison was removed from further analyses.

Results

The mean reaction times to the CMLD task for the aphasic and normal subjects by preferred and non-preferred sentence frameworks are presented in table 4. Separate *t*-tests for unequal variances were computed for each group and demonstrated that the normal subjects responded significantly faster ($p = 0{\cdot}049$) for preferred versus non-preferred sentences while the aphasic subjects showed no statistical effect ($p = 0{\cdot}20$). To allow a direct comparison between the two groups, difference scores for the RTs to non-preferred and preferred sentences were calculated and subjected to a *t*-test for unequal variances (see table 5). Again, normal subjects responded significantly faster ($p = 0{\cdot}045$) to preferred versus non-preferred sentences than did the aphasic subjects. Visual inspection of the data for the individual subjects supported these group findings. Four of the five normal subjects showed faster RTs for the preferred sentences when compared to the non-preferred sentences while only one aphasic subject demonstrated this predicted difference. Severity of aphasia also appeared to exert a negligible effect on these findings (see table 6).

Table 5. Difference scores (non-preferred RTs – preferred RTs) based on CMLD task for aphasic and normal subjects

Subjects	Difference scores
Aphasia	
1	−68·23
3	111·54
4	−119·25
5	−147·75
Mean	55·92
Normal	
6	121·26
7	205·25
8	119·5
9	29·9
10	−33·26
Mean	88·53

Table 6. Mean reaction times (in ms) to CMLD task for aphasic subjects by level of severity

Severity level	Preferred	Non-Preferred
Mild		
1	1015·46	947·23
5	1256·13	1108·38
Mean	1135·79	1027·80
Moderate		
3	996·13	1107·67
4	1359	1239·75
Mean	1177·56	1173·71

Discussion

It has been suggested that lexical and syntactical information related to the verb guides sentence processing operations. The verb is considered to be a critical component in the temporal unfolding and processing of sentences. In normal subjects, studies have demonstrated that verbs which allow numerous argument structure possibilities result in greater interference and processing complexity, yielding slower reaction times (Shapiro and Levine 1990). Verb type has also been shown to affect sentence processing in normal subjects. Pure transitive verbs yield faster reaction times than other verb types (Shapiro *et al.* 1993a). Furthermore, Connine *et al.* (1984) found that normal subjects also demonstrate preferences for the frameworks associated with these verbs. Such preferences activate thematic information required for normal operation of the sentence processing system (Shapiro *et al.* 1987, 1991). Considering that these characteristics are present in normal subjects, similar sensitivity to verb type and structural framework might be expected in subjects with aphasia.

The data from the control subjects support research suggesting that lexical and syntactical information related to the verb guides sentence processing operations.

Preferred frameworks associated with a verb are initially parsed, guiding normal operation of the sentence processing system. Verbs in non-preferred frameworks yielded slower reaction times, indicating greater interference and processing complexity during sentence processing of verbs in non-preferred structural frameworks.

The data from the subjects with aphasia suggest that, unlike the controls, they are not sensitive to this particular type of lexical information. Shapiro and Levine (1990) and Shapiro *et al.* (1993a) have previously shown that fluent aphasic patients are not sensitive to the argument structure properties of verbs. In a sense, these data corroborate this finding and further suggest that access to lexical information and the utilization of this information is compromised. That is, subjects with aphasia do not use argument structure to assist with comprehension of sentences after lexical information associated with a verb is activated.

Furthermore, the subjects did not show normal sensitivity to the thematic properties associated with particular verbs, that is, they did not show the normal thematic representations reflecting the verbs preferred argument structure arrangement. This suggests that the normally preferred framework associated with a particular verb may no longer be parsed initially during sentence processing routines in subjects with comprehension impairments due to aphasia. That is, the normally preferred framework for a verb is not projected as the initial parse during sentence processing, or an insensitivity to preference exists in subjects with fluent aphasia.

In addition, the severity of the comprehension impairment in the subjects with aphasia did not alter the pattern observed regarding preferences for structural framework. Qualitative distinctions were not observed in the manner by which individuals with aphasia process verbs in their preferred and non-preferred frameworks when analysed informally according to aphasia severity. Regardless of severity, the majority of subjects did not show faster reaction times to the preferred frameworks. A slight quantitative pattern was observed with regard to the level of severity and reaction time measurement. The reaction times to the cross-modal lexical decision task were slower with greater severity. This suggests that either the access of lexical information, the utilization of this information, or a combination of both, are further compromised with greater levels of severity. However, the product of these computations is not affected and the sentences are processed in a similar way.

The results of this investigation may contribute to the development of clinical materials for aphasic individuals with comprehension impairments. Clinicians may be able to determine argument structure preferences for various verb types. As such, comprehension training may be facilitated when the verb preferences are assimilated into treatment procedures. At the initial level, materials might be developed to follow verb preferences and proceed to non-preferred frameworks as a means of increasing complexity. Future research further probing the activation of thematic information and the representation once it has been accessed might be beneficial in developing successful treatment protocols for individuals demonstrating comprehension impairments. Treatment programmes controlling the lexical properties of verbs and sentences may assist in reducing the comprehension impairments in fluent aphasic subjects, especially when one considers research which indicates that thematic information and lexical preferences associated with particular verbs are required for the activation of the sentence processing system.

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