Deficits in thematic integration processes in Broca’s and Wernicke’s aphasia

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Abstract

This study investigated how normal subjects and Broca’s and Wernicke’s aphasics integrate thematic information incrementally using syntax, lexical-semantics, and pragmatics in a simple active declarative sentence. Three priming experiments were conducted using an auditory lexical decision task in which subjects made a lexical decision on a ‘target’ (the last word of each sentence) preceded by a ‘prime’ (a subject noun phrase and verb). The presence and magnitude of priming was compared to a baseline condition in which non-words systematically replaced real word primes. Normal subjects showed evidence for combinatorial thematics by exhibiting significant and larger amounts of thematic priming in the condition where two real words were present in the prime than in the conditions in which only one real word was present in the prime. Additionally, normal subjects showed sensitivity to both syntactic structures and pragmatics. In contrast, Broca’s patients did not show significant priming for any condition nor did they show a difference in the magnitude of priming among the conditions. Nonetheless, they showed sensitivity to pragmatics. Wernicke’s patients showed significant priming for all conditions, but did not show differences in the magnitude of priming among the conditions. However, they showed sensitivity to sentence grammaticality and pragmatics. The distinct patterns of performance of Broca’s and Wernicke’s aphasics are discussed in terms of the nature of their impairments in the processes of combinatorial thematics.

Keywords: Thematic information; Sentence processing; Broca’s; Wernicke’s; Aphasia; Pragmatics; Syntax; Semantics

1. Introduction

Sentence understanding requires the integration of syntactic, semantic, and pragmatic information. Such integration processes require establishing a relationship between the morpho-syntactic structure of a sentence, the thematic roles that words play in the sentence, and real world knowledge.

Among a number of sentence processing models, Haarmann, Just, and Carpenter’s (1997) computational model takes into account ‘incremental processes of thematic role assignment.’ The model is designed to parse sentences by incrementally assigning thematic roles based on the syntactic information of an argument structure specified in a verb. Nonetheless, the model builds up the argument structure of a sentence without recourse to the semantic properties of lexical items in a sentence and their pragmatic relationships. Thus, the model predicts the same pattern of performance regardless of the semantic meaning of the nouns and thematic relationship with the verb in a sentence.

Eye-tracking reading studies with normal subjects (Boland, Tanenhaus, Garnsey, & Carlson, 1995; McRae, Ferretti, & Amyote, 1997; Tanenhaus, Carlson, & Trueswell, 1989; Trueswell, Tanenhaus, & Garnsey, 1994), however, have shown that subjects make use of subtle lexical and pragmatic information in assigning thematic roles to nouns as they are interpreting sentences. These results suggest that both lexical and pragmatic information influences the process of thematic role assignment and may affect processes of the syntactic information used in thematic role assignment.
Normal studies of lexical access in sentential contexts provide evidence that both lexical information and syntactic information are integrated on line (Duffy, Henderson, & Morris, 1989; Foss, 1982; Masson, 1986; Morris, 1994; O’Seaghdha, 1989; Simpson, Peterson, Castell, & Burgess, 1989; Stanovich, Nathan, West, & Vla-Rossi, 1985; Stanovich & West, 1981). As an example, when two semantically related words were placed in a grammatical and an ungrammatical sentence, e.g., ‘he writes the letter’ and ‘the writes he letter,’ respectively, facilitation was observed only in the grammatical sentence (Foss, 1982; Masson, 1986; O’Seaghdha, 1989; Simpson et al., 1989). This indicates that facilitation results from the integration of both lexical and syntactic information.

A great deal of research has explored the nature of sentence processing impairments in aphasia. Most have focused on potential impairments in components of the grammar. Few, however, have investigated whether the deficits lie in the processes of integration of information in the course of sentence processing. A few studies have considered this question. Tyler, Moss, Patterson, and Hodges (1997) reported on a patient with progressive fluent aphasia who exhibited a gradual deterioration in combining the meanings of words in a sentence as well as in combining an adjective and a noun to compose a new pragmatic concept. Similarly, Pinango and Zurif (2001) observed that Wernicke’s aphasics exhibited impairments in compositional semantics determined by the integration of lexical conceptual structures in a sentence. These same patients showed preserved understanding of individual word meanings. Although Pinango and Zurif found that Broca’s aphasics were generally similar to normals, recent electrophysiological data suggest that both Broca’s and Wernicke’s aphasics have lexical integration deficits during sentence comprehension (Hagoort, Brown, & Swaab, 1996; Swaab, Brown, & Hagoort, 1997, 1998). Taken together, these results suggest that both Broca’s and Wernicke’s aphasics may have deficits in thematic integration processes.

The current study investigated thematic integration processes to see how normal subjects and both Broca’s and Wernicke’s aphasics patients combine syntactic, semantic, and pragmatic information that indicates a thematic structure of a sentence. Specifically, this research explored how syntactic, semantic and pragmatic information from a subject noun, verb, and object noun within a simple active declarative structure is integrated on-line. To this end, a series of experiments was designed to explore whether sentence grammaticality and the pragmatics of an agent argument-verb relationship influence combinatorial theamics.

Experiments were designed to elicit subjects’ implicit knowledge about thematic structures, using an auditory priming paradigm. In this paradigm, subjects were asked to make a lexical decision on a ‘target’ (the last word of each sentence), preceded by a ‘prime,’ which was the thematic structure established by the integration of information in a subject noun phrase and verb. The assumption was that the recognition of the last word (the object noun) would be influenced by combinatorial theamics of the subject noun phrase and the verb. If a target word is associated with the thematic structure built up by combining information in the subject noun phrase and in the verb, faster response time latencies should emerge in the lexical decision task compared to a baseline.

Three separate experiments were conducted. The first explored how subjects build up thematic structures combining lexical, syntactic, and pragmatic information in a simple active declarative sentence. The second investigated the influence of syntactic information, and the third investigated the influence of pragmatic information.

2. Study I: Sentential thematic priming in normal subjects

2.1. High Cloze—Syntactic experiment

The aim of this experiment was to investigate processes of combining thematic information from a subject noun phrase and verb with pragmatic information that had a high probability bias to build up a thematic structure of a sentence. Thematic information arises from lexical meaning in conjunction with verb semantics, syntactic structures, and pragmatics. For instance, in the sentence, ‘the bartender is kicking out the drunk,’ the lexical meaning of the word ‘bartender,’ (e.g., ‘barkeeper’), is combined with verbal semantic information from the verb ‘kick out,’ (e.g., ‘reject, dismiss’: ‘the Agent must be sentient,’ and ‘the Theme must be mobile’). The thematic information of the syntactic structure such that ‘the subject noun is the Agent and the object noun is the Theme’ is also combined to identify the word ‘bartender’ as the subject of this sentence, and thus, the Agent. All of this information is combined with pragmatic information, providing some conceptual constraints about thematic structures based on real world-knowledge, (e.g., ‘a bartender is likely to see an unpleasant customer to the door’). The combined information will build up a thematic structure that involves the Theme ‘drunk.’ The word ‘drunk’ is strongly associated with the thematic structure; but, it is only weakly associated with each of the words individually, ‘bartender’ or ‘kick out.’

1 In this paper, the terms Agent and Theme are used to refer to semantic roles associated to a subject noun and an object noun, respectively.

2 Results from pretests conducted for the creation of the test sentences indicated that the probability of the association between subject nouns, e.g., ‘bartender,’ and object nouns, e.g., ‘drunk,’ was 3.6%; between verb clusters, ‘is kicking out the’ and object nouns, e.g., ‘drunk,’ was 4.6%; and between incomplete sentences, e.g., ‘the bartender is kicking out the,’ and object nouns, e.g., ‘drunk,’ was 65.3%.
2.1.1. Method

2.1.1.1. Stimuli. Simple active declarative progressive sentences were constructed. In all sentences, ‘the-N-is-ving-the’ was the prime, e.g., ‘The bartender is kicking out the,’ and the final noun was the target, e.g., ‘drunk.’ For all sentences, the prime was strongly associated with the target identity. Thus the sentences had a high Cloze probability\(^3\) (Taylor, 1953) (average 65.3%). A list of the 36 sentences is shown in Appendix A.

Four priming conditions were created: two real content words were in the prime, e.g., ‘the bartender is kicking out the,’ (Real word−Real word−Target: RRT); a real word subject and a non-word verb were in the prime, e.g., ‘the bartender is thazing out the,’ (RNT); a non-word subject and a real word verb were in the prime, e.g., ‘the quajeter is kicking out the,’ (NRT); and two non-words were in the prime, e.g., ‘the quajeter is thazing out the,’ (NNT). The NNT condition served as the baseline. For all four conditions, the target word was identical, e.g., ‘drunk.’ All non-words in the experiment were phonologically permissible in English.

The average word frequencies for subject nouns and verbs were 79.6 and 157.4, respectively (Francis & Kučera, 1982). A t test showed no difference between the two groups, \(p = .11\). The average word length, in terms of the number of syllables, for subject nouns and verbs were 2.53 and 2.78, respectively. A t test showed no difference between the two groups, \(p = .23\).

In addition to the test stimuli, 36 distracter sentences and four practice sentences were developed. Distracter sentences were in different syntactic structures from the structure used in the test sentences. Half of the distracter sentences were in the passive voice and contained adjectives or adverbs, and half were in the active voice and also contained adjectives or adverbs. All distracter and practice sentences described events that were likely to occur in the real world. Four conditions (RRT, RNT, NRT, and NNT) were also created for the distracter and practice sentences.

For all test sentences, and distracter and practice sentences, equivalent conditions were created using non-word targets. Thus, the experimental list consisted of 144 trials with 72 test sentences and 72 distracter sentences, each of which consisted of 36 ‘word’ responses and 36 ‘non-word’ responses.

The sentence stimuli were recorded on to a DAT tape by a female native speaker of American English. All the test stimuli including sentences containing non-word stimuli were read in a ‘careful reading’ style with a natural sentential prosody. The recorded stimuli were sampled into words. Each word was acoustically edited and a separate audio file was created. In order for a subject to listen to acoustically the same material, the same audio files that corresponded to the verb phrase fragment and the object noun were used across all the four conditions. Each audio file was connected with a 50 ms silence interval between adjacent files to make a sentence. Thus, the inter-stimulus interval (ISI) between a prime and a target was 50 ms. The inter-trial interval (ITI) was 3 s; and the maximum waiting time was 5 s.

2.1.1.2. Participants. Twelve native speakers of English from the Brown University community (8 female, 4 male; mean age = 26.9 years) participated. No participants had hearing or language impairments.

2.1.1.3. Procedure. Test sentence stimuli were divided into four blocks (A, B, C, and D). Three different subjects were assigned to each block. No subject heard the same prime more than once, and each subject heard all target words and all conditions.

Subjects sat in a sound-attenuated room and heard stimulus sentences through headphones. Subjects were instructed to listen to each sentence very carefully from the beginning to the end and indicate whether the last word of each sentence was a real word or not by pressing one of two buttons labeled either ‘Word’ or ‘Non-Word.’ It was emphasized that it was important to listen to the whole sentence carefully and press a button as quickly as possible without making mistakes. Response time latencies (RTs) and decision accuracy were recorded. RTs were recorded from the off-set of the target words.

For each subject, the presentation of 144 trials was randomized and controlled by a subject-testing program, AVRunner of BLISS (Mertus, 2000). Subjects were informed, before the trials, that they could request a break during the experiment. Half-way through the experiment, subjects were asked if they needed to take a break. Some took 3–10 min breaks, and others did not take any. Each experiment lasted approximately 17 min.

2.1.2. Results

Mean percent correct lexical decision responses was 99, 100, 100, and 99% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA (Integration) revealed no significant differences among the conditions, \(F(3, 33) = .647, p_1 = .590; F(3, 105) = .660, p_2 = .578\).

There were two measures of interest in the reaction-time data. The first was the presence of priming in the three test conditions (NRT, RNT, and RRT) relative to the baseline (NNT) condition. The second measure was the potential difference in the magnitude of priming among the conditions. The magnitude of priming was determined by subtracting the RT difference in the

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\(^3\) A Cloze probability represents the probability of saying a word given one or several preceding word(s) (see Taylor, 1953).
baseline condition (NNT) from each of the test conditions (RRT, NRT, and RNT).

Table 1 shows the mean RTs and standard deviations (ms) for each condition. In order to determine if there was a priming effect for each condition, RTs for correct responses for the test target items were submitted to a one-way repeated measure ANOVA. Results showed a significant effect, $F(3, 33) = 8.875$, $p_1 = .0002; F(2, 3, 105) = 8.005, p_2 = .0001$. Pair-wise means comparisons revealed that compared to the baseline (NNT) condition, subjects responded faster in the RRT condition, $p_1 = .0001, p_2 = .0001$, and marginally faster in the NRT condition, $p_1 = .0440, p_2 = .0623$.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measure ANOVA was significant, $F(2, 2.22) = 6.960$, $p_1 = .0046; F(2, 7.0) = 6.588$, $p_2 = .0024$. Pair-wise means comparisons showed significant differences between the RRT condition and the NRT condition, $p_1 = .0092, p_2 = .0086$; and between the RRT condition and the NRT condition, $p_1 = .002, p_2 = .001$.

In summary, normal subjects showed evidence for combinatorial thematics by exhibiting significant facilitation for the RRT condition, in which a real word subject noun and verb were present in the prime, as well as a greater magnitude of priming for the RRT condition than either the NRT or the RNT conditions, in which only one real word was present in the prime (i.e., a subject noun for NRT and a verb for RNT). These results indicate that the facilitation observed for the RRT condition is not due to an intra-lexical priming effect of the subject noun or verb with the target, but can rather be attributed to the integration of thematic information derived from the subject noun phrase, and verb.

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**Table 1**

Mean response times (ms) and standard deviations (ms) as a function of condition for normal subjects and aphasic patients in the three experiments

<table>
<thead>
<tr>
<th>Condition</th>
<th>NNT</th>
<th>NRT</th>
<th>RNT</th>
<th>RRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cloze—Syntactic</td>
<td>383 (130)</td>
<td>331 (151)</td>
<td>347 (163)</td>
<td>258* (148)</td>
</tr>
<tr>
<td>High Cloze—Asyntactic</td>
<td>398 (165)</td>
<td>372 (137)</td>
<td>421 (173)</td>
<td>427 (203)</td>
</tr>
<tr>
<td>Low Cloze—Syntactic</td>
<td>407 (142)</td>
<td>377 (162)</td>
<td>432 (173)</td>
<td>425 (158)</td>
</tr>
<tr>
<td>Broca’s aphasics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cloze—Syntactic</td>
<td>445 (141)</td>
<td>435 (166)</td>
<td>424 (140)</td>
<td>395 (151)</td>
</tr>
<tr>
<td>High Cloze—Asyntactic</td>
<td>437 (198)</td>
<td>389 (124)</td>
<td>409 (133)</td>
<td>450 (206)</td>
</tr>
<tr>
<td>Low Cloze—Syntactic</td>
<td>389 (188)</td>
<td>374 (142)</td>
<td>397 (142)</td>
<td>412 (138)</td>
</tr>
<tr>
<td>Wernicke’s aphasics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cloze—Syntactic</td>
<td>760 (372)</td>
<td>640* (285)</td>
<td>587* (212)</td>
<td>634* (301)</td>
</tr>
<tr>
<td>High Cloze—Asyntactic</td>
<td>655 (262)</td>
<td>683 (396)</td>
<td>680 (282)</td>
<td>640 (224)</td>
</tr>
<tr>
<td>Low Cloze—Syntactic</td>
<td>650 (340)</td>
<td>640 (331)</td>
<td>643 (284)</td>
<td>676 (381)</td>
</tr>
</tbody>
</table>

Standard deviations are in parentheses. The asterisk * indicates that the RT is significantly shorter than that of the baseline (NNT).

**Table 2**

Magnitude of priming (ms) as a function of condition for normal subjects and aphasic patients in the three experiments

<table>
<thead>
<tr>
<th>Condition</th>
<th>NRT</th>
<th>RNT</th>
<th>RRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cloze—Syntactic</td>
<td>52</td>
<td>36</td>
<td>125**</td>
</tr>
<tr>
<td>High Cloze—Asyntactic</td>
<td>26</td>
<td>–23</td>
<td>–29</td>
</tr>
<tr>
<td>Low Cloze—Syntactic</td>
<td>30</td>
<td>–25</td>
<td>–18</td>
</tr>
<tr>
<td>Broca’s aphasics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cloze—Syntactic</td>
<td>10</td>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>High Cloze—Asyntactic</td>
<td>48</td>
<td>28</td>
<td>–13</td>
</tr>
<tr>
<td>Low Cloze—Syntactic</td>
<td>15</td>
<td>–8</td>
<td>–23</td>
</tr>
<tr>
<td>Wernicke’s aphasics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Cloze—Syntactic</td>
<td>120</td>
<td>173</td>
<td>126</td>
</tr>
<tr>
<td>High Cloze—Asyntactic</td>
<td>–28</td>
<td>–25</td>
<td>15</td>
</tr>
<tr>
<td>Low Cloze—Syntactic</td>
<td>10</td>
<td>7</td>
<td>–26</td>
</tr>
</tbody>
</table>

The asterisks * and ** indicate that the magnitude of priming for the RRT condition was significantly greater than the NRT condition and RNT condition, respectively.

### 2.2. High Cloze—Asyntactic experiment

Subjects in the High Cloze—Syntactic experiment showed a significant amount of priming for the RRT condition. One question is the role that syntactic structure plays in such priming. If the facilitation on the last word in the High Cloze—Syntactic experiment was due simply to the juxtaposition of lexical information, and not due to the integration of lexical and syntactic information, similar priming patterns should emerge in a word sequence where the same lexical items are present but in an ungrammatical frame. The next experiment explored whether the combinatorial thematics observed in the High Cloze—Syntactic experiment would occur in the absence of a grammatical syntactic structure.

#### 2.2.1. Method

**2.2.1.1. Stimuli.** The test sentence stimuli in the previous experiment were modified so that the same lexical items
were used, but placed in an ungrammatical structure. An ungrammatical sentence structure was created by switching the positions of the subject noun and the verb. Thus, the grammatical sentence ‘the bartender is kicking out the drunk’ became the ungrammatical string ‘the kicking out is bartender the drunk.’ All four conditions, RRT, RNT, and NRT and the baseline NNT, were modified in the same way: ‘the kicking out is bartender the drunk’ (RRT), ‘the kicking out is quajeter the drunk’ (RNT), ‘the thazing out is bartender the drunk’ (NRT), ‘the thazing out is quajeter the drunk’ (NNT).

2.2.1.2. Participants. Twelve native speakers of English from the Brown University community (9 female, 3 male; mean age = 26.7 years) participated. No participants had hearing or language impairments. No participants in the High Cloze—Syntactic experiment participated in this experiment.

2.2.1.3. Procedure. The procedure was the same as in the High Cloze—Syntactic experiment.

2.2.2. Results

The mean percent correct responses were 99, 99, 99, and 98% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, $F(1,33) = .216$, $p_1 = .885$; $F(2,105) = .226$, $p_2 = .878$.

Table 1 shows the mean RTs and standard deviations (ms) for correct responses for the test target items in each condition. A one-way ANOVA was not significant, $F(1,33) = 1.398$, $p_1 = .261$; $F(2,105) = .903$, $p_2 = .442$.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measure ANOVA yielded no significant effects, $F(1,22) = 1.731$, $p_1 = .200$; $F(2,70) = 1.006$, $p_2 = .371$.

In summary, normal subjects did not show significant priming in any of the three conditions (NRT, RNT, and RRT) nor were there any differences in the magnitude of priming across the three conditions. Thus, in the context of ungrammatical syntactic structures, thematic integration fails to emerge.

2.3. Low Cloze—Syntactic experiment

This experiment investigated the extent to which pragmatic information influences combinatorial thematics. The same syntactic structure and the same lexical items in the prime stimuli from the High Cloze—Syntactic experiment were employed in the current experiment, but the target words (i.e., the last words of the sentences), did not fit with the thematic structure of the sentence built up by the subject noun phrase and verb.

2.3.1. Method

2.3.1.1. Stimuli. The sentence stimuli in the High Cloze—Syntactic experiment were modified by changing the target words so that they reduced the pragmatic congruency of the sentences. For example, the word ‘drunk’ in the sentence ‘the bartender is kicking out the drunk’ was replaced by the word ‘witness.’ The selection of the target words was based on a pretest used in selecting the high cloze targets. Caution was taken not to create pragmatically or semantically improbable contexts. Thus, the new sentences described events that were possible in the real world, but these events were not likely to happen. One third of the 36 target words consisted of the same words in the High Cloze experiment but matched with different sentences (see Appendix A), and two thirds consisted of newly introduced words. All four conditions, RRT, RNT, NRT and the baseline NNT, were modified in the same way: ‘the bartender is kicking out the witness’ (RRT), ‘the bartender is thazing out the witness’ (RNT), ‘the quajeter is kicking out the witness’ (NRT), ‘the quajeter is thazing out the witness’ (NNT).

The average word frequencies for the target words for Low Cloze and High Cloze were 62.5 and 117, respectively (Francis & Kucera, 1982). A $t$ test showed no difference between the two groups, $p = .167$. The average word length for the Low Cloze and High Cloze stimuli were 2.14 and 2.06 syllables, respectively. A $t$ test showed no difference between the two groups, $p = .665$.

2.3.1.2. Participants. Twelve native speakers of English from the Brown University community (8 female, 4 male; mean age = 25.6 years) participated. No participants had hearing or language impairments. No participants participated in the earlier experiments.

2.3.1.3. Procedure. The procedure was the same as in the previous two experiments: High Cloze—Syntactic and High Cloze—Asyntactic.

2.3.2. Results

Mean percent correct responses were 99, 100, 99, and 97% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, $F(1,33) = 1.526$, $p_1 = .226$; $F(2,105) = .902$, $p_2 = .443$.

Table 1 shows the mean RTs and standard deviations (ms) for correct responses for the test target item in each condition. A one-way repeated measures ANOVA revealed a significant effect by subjects, $F(1,33) = 3.452$, $p_1 = .028$, but not by item, $F(2,105) = .793$, $p_2 = .500$. Pair-wise means comparisons showed no differences between any of the three conditions (NRT, RNT, and RRT) and the baseline (NNT) condition.
Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measure ANOVA yielded a significant effect by subjects, $F(1, 22) = 5.152$, $p = .015$, but not by items, $F(2, 70) = 1.072$, $p = .348$. Pair-wise means comparisons by subjects showed significant differences between the RNT condition and the NRT condition, $p = .007$; and between the RRT condition and the NRT condition, $p = .017$. However, given that the item analysis was non-significant, this effect is weak.

In summary, priming effects were weak or failed to emerge when target words were not pragmatically linked to thematic structures built up in the preceding primes.

2.3.3. Comparison of Experiments 1–3

Of the three experiments, only the High Cloze—Syntactic experiment produced significant priming effects. In the other two experiments, when the sentences were ungrammatical or when pragmatic information was weak, no significant priming effects emerged. Nonetheless, significant priming in one experiment and the loss of priming in another does not necessarily indicate that there is a significant difference between the two experiments. Hence, two further analyses were conducted to determine whether there was a significant difference in the magnitude of priming in the High Cloze—Syntactic experiment compared to the High Cloze—Asyntactic experiment, on the one hand, and the Low Cloze—Syntactic experiment, on the other.

The first analysis determined whether there was a difference in the magnitude of priming as a function of syntactic structure. The magnitude of priming for the three conditions (NRT, RNT, and RRT) in the High Cloze—Syntactic and High Cloze—Asyntactic experiments were submitted to a two way mixed design (one repeated, one independent) measure ANOVA (Syntax × Integration). There was a main effect of Syntax by subjects, $F(1, 22) = 8.287$, $p = .0087$, but not by item $F(2, 140) = 1.812$, $p = .183$, indicating a greater magnitude of priming when sentences were grammatical. There was also a significant interaction, $F(2, 44) = 5.172$, $p = .0096$; $F(2, 140) = 4.399$, $p = .014$. Post hoc LSD T tests revealed a significantly greater magnitude of priming in the RRT ($p < .001$, $p < .001$) and NRT (only by subjects, $p < .005$) for the grammatical sentences compared to the ungrammatical sentences.

The second analysis determined whether there was a difference in the magnitude of priming as a function of pragmatics. Magnitude of priming for the three conditions (NRT, RNT, and RRT) in the High Cloze—Syntactic and Low Cloze—Syntactic experiments were submitted to a two-way mixed design (one repeated, one independent) measure ANOVA (Cloze × Integration).

There was a main effect of Cloze, $F(1, 22) = 9.144$, $p = .006$, $F(2, 70) = 5.253$, $p = .025$ indicating a larger magnitude of priming in the High Cloze than the Low Cloze experiment. The main effect of Integration was also significant, $F(1, 22) = 5.014$, $p = .011$, $F(2, 140) = 3.276$, $p = .047$. Pair-wise means comparison analyses revealed that the RRT condition resulted in a greater magnitude of priming than the RNT condition, $p = .004$, $p = .013$; and the NRT condition obtained more priming than the RNT condition (only by subjects), $p = .028$.

There was also a significant interaction, $F(1, 22) = 7.631$, $p = .0014$; $F(2, 140) = 2.951$, $p = .056$ (marginal by items). Post hoc LSD T tests revealed that there was a significant difference for the RRT condition ($p < .001$, $p < .001$); and the RNT condition (only by subjects, $p < .01$) in the High Cloze compared to the Low Cloze experiments.

2.3.4. Discussion

Normal subjects showed evidence for combinatorial thematics in the High Cloze—Syntactic experiment. They combined thematic information in a subject noun phrase and a verb and built up a thematic structure that influenced their responses to an object noun. This was indicated by a greater magnitude of priming when both the subject noun and verb were presented with real words than when only a subject noun or a verb was presented with a real word target. The larger magnitude of priming in the High Cloze—Syntactic experiment is attributable to the process of combining thematic information in a subject noun phrase and in a verb, which generated a thematic structure that could be integrated with the last word (the object noun) of the sentence. Similar results have been obtained in visual naming or eye-tracking studies (Duffy et al., 1989; Morris, 1994; Stanovich et al., 1985; Stanovich & West, 1981). Of importance, the results showed that the effects of combinatorial thematics in the High Cloze—Syntactic experiment were not simply due to intra-lexical priming effects, since priming was lost in the High Cloze—Asyntactic experiment when no thematic information from syntax was available.

In the process of combinatorial thematics in the High Cloze—Syntactic experiment, subjects combined thematic information from both syntax and pragmatics. That both syntax and pragmatics contributed to the thematic structure was evidenced by no priming effects when the syntactic structure was ungrammatical in the High Cloze—Asyntactic experiment, and when pragmatic information was uninformative in the Low Cloze—Syntactic experiment. The syntactic and pragmatic effects were particularly obvious when both the subject noun and verb were real words.
3. Study II: Sentential thematic priming in aphasic subjects

The second study explored whether aphasic patients show the same patterns that normal subjects exhibited in this series of thematic priming experiments. While the preceding experiments with normal subjects were conducted using a between-subjects design, the experiments with the aphasic patients were conducted using a within-subject design. This design was used because of the small numbers of appropriate patients available and the potential heterogeneity of the patient population even within each diagnostic group. Thus, each patient served as his/her own control. Each patient was tested on the three experiments on different days, with 7–20 days between sessions. The order of the presentation of the three experiments was counterbalanced across patients. In addition, a longer ITI and maximum waiting time than normals' were employed in the stimuli material.

3.1. Method

3.1.1. Stimuli

The stimuli for the three experiments, High Cloze—Syntactic, High Cloze—Asyntactic, and Low Cloze—Syntactic, were the same as those presented to normal subjects, except that the ITI was changed from 3 to 6 s, and maximum waiting time was changed from 5 to 10 s.

3.1.2. Participants

Nine Broca's aphasics (3 female, 6 male, mean age = 62.6 years) and six Wernicke's aphasics (6 male, mean age = 62.2 years) participated. All patients were native speakers of English. The aphasia types were diagnosed based on the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1972). Table 3 shows a summary of patient information.

3.1.3. Procedure

The same procedures were used as that for normal subjects except for the testing location. Subjects were tested either in their homes, in one of the rooms designated for testing at the Boston VA Medical Center, or in the audio room in the speech laboratory at Brown University. All subjects were tested using an IBM laptop computer and a response box, which were set up on the table at which the subject and experimenters seated. Each experiment lasted for approximately 30 min on average.

3.2. Results for Broca's aphasics

3.2.1. High Cloze—Syntactic experiment

Mean percent correct responses were 96, 94, 94, and 96% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measures ANOVA revealed no significant differences among the conditions, $F(3,24) = .372, p = .774$.\(^5\)

Table 1 shows the mean RTs and standard deviations (ms) correct responses for the test target items for each condition. A one-way repeated measures ANOVA was not significant, $F(3,24) = .774, p = .520$.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measure ANOVA was not significant, $F(2,16) = .942, p = .411$.

In summary, unlike normal subjects, Broca’s aphasics showed no significant priming in any of the three conditions (NRT, RNT, and RRT). Furthermore, there were no differences in the amount of priming among these three conditions (NRT, RNT, and RRT). Thus, Broca's aphasics showed no evidence for combinatorial thematics in that their reaction-time latencies were not influenced by the nature of the noun phrase subject or verb prime.

3.2.2. High Cloze—Asyntactic experiment

Mean percent correct responses were 95, 94, 99, and 96% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, $F(3,24) = 1.818, p = .171$.

Table 1 shows the mean RTs and standard deviations (ms) for correct responses in each condition. A one-way ANOVA was not significant, $F(3,24) = .650, p = .591$.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way ANOVA was not significant, $F(2,16) = .878, p = .435$.

In summary, Broca’s patients showed no priming in any of the three conditions (NRT, RNT, and RRT) compared to the baseline (NNT). There were no differences in the magnitude of priming among these three conditions (NRT, RNT, and RRT).

3.2.3. Low Cloze—Syntactic experiment

Mean percent correct responses were 91, 90, 91, and 91% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, $F(3,24) = .040, p = .989$.

Table 1 shows the mean RTs and standard deviations (ms) for correct responses for each condition of Integration. A one-way repeated measures ANOVA was not significant, $F(3,24) = .370, p = .775$.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measures showed that the results were not significant, $F(2,16) = 1.028, p = .380$.

\(^5\) Due to the limited sample size, only the subject analysis was performed for all statistics for both Broca’s and Wernicke’s aphasic groups in this study.
Table 3
Patient summary

<table>
<thead>
<tr>
<th>Type aphasia/patient #</th>
<th>Age at testing</th>
<th>Years post onset</th>
<th>Auditory comprehension</th>
<th>Fluency</th>
<th>Etiology</th>
<th>Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broca 1</td>
<td>55</td>
<td>11</td>
<td>+0.94</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Large insular lesion extending to temporal lobe, sparing Wernicke's area and part of Broca's area</td>
</tr>
<tr>
<td>Broca 2</td>
<td>71</td>
<td>25</td>
<td>+0.88</td>
<td>Nonfluent</td>
<td>Hemorrhage</td>
<td>Left interior lesion, frontal to Sylvain fissure, deep to ventricles</td>
</tr>
<tr>
<td>Broca 3</td>
<td>82</td>
<td>22</td>
<td>+0.75</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Left frontal lesion involving Broca's area with deep extension across to left frontal horn-lower motor cortex (face and lips). Includes part of left temporal lobe</td>
</tr>
<tr>
<td>Broca 4</td>
<td>55</td>
<td>13</td>
<td>+0.63</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Left caudate and global pallidus, anterior internal capsule to medial temporal cortex and insula, anterior PVWM</td>
</tr>
<tr>
<td>Broca 5</td>
<td>54</td>
<td>6</td>
<td>+0.81</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Large left front-parietal lesion involving all of the inferior frontal gyrus including all of Broca's area and white matter deep to it; also involving insular cortex, lateral putamen, with extension across anterior temporal isthmus; also lower pre-motor and motor cortex, supramarginal gyrus and PVWM</td>
</tr>
<tr>
<td>Broca 6</td>
<td>61</td>
<td>4</td>
<td>+1.02</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Left temporoparietal lesion involving half of Wernicke's area with superior extension into supramarginal gyrus and a small portion of lower sensory cortex; also anterior 1/3 of PVWM; complete sparing of Broca's area and motor cortex</td>
</tr>
<tr>
<td>Broca 7</td>
<td>66</td>
<td>25</td>
<td>+0.87</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Left hemisphere lesion in Broca's area and the white matter deep to it. Lower 2/3 of the pre-motor, motor, and sensory cortex; white matter and PVWM deep to those areas</td>
</tr>
<tr>
<td>Broca 8</td>
<td>63</td>
<td>6</td>
<td>+0.77</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Large lateral frontal lesion, a large lesion in the frontal operculum, and two small lesions, one in the motor cortex and the other in the caudate, putamen, ALIC</td>
</tr>
<tr>
<td>Broca 9</td>
<td>55</td>
<td>3</td>
<td>+0.97</td>
<td>Nonfluent</td>
<td>CVA</td>
<td>Lesion in anterior left MCA distribution centered on the Sylvian fissure and involving both gray and white matter; some extension into the left temporal and parietal lobes</td>
</tr>
<tr>
<td>Wernicke 1</td>
<td>71</td>
<td>14</td>
<td>−0.33</td>
<td>Fluent</td>
<td>CVA</td>
<td>Left posterior temporal lobe lesion with superior extension into supramarginal and angular gyri. Large occipital lesion</td>
</tr>
<tr>
<td>Wernicke 2</td>
<td>80</td>
<td>11</td>
<td>+0.53</td>
<td>Fluent</td>
<td>Hemorrhage</td>
<td>Large left posterior hemorrhage in the parietal occipital region</td>
</tr>
<tr>
<td>Wernicke 3</td>
<td>62</td>
<td>13</td>
<td>−0.80</td>
<td>Fluent</td>
<td>CVA</td>
<td>Left infarct deep to angular gyrus cutting off arcuate fasiculus and temporal isthmus. Includes posterior PVWM</td>
</tr>
<tr>
<td>Wernicke 4</td>
<td>66</td>
<td>4</td>
<td>+0.37</td>
<td>Fluent</td>
<td>CVA</td>
<td>Left infarct in the temporal and parietal lobes extending into the basal ganglia and internal capsule region</td>
</tr>
<tr>
<td>Wernicke 5</td>
<td>54</td>
<td>5</td>
<td>+0.51</td>
<td>Fluent</td>
<td>Hemorrhage</td>
<td>Hemorrhage post left craniotomy in the area of the posterior left parietal lobe</td>
</tr>
<tr>
<td>Wernicke 6</td>
<td>40</td>
<td>1.5</td>
<td>−0.39</td>
<td>Fluent</td>
<td>CVA</td>
<td>Left infarct in anterior temporal lobe, adjacent frontal lobe, and basal ganglia</td>
</tr>
</tbody>
</table>

In summary, Broca’s patients failed to show priming in any of the three conditions (NRT, RNT, and RRT) compared to the baseline (NNT). In addition, there were no differences in the magnitude of priming among these three conditions (NRT, RNT, and RRT).

3.3. Comparison of Experiments 1–3

Broca’s patients did not show significant effects in any of the three experiments. Nonetheless, it is instructive to determine whether there were any differences in the
patterns of priming in the High Cloze—Syntactic experiment compared to each of the other two experiments, the High Cloze—Asyntactic experiment and the Low Cloze—Syntactic experiment.

The first analysis considered potential differences as a function of syntax. The magnitude of priming for the three Integration conditions (NRT, RNT, and RRT) in the High Cloze—Syntactic and High Cloze—Asyntactic experiments were submitted to a two way repeated measure ANOVA (Syntax × Integration). There were no significant main effects nor was there a significant interaction (for the interaction, F(2,16) = 2.096, p = .156). Based on the assumption that the syntactic information affected the RRT condition for the Syntactic experiment, planned comparison analyses were performed. Results showed a non-significant but marginal effect for the RRT condition between the Syntactic and Asyntactic experiments, F(1,16) = 3.097 (F(1,16) = 4.49 at x = .05).

The second analysis considered the potential effects of pragmatics. The magnitude of priming for the three Integration conditions (NRT, RNT, and RRT) in the High Cloze—Syntactic and Low Cloze—Syntactic experiments were submitted to a two way repeated measure ANOVA (Cloze × Integration). There were no significant main effects. However, there was a significant interaction, F(2,16) = 4.010, p = .039. Post hoc LSD T tests revealed that there was a significant difference for the RRT condition between the High Cloze and Low Cloze experiments, t = 3.725, p < .010 indicating that there was greater priming in the High Cloze experiment than in the Low Cloze experiment. The interaction indicates that pragmatic information was in fact used to form a thematic structure in the High Cloze—Syntactic experiment in Broca’s aphasia.

### 3.4. Results for Wernicke’s aphasics

#### 3.4.1. High Cloze—Syntactic experiment

Mean percent correct responses were 89, 94, 94, and 98% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, F(3,15) = .955, p = .439.

Table 1 shows the mean RTs and standard deviations (ms) for correct responses for each condition. A one-way repeated measures ANOVA was significant, F(3,15) = 3.401, p = .046. Post-hoc LSD analyses revealed that compared to the baseline NNT condition, the NRT, RNT, and RRT conditions produced significantly shorter response times, p = .050, p = .008, p = .041, respectively.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measures ANOVA was not significant, F(2,10) = .763, p = .492.

In summary, unlike normal subjects, Wernicke’s patients showed significant priming in all of the three conditions (NRT, RNT, and RRT). Furthermore, there was no difference in the magnitude of priming among these three conditions (NRT, RNT, and RRT). The comparable amount of priming suggests impairment in the processes of combinatorial thetas.

#### 3.4.2. High Cloze—Asyntactic

Mean percent correct responses were 91, 98, 93, and 98% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, F(3,15) = 1.065, p = .393.

Table 1 shows the mean RTs and standard deviations (ms) for correct responses for each condition. A one-way repeated measures ANOVA was not significant, F(3,15) = .366, p = .778.

Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measure ANOVA was not significant, F(2,10) = .366, p = .703.

In summary, Wernicke’s patients showed no significant amount of priming in any of the three conditions (NRT, RNT, and RRT) compared to the baseline (NNT). Additionally, there was no difference in the magnitude of priming among these three conditions (NRT, RNT, and RRT).

#### 3.4.3. Low Cloze—Syntactic experiment

Mean percent correct responses were 81, 87, 83, and 91% for the NNT, NRT, RNT, and RRT conditions, respectively. A one-way repeated measure ANOVA revealed no significant differences among the conditions, F(3,15) = .701, p = .566.

Among the six subjects, one subject showed chance performance for lexical decision. As a result, this subject’s RT data were excluded from the remaining analyses. Table 1 shows the mean RTs and standard deviations (ms) for correct responses for each condition. A one-way repeated measures ANOVA was not significant, F(3,12) = .331, p = .803. Table 2 shows the magnitude of priming for the NRT, RNT, and RRT conditions. A one-way repeated measure ANOVA yielded no significant effects, F(2,8) = .397, p = .686.

In summary, Wernicke’s patients showed no significant amount of priming in any of the three conditions (NRT, RNT, and RRT), compared to the baseline (NNT). There were no differences in the magnitude of priming among these three conditions (NRT, RNT, and RRT).

#### 3.5. Comparison of Experiments 1–3

Among the three experiments, Wernicke’s patients showed significant priming effects only in the High
Cloze—Syntactic experiment. In the other two experiments, where the sentences were ungrammatical or when pragmatic information was weak, no significant priming effects emerged. Two further analyses were conducted to see whether there was a difference in the magnitude of priming between the High Cloze—Syntactic experiment and each of the other two experiments.

The magnitude of priming for the three Integration conditions (NRT, RNT, and RRT) in the High Cloze—Syntactic and High Cloze—Asyntactic experiments were submitted to a two-way repeated measure ANOVA (Syntax × Integration). A main effect of Syntax approached significance, \( F(1, 5) = 5.358, p = .069 \). There was no significant interaction between Syntax and Integration, which indicates that syntactic information affected all of the conditions equally.

Planned comparison analyses were performed based on the assumption that the correct syntactic information affected each condition only for the Syntactic experiment. Differences in magnitude of priming for the NRT, RNT, and RRT conditions between Syntactic and Asyntactic were significant, \( F(1, 10) = 8.068 \) for NRT; \( F(1, 10) = 14.41 \) for RNT; \( F(1, 10) = 4.494 \) for RRT \( (Fc(1, 10) = 4.96 \) at \( a = .05 \)). These results confirmed that syntactic information was influential when thematic information from a subject noun phrase and a verb was combined to build up a thematic structure in Wernicke’s aphasia.

The magnitude of priming for the three Integration conditions (NRT, RNT, and RRT) in the High Cloze—Syntactic and Low Cloze—Syntactic experiments were submitted to a two-way repeated measure ANOVA (Cloze × Integration). A main effect of Cloze approached significance, \( F(1, 4) = 5.358, p = .080 \). There was no other main effect or interaction. The null interaction indicates that pragmatic information affected all of the conditions (NRT, RNT, and RRT) equally.

Planned comparison analyses were performed based on the assumption that the pragmatic information affected each condition only for the High Cloze experiment. Differences in magnitude of priming for the NRT, RNT, and RRT conditions between High Cloze and Low Cloze were significant, \( F(1, 8) = 9.391 \) for NRT; \( F(1, 8) = 19.686 \) for RNT; \( F(1, 8) = 14.858 \) for RRT \( (Fc(1, 8) = 5.32 \) at \( a = .05 \)). These results confirmed that thematic information from pragmatics contributed in the process of thematic combinatorial integration in Wernicke’s aphasia.

3.6. Discussion

Broca’s aphasics did not show priming effects in any experiments. However, there was a significant difference between the High Cloze—Syntactic and Low Cloze—Syntactic experiments, showing an influence of pragmatics for the RRT condition. These results indicate that Broca’s aphasics were in fact integrating pragmatic information in the High Cloze—Syntactic experiment.

However, the pattern that represents the process of combinatorial thematics in the High Cloze—Syntactic experiment was deviant from the normal pattern. Normal subjects showed thematic priming effects in the RRT condition and a larger magnitude of priming in the RRT condition than in the other two conditions (NRT and RNT). In contrast, Broca’s aphasics not only exhibited no priming effects, but also showed no difference in the magnitude of priming between the RRT condition and the other two conditions (NRT and RNT). Thus, Broca’s aphasics showed a reduced sensitivity in integrating thematic information even in simple active declarative sentences. Overall, the pattern of results indicates that Broca’s aphasics have a deficit in combinatorial thematics. They failed to integrate normally information derived from syntax and only were able to do so weakly with information derived from pragmatics.

Wernicke’s aphasics showed priming effects in the High Cloze—Syntactic experiment, and similar to normals, the effects disappeared in the High Cloze—Asyntactic and Low Cloze—Syntactic experiments. This indicates that Wernicke’s aphasics were sensitive to syntactic and pragmatic information and in fact used this information in the High Cloze—Syntactic experiment. However, the pattern of priming effects in the High Cloze—Syntactic experiment was deviant from the normal pattern. Wernicke’s aphasics showed priming effects in all of the conditions; and importantly, there was no difference in the magnitude of priming between the RRT condition and the other two conditions (NRT and RNT). Thus, Wernicke’s aphasics were not building up thematic structures incrementally, as were normals, by integrating information from a subject noun phrase and a verb.

4. General discussion

In this study, the process of incremental combinatorial thematics (i.e., the integration process of thematic information derived from lexical semantics, syntax, and pragmatics) was investigated. The primary question was how normal subjects and aphasic patients integrate lexical-semantic and pragmatic information with a canonical simple active syntactic structure to form an appropriate thematic interpretation of the sentence.

Normal subjects showed evidence for combinatorial thematics by exhibiting significant and larger amounts of thematic priming in the condition where two real words were present in the prime than in the conditions in which only one real word was present in the prime. The larger magnitude of priming was attributed to the processes of combining information from a subject noun phrase and a verb, which generated a thematic structure.
that was strongly linked to the last word of the sentence. In the process of combinatorial thematics, thematic information was combined and integrated from both syntax and pragmatics. This was evidenced by the fact that no priming effects were observed in the experiments in which ungrammatical syntactic information was present, and in which weak thematic information from pragmatics was present.

Both Broca’s and Wernicke’s aphasic groups showed no evidence for integrating thematic information derived from a subject noun phrase and verb to generate a relevant thematic structure in a simple active sentence. Nonetheless, the patterns of performance of these two groups were different. These distinct patterns provide some insights into the underlying mechanisms responsible for the deficits.

Broca’s aphasics failed to show priming in any condition, and also did not show any evidence for an increase in the magnitude of priming as syntactic and lexical information was presented incrementally in the subject noun phrase and verb. Moreover, they showed no sensitivity to syntax and only weak sensitivity to the pragmatics of the sentence. The failure of Broca’s aphasics to show any sensitivity to syntax is surprising given that a simple active declarative sentence structure was used throughout this study. It has generally been argued in the literature that this canonical sentence structure is retained by the patients in part because of the ease with which syntactic structures map on to thematic roles. The failure of the patients to process simple active declarative sentences in the current experiment suggests an impairment in processing structural information in general in building up thematic roles, rather than an impairment in the processing of specific syntactic structures such as the passive voice or object relative clauses.

Wernicke’s aphasics showed priming in all conditions of the High Cloze—Syntactic Experiment. However, in contrast to normal subjects, they failed to show an increase in the magnitude of priming as more syntactic and semantic information was provided incrementally. Thus, although they were sensitive to both the syntactic and pragmatic information in the sentences, they were unable to combine or integrate this information on line. These findings are consistent with recent results showing that Wernicke’s aphasics display deficits in semantic combinatorial operations (Pinango & Zurif, 2001) as well as lexical-semantic integration processes (Milberg, Blumstein, Sullivan-Giovanello, & Misiurski, 2003).

It is worth briefly considering what aspects of the functional architecture of the language processing system might give rise to deficits in the processes of combinatorial thematics in both Broca’s and Wernicke’s aphasics. It has been proposed that aphasics have deficits in the dynamics of lexical activation, with Broca’s aphasics showing reduced lexical activation and Wernicke’s aphasics showing increased lexical activation (Blumstein & Milberg, 2000; McNellis & Blumstein, 2001). Reduced lexical activation could result in a deficit of combinatorial thematics because the lexical entries would only weakly map on to the thematic roles they play. Overactivation of the lexicon would also result in a deficit in combinatorial thematics because the overly activated system would be unable to ‘inhibit’ or select the appropriate thematic structures from all of those that are activated. Whether the proposal that the dynamics of lexical activation can account for impairments in combinatorial thematics is correct or not, it is the case that both Broca’s and Wernicke’s aphasics fail to normally integrate and combine syntactic, lexical, and semantic information even in a simple active declarative sentence structure. Thus, any explanation of the basis of language deficits in aphasia will need to take account of these impairments as well.

Acknowledgments

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Appendix A

Test sentence stimuli used in the on-line sentential thematic priming experiment: High Cloze—Syntactic/ Low Cloze—Syntactic.

1. The advertisement is misleading the public/princess.
2. The air traffic controller is talking to the pilot/witness.
3. The assistant is obeying the boss/helper.
4. The attorney is counseling the client/toddler.
5. The barber is trimming the mustache/article.
6. The bartender is kicking out the drunk/patient.
7. The chairman is moderating the meeting/temperature.
8. The CIA is spying on the Russian/kindergarten.
9. The citizen is criticizing the government/tractor.
10. The climber is reaching the summit/babysitter.
11. The doctor is curing the patient/meat.
12. The dog is guiding the blind man/government.
13. The expert is training the novice/master.
14. The farmer is driving the tractor/tank.
15. The father is protecting the child/Russian.
16. The hairdresser is recommending the style/pilot.
17. The interpreter is working for the UN/infant.
18. The Japanese man is eating the sushi/kosher food.
19. The judge is questioning the witness/public.
20. The kitten is drinking the milk/bourbon.
21. The knight is saving the princess/money.
22. The mortician is examining the cadaver/milk.
23. The nurse is weighing the infant/sushi.
24. The parent is hiring the babysitter/customer.
25. The policeman is catching the robber/butterfly.
26. The pupil is following the teacher/bee.
27. The sculptor is looking at the model/data.
28. The scientist is collecting the data/rent.
29. The senior is advising the freshman/astronaut.
30. The soldier is tying up the captive/newspaper.
31. The stewardess is greeting the passenger/parliament.
32. The surgeon is performing the operation/dance.
33. The terrorist is bombing the building/cornfield.
34. The tornado is destroying the town/mood.
35. The waitress is taking care of the customer/sheep.
36. The warden is watching over the inmate/flock.

References


