Comprehending Noun Phrase Arguments and Adjuncts

Shelia M. Kennison

Two experiments investigated how readers comprehend noun phrase (NP) arguments and adjuncts. Previous research suggested that argument phrases are processed more quickly than adjunct phrases (Clifion, Speer, & Abney, 1991; Kennison, 1999; Schütze & Gibson, 1999; Speer & Clifion, 1998). The present experiments investigated whether the type of verb in the sentence context could influence how NP arguments and adjuncts were processed. Reading time was measured on sentences containing NP arguments and adjuncts preceded either by verbs occurring most frequently with NP arguments (biased transitive verbs) or by verbs occurring most frequently without NP arguments (biased intransitive verbs) (e.g., “Meredith read/performed every play/week.”). In Experiment 1, reading time was measured using a self-paced phrase-by-phrase moving window. In Experiment 2, reading time was measured using eye tracking. The results of both experiments indicated that, following biased transitive verbs, NP arguments were processed more quickly than NP adjuncts. When NPs followed biased intransitive verbs, there was no significant difference between the processing time of NP arguments and adjuncts.

KEY WORDS: NP arguments; adjuncts; sentence processing.

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COMPREHENDING NOUN PHRASE ARGUMENTS AND ADJUNCTS

One of the central goals of sentence processing research is to understand how comprehenders construct the syntactic analysis of newly encountered words and phrases. In the sentence processing literature, there are some constructions that have received a great deal of attention, while others have not. The purpose of the present paper is to focus attention on a linguistically important syntactic distinction that has, thus far, received only minimal attention from sentence processing researchers: the argument/adjunct distinction. Arguments typically designate a central aspect of an action, and adjuncts typically designate some other noncentral aspect of the action (Radford, 1988), as shown in (1a) and (1b).

(1) a. The doctor lectured on heart disease. Argument PP
    b. The doctor lectured on Sunday. Adjunct PP

It is generally believed that the arguments that a specific verb can take are lexically specified, but information about adjuncts is not lexically specified, because their occurrence with verbs is relatively unrestricted.

The linguistic distinction between arguments and adjuncts has ramifications in the realm of sentence processing. Multiple theories of sentence processing predict that comprehenders should find argument phrases easier to process than adjunct phrases. For example, there are sentence processing theories in which a structural analysis of a newly encountered word is constructed only after lexical information is consulted for the purpose of determining the possible uses of that word or for the purpose of determining the preferred usage among all possible usages (e.g., partial activation hypothesis, MacDonald, 1994; also, the more general constraint satisfaction approach in which lexical information is just one of many possible constraints, MacDonald, Pearlmutt, & Seidenberg, 1994; Spivey-Knowlton & Sedivy, 1995; Trueswell, Tanenhaus, & Kello, 1993). When a phrase is encountered that can be either an argument or an adjunct, comprehenders are believed to prefer the argument analysis, because information about arguments is lexically specified. There are also theories in which a structural analysis is initially built following the application of parsing principles that are based on the initial process of consulting phrase structure information (e.g., garden path model, Frazier, 1978; Frazier & Fodor, 1978; Frazier & Rayner, 1982). When a phrase is encountered that can be either an argument or an adjunct, comprehenders are believed to prefer the argument analysis, as arguments are attached to the more recent part of the phrase marker.
Arguments are attached as sisters of X’ and adjuncs are attached as sisters of XP. This choice reflects the preference predicted by the late closure principle.3

Thus far, the empirical evidence about the processing of arguments and adjuncs is sparse, but the reported evidence generally supports the prediction that argument phrases are easier to process than adjunc phrases. Clifton, Speer, and Abney (1991) reported two reading experiments in which participants read sentences containing arguments and adjuncs modifying either preceding verbs or preceding nouns. The results showed that sentences containing argument phrases were processed more quickly than sentences containing adjunc phrases. Schütze and Gibson (1999) reported the results of two experiments in which reading time was measured on sentences containing verb+direct object+prepositional phrase sequences in which the prepositional phrase was either an argument of the preceding direct object noun or was an adjunc of the preceding verb. Readers processed arguments of noun phrases more quickly than adjuncs of verb phrases. Speer and Clifton (1998) reported two reading experiments in which participants read sentences containing plausible or implausible arguments and adjuncs of preceding verb phrases. The results showed that sentences containing argument phrases were generally processed more quickly than sentences containing adjunc phrases. The effects of plausibility occurred earlier in processing and were more robust than the effect of type of phrase. Kennison (1999) reported a reading experiment showing that the same agentive by phrase was read faster when it occurred in a complex event nominal (e.g., “The frequent collection of butterflies by the children. . ..”) in which it served as an argument phrase than when it occurred in a complex non-event nominal (e.g., “The various collections of butterflies by the children. . ..”) in which it served as an adjunc phrase. Liversedge, Pickering, Branigan, and van Gompel (1998) reported two reading experiments showing that argument by phrases (e.g., “The shrubs were planted by the apprentice. . ..”) were processed more quickly than adjunc by-phrases (locatives) (e.g., “The shrubs were planted by the greenhouse . . .”) in isolation or in sentence context, that promoted the agentive role, but the phrases were not processed differently when they occurred in a sentence context promoting the locative role.

3 A third type of theory specifies that a structural analysis is initially built after consulting both lexical and phrase structure information, therefore also predicting a preference for arguments (e.g., licensing parser, Abney, 1989).
The purpose of the experiments described in this paper was to document how readers process sentences containing NP arguments and adjuncts of the type shown in (2).

(2) a. Meredith read *every play* despite her busy NP argument schedule
b. Meredith read *every week* despite her busy NP adjunct schedule

There have been few, if any, empirical studies investigating NP arguments and adjuncts of this type. The previous empirical studies that investigated the processing of arguments and adjuncts focused on prepositional phrase (PP) attachment ambiguities (Clifton *et al.*, 1991; Kennison, 1999; Liversedge, Pickering, Branigan, & van Gompel, 1998; Schütze & Gibson, 1999; Speer & Clifton, 1998). The central question of the research focused on whether NP arguments would generally take less time to comprehend than NP adjuncts, as had been suggested by the previous studies. In the present research, the role of sentence context was addressed. Specifically, are there some sentence contexts in which arguments would not be processed more quickly than adjunct phrases?

In the two reading experiments that are reported in this paper, the sentence contexts were varied. The type of verb occurring in the preceding sentence context was either a verb that occurs most frequently with NP arguments (biased transitive verbs) or a verb that occurs most frequently without NP arguments (biased intransitive verbs). The decision to use verb type as the primary way to vary sentence context was influenced by the growing number of studies showing that comprehenders use verb information during sentence processing. One of the primary findings is that comprehenders resolve a temporarily ambiguous phrase as being consistent with the most frequent usage of the preceding verb (Garnsey, Pearlmuter, Myers, & Lotocky, 1997; Holmes, Stowe, & Cupples, 1989; MacDonald, 1994; Spivey-Knowlton & Sedivy, 1995; Trueswell, Tanenhaus, & Kello, 1993). If comprehenders use verb information to process NP arguments and adjuncts, then it would be expected that NP arguments would be easier to process than NP adjuncts that follow biased transitive verbs. When the preceding verb is a biased intransitive verb, comprehenders are not expected to analyze the NP as an argument of the preceding verb on the basis of lexical information, as neither the argument nor the adjunct is lexically specified or preferred, in terms of frequency of usage, by the preceding verb.

In both experiments, reading time was measured on the same 20 sets of sentences, four versions each: (1) NP argument, preceded by biased transitive verb; (2) NP adjunct, preceded by biased transitive verb; (3) NP argument, preceded by biased intransitive verb; and (4) NP adjunct, preceded by
In Experiment 1, reading time was measured on sentences containing temporarily ambiguous NP arguments and adjuncts preceded either by biased transitive or biased intransitive verbs. NP argument and adjunct continuations were constructed to be plausible. Their plausibility was verified in a plausibility-rating questionnaire with an additional group of participants. Reading time was measured using phrase-by-phrase self-paced reading, a common method used in the study of reading comprehension (for review, see Mitchell, 1984).

Method

Participants

Fifty-six undergraduates at the University of Massachusetts, Amherst, participated in the experiment for class credit. All participants were fluent

<table>
<thead>
<tr>
<th>Table I. Sample Sentences from Experiments 1 and 2</th>
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<tbody>
<tr>
<td><strong>Biased Transitive Verb</strong></td>
</tr>
<tr>
<td>Noun Phrase Argument</td>
</tr>
<tr>
<td>Everyone knew that Meredith read every play despite her busy schedule.</td>
</tr>
<tr>
<td>Noun Phrase Adjunct</td>
</tr>
<tr>
<td>Everyone knew that Meredith read every week despite her busy schedule.</td>
</tr>
<tr>
<td><strong>Biased Intransitive Verb</strong></td>
</tr>
<tr>
<td>Noun Phrase Argument</td>
</tr>
<tr>
<td>Everyone knew that Meredith performed every play despite her busy schedule.</td>
</tr>
<tr>
<td>Noun Phrase Adjunct</td>
</tr>
<tr>
<td>Everyone knew that Meredith performed every week despite her busy schedule.</td>
</tr>
</tbody>
</table>

* The vertical bar (|) indicates presentation regions and was not visible to readers during the experiment.
speakers of American English and were naive to the purposes of the experiment.

Materials

Biased transitive and biased intransitive verbs were initially selected from Connine, Ferreira, Jones, Clifton, & Frazier (1984). The usage preferences of the selected verbs were assessed in a separate normative study, similar in method to the method of Connine et al. (1984). Forty undergraduates from the University of Illinois, Urbana-Champaign, participated for course credit. Each participant was given a list of 100 English verbs in past tense form. Twelve pre-selected biased transitive verbs, 11 pre-selected biased intransitive verbs, and 50 filler verbs were presented in random order to participants. Participants were instructed to provide a sentence for each verb. The usage of each pre-selected verb was coded and the frequencies of transitive and intransitive usages were calculated. Biased transitive verbs were used transitively 88% of the time; intransitively, 9% of the time; and in other usages, 1% of the time. Biased intransitive verbs were used intransitively 79% of the time; transitively, 14% of the time; and in other usages, 7% of the time. Twenty sets of experimental sentences were constructed, each set composed of a biased transitive verb followed by an NP argument, a biased transitive verb followed by an NP adjunct, a biased intransitive verb followed by an NP argument, and a biased intransitive verb followed by an NP adjunct. All adjunct continuations were phrases specifying time (e.g., “week,” “month”). For each item, the argument noun and the adjunct noun were matched on length (±2 letters) and printed word frequency (as assessed by Francis & Kučera, 1982). A complete list of experimental materials is provided in the Appendix.

Plausibility ratings were obtained for each item. An additional group of 48 participants at the University of Illinois, Urbana-Champaign, participated for course credit. Sentences were presented in the form “subject-verb-NP . . .” and participants rated on a 1-to-7 scale how plausible the fragment was as the beginning of a sentence that they would encounter in the real world. These ratings verified that the verb-argument and verb-adjunct relationships were plausible (mean = 6.11, SD = .75, maximum = 7.0, minimum = 3.3).

Procedure

Each participant was tested individually in a well-lit, private cubicle. Sentences were presented phrase-by-phrase on a cathode ray tube (CRT) interfaced with a microcomputer. The initial display instructed the partici-
pant to pull the right trigger to continue. Sentences were presented using a noncumulative display procedure (Kennedy & Murray, 1984). When the participant pulled the trigger, a series of dashes was presented on the computer screen, which corresponded to where the characters of the sentence would appear. When the participant pulled the trigger again, the first phrase of the sentence replaced the corresponding dashes. As soon as the participant pulled the trigger again, the first phrase was replaced by dashes and the second phrase appeared. When the participant pulled the trigger again, the second phrase was replaced with dashes and the third phrase appeared. The participant read in this way until the entire sentence was read. The session began with a practice set of 10 sentences and then the set of 140 sentences (40 experimental sentences and 100 fillers). Participants received simple true/false comprehension questions after 58% of the sentences. After an incorrect response, the word “ERROR” appeared on the computer screen.

Results and Discussion

Reading times longer than 3000 ms and shorter than 100 ms were trimmed from the dataset, resulting in a loss of less than 1% of observations. Reading time was analyzed for each presentation region in milliseconds and also as deviation from reading time predicted on the basis of region length (for similar use of this analysis, see Clifton & Ferreira, 1987; Trueswell, Tanenhaus, & Garnsey, 1994). The latter analysis reduces variability by taking into account the different reading rates across readers for regions that vary in length (in characters) across items. Analyses of variance (ANOVA) were conducted using verb type and NP type as within-participants factors for each presentation region. All ANOVAs reported in this paper were conducted using participants ($F_1$) and items ($F_2$) as random effects, as in Clark (1973). Table II displays mean reading time in millisecond-

<table>
<thead>
<tr>
<th>Sentence region</th>
<th>BT-ARG</th>
<th>BT-ADJ</th>
<th>BI-ARG</th>
<th>BI-ADJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 Everyone knew that</td>
<td>956 (+16)</td>
<td>976 (+50)</td>
<td>948 (+7)</td>
<td>1000 (+65)</td>
</tr>
<tr>
<td>R2 Meredith</td>
<td>711 (-18)</td>
<td>751 (+15)</td>
<td>711 (-18)</td>
<td>727 (-5)</td>
</tr>
<tr>
<td>R3 read/performd</td>
<td>593 (-14)</td>
<td>583 (-31)</td>
<td>582 (-27)</td>
<td>580 (-26)</td>
</tr>
<tr>
<td>R4 every play/week</td>
<td>746 (-87)</td>
<td>830 (-19)</td>
<td>770 (-66)</td>
<td>749 (-97)</td>
</tr>
<tr>
<td>R5 despite</td>
<td>651 (-31)</td>
<td>707 (+36)</td>
<td>642 (-35)</td>
<td>657 (-20)</td>
</tr>
<tr>
<td>R6 her busy schedule</td>
<td>902 (67)</td>
<td>913 (+98)</td>
<td>885 (+60)</td>
<td>857 (+39)</td>
</tr>
</tbody>
</table>
onds (and in mean deviation from predicted reading time) by presentation region by condition. The pattern of results was the same for both types of analyses.

The only presentation region for which there were reliable results was the NP region ("every play"/"every week"). Reading time on the NP region was significantly influenced by an interaction of verb type and NP type in milliseconds, $F(1,55) = 6.49, \text{MSE} = 22778, p < .02, F(1,18) = 7.19, \text{MSE} = 6431, p < .02$, and in mean deviation from predicted reading time, $F(1,55) = 7.01, \text{MSE} = 19299, p < .02, F(1,18) = 4.89, \text{MSE} = 8031, p < .05$. The interaction reflected that when NP arguments followed biased transitive verbs, they were read more quickly than NP adjuncts, a difference that was statistically significant in milliseconds, $F(1,55) = 9.31, \text{MSE} = 23899, p < .004, F(1,18) = 4.89, \text{MSE} = 9643, p < .05$, and in mean deviation from predicted reading time, $F(1,55) = 7.19, \text{MSE} = 21400, p < .01, F(1,18) = 5.04, \text{MSE} = 7097, p < .04$. When NP arguments followed biased intransitive verbs, they were read less quickly than NP adjuncts; however, this difference was not significant in any analysis, $F$s < 1.25, ps > .20.

Further analyses revealed that NP adjuncts were read significantly faster following biased intransitive verbs than following biased transitive verbs in milliseconds, $F(1,55) = 8.02, \text{MSE} = 19676, p < .007, F(1,18) = 9.99, \text{MSE} = 4619, p < .006$, and in mean deviation from predicted reading time, $F(1,55) = 7.44, \text{MSE} = 19747, p < .009, F(1,18) = 8.83, \text{MSE} = 5106, p < .009$. In contrast, NP arguments were read more quickly following biased transitive verbs than following biased intransitive verbs; however, this difference was not significant in any analysis, $F$s < 1.04. The main effects of verb type and noun type were not significant in any analysis: Verb type, $F$s < 2.01, ps > .17, and noun type, $F$s < 3.29, ps > .07. Further analyses indicated that plausibility differences among conditions for each item did not predict the interaction between verb type and noun type (milliseconds: $r^2 = .15, p > .09$, intercept = .06, and mean deviation from predicted reading time, $r^2 = .19, p > .06$, intercept = .16); the effect of noun type for biased transitive verb conditions (milliseconds: $r^2 = .05, p > .36$, intercept = .17, and mean deviation from predicted reading time, $r^2 = .05, p > .33$, intercept = .17); or the effect of verb type for adjunct conditions (milliseconds: $r^2 = .005, p > .77$, intercept = .30, and mean deviation from predicted reading time, $r^2 = .02, p > .52$, intercept = .04).

In summary, the results suggest that the type of verb preceding the NP argument or adjunct influenced how NPs were processed. NP arguments were easier to process than NP adjuncts when sentences contained biased transitive verbs. However, there was no significant difference observed in

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4 One item was removed from the analysis because a verb was misclassified.
the processing of NP arguments and adjuncts when sentences contained biased intransitive verbs.

The purpose of Experiment 2 was to measure reading time on the same sentences used in Experiment 1 using eye tracking, a method that can provide better information about initial processing on individual words and sentence regions than the self-paced moving window technique used in the Experiment 1.

EXPERIMENT 2

In Experiment 2, eye tracking was used to measure reading time on the same sentences used in Experiment 1. As the collection of eye movement data occurs throughout a trial, a readers’ initial processing of a region and any rereading that occurs can be analyzed separately. Consequently, early and late effects of verb information could be observed and compared.

Method

Participants

Twenty-four undergraduate and graduate students at the University of Massachusetts, who had normal or corrected vision, were fluent in American English, and were naive to the purpose of the experiment, participated for course credit or for $5.00.

Materials

The same materials were used as were used in Experiment 1.

Apparatus

Eye movements were recorded by a Stanford Research Institute Dual Purkinje Eye Tracker, which has a resolution of less than 10 minutes of arc. Viewing was binocular with eye position recorded from the right eye. The eye tracker was interfaced with an 80486 microcomputer, which controlled the presentation of the sentences. Up to 80 character spaces per line were used. The characters were in lower case, except where capital characters were required (at the beginning of sentences and proper names). Participants were seated 62 cm (25 inches) from the monitor and four characters equaled 1° of visual angle. The luminance from the monitor was adjusted to a comfortable brightness level for the participant and then held constant throughout the study, and the room was dark.
Procedure

For each participant, a bite-bar was constructed to minimize head movements during the experiment. The eye tracking system was then calibrated. This procedure required the participant to fixate nine markers sequentially (three markers at the top, middle, and bottom rows of the computer screen). The voltage was recorded and interpolated for the intervening columns and rows. Before each trial, the participant was asked to serially fixate a row of five markers equally spaced across the computer screen to check this interpolation. If the interpolation deviated substantially from the markers, then the calibration was repeated. At the beginning of each trial, the participant was asked to fixate a box in the center of the screen and then on one at the left of the screen. When a marker that followed the eye indicated a successful fixation, the sentence appeared. Comprehension questions appeared in the lower half of the computer screen. After incorrect responses, the word “ERROR” appeared on the computer screen. Fifty percent of sentences had comprehension questions. The participant read 10 practice sentences, followed by 120 experimental sentences (i.e., 20 experimental sentences and 100 fillers). Four counterbalancing lists were used to ensure that each condition of an item was viewed equally often across participants. Each session lasted between 30 and 50 minutes.

Results and Discussion

Eye movement data were initially screened to identify trials on which track loss occurred. These trials (less than 5%) were eliminated from the data set. All remaining trials were screened for false fixations, following the recommendations of Rayner, Sereno, Morris, Schmauder, & Clifton (1989). Fixations shorter than 80 ms in duration and only one character away from the previous or next fixation were merged with that fixation. Fixations shorter than 40 ms and less than three characters away from the previous or next fixation were deleted. Remaining individual fixations longer than 1000 ms or shorter than 50 ms were deleted. Analysis regions corresponded to the presentation regions used in Experiment 1. These regions are displayed in Table I. Two measures of reading time were analyzed: (1) first pass reading time, which was defined as the sum of the fixations made in a region from first entering the region to first exiting the region, either left or right, and (2) total reading time, which was defined as the sum of all fixations made in the region. As in Experiment 1, reading time was also analyzed as deviation from reading time predicted on the basis of region length, in this case for both first-pass and total reading time. Table III displays mean first-pass and total reading time in milliseconds and in deviation from predicted reading time by condition for each analysis region. The pattern of
Analyses of first-pass reading time and mean deviation from predicted first pass indicated no reliable results for any analysis region, $F_s < 2.74$, $p > .11$. Although it may be somewhat surprising that the processing differences between NP arguments and adjuncts did not emerge until after the NP region was processed and rereading was initiated, it is a finding that is consistent with previous research. Clifton et al. (1991) found that the reading time difference between sentences containing arguments and adjuncts emerged relatively late during processing—at two regions following the argument/adjunct phrase, when reading time was measured using a self-paced moving window (Experiment 1) and in total reading time when eye movements were recorded (Experiment 2). Kennison (1999) found that the processing difference between agentive by-phrases that served as arguments within complex event nominals and agentive by-phrases that served as arguments within complex nonevent nominals was observed in total reading time but not in first-pass reading time.

Total reading time results were consistent with the results observed in Experiment 1. Total reading time was influenced by an interaction of verb type and NP type, significant by participants in the analyses of mean total reading time in milliseconds, $F_i(1,23) = 8.04, MSE = 24213, p < .01$, $F_j(1,18) = 2.15, MSE = 42442, p < .16$, and by both participants and items in the analyses of mean deviation from predicted total time, $F_i(1,23) =$

<table>
<thead>
<tr>
<th>Table III. Mean First Pass and Total Reading Time (ms) with Mean Deviation from Predicted Time by Condition for Each Analysis Region</th>
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<tbody>
<tr>
<td><strong>Mean First Pass Reading Time</strong></td>
</tr>
<tr>
<td>R1 Everyone knew that</td>
</tr>
<tr>
<td>R2 Meredith</td>
</tr>
<tr>
<td>R3 read/performanced</td>
</tr>
<tr>
<td>R4 every play/week</td>
</tr>
<tr>
<td>R5 despite</td>
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<tr>
<td>R6 her busy schedule</td>
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<tr>
<td><strong>BT-ARG</strong></td>
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<tr>
<td><strong>BT-ADJ</strong></td>
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<tr>
<td><strong>BI-ARG</strong></td>
</tr>
<tr>
<td><strong>BI-ADJ</strong></td>
</tr>
<tr>
<td>Mean Total Reading Time</td>
</tr>
<tr>
<td>R1 Everyone knew that</td>
</tr>
<tr>
<td>R2 Meredith</td>
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<tr>
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<td>R6 her busy schedule</td>
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<tr>
<td><strong>BT-ARG</strong></td>
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<tr>
<td><strong>BI-ARG</strong></td>
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<tr>
<td><strong>BI-ADJ</strong></td>
</tr>
</tbody>
</table>
The interaction reflected that when NP arguments followed biased transitive verbs, they were read more quickly than NP adjuncts, a difference that was statistically significant by participants in the analyses of mean total reading time in milliseconds, $F_1(1, 23) = 8.31, \, MSE = 28556, \, p < .009, \, F_2(1, 18) = 1.87, \, MSE = 73983, \, p < .19$, and by both participants and items in mean deviation from predicted total reading time, $F_1(1, 23) = 11.54, \, MSE = 22018, \, p < .003, \, F_2(1, 18) = 4.74, \, MSE = 39493, \, p < .05$. However, when NP arguments followed biased intransitive verbs, they were read less quickly than NP adjuncts, but this difference was not significant in any analysis, $F_s < 2.02, \, ps > .16$. Further analyses revealed that NP adjuncts were read significantly faster following biased intransitive verbs than following biased transitive verbs, a difference that was significant by items in the analyses of mean total reading time in milliseconds, $F_1(1, 23) = 10.49, \, MSE = 30680, \, p < .004$, and by both participants and items in the analyses of mean deviation from predicted total reading time, $F_1(1, 23) = 10.49, \, MSE = 28698, \, p < .004, \, F_2(1, 18) = 9.20, \, MSE = 23729, \, p < .008$.

In contrast, NP arguments were read more quickly following biased transitive verbs than following biased intransitive verbs; however, this difference was not significant in any analysis, $F_s < 1$. The main effect of verb type was significant by participants in the analyses of mean total reading time in milliseconds, $F_1(1, 23) = 6.37, \, MSE = 20486, \, p < .02, \, F_2(1, 18) = 2.31, \, MSE = 25417, \, p < .15$, and in mean deviation from predicted total reading time, $F_1(1, 23) = 5.18, \, MSE = 20784, \, p < .04, \, F_2(1, 18) = 3.88, \, MSE = 17705, \, p < .07$. The main effect of noun type was significant by participants in the analyses of mean total reading time in milliseconds, $F_1(1, 23) = 4.50, \, MSE = 13612, \, p < .05, \, F_2(1, 18) < 1$, and in the analysis of mean deviation from predicted total reading time, $F_1(1, 23) = 5.95, \, MSE = 11806, \, p < .03, \, F_2(1, 18) = 1.32, \, MSE = 34092, \, p < .27$. Additional analyses indicated that plausibility differences among conditions for each item did not predict the interaction between verb type and noun type (total reading time in milliseconds, $r^2 = .01, \, p > .73, \, \text{intercept} = .34$), and deviation from predicted total reading time, $r^2 = .02, \, p > .53, \, \text{intercept} = .04$; the effect of noun type for biased transitive verb conditions (total reading time in milliseconds, $r^2 = .01, \, p > .73, \, \text{intercept} = .34$, and deviation from predicted total reading time, $r^2 = .02, \, p > .58, \, \text{intercept} = .14$); or the effect of verb type for adjunct conditions (total reading time in milliseconds, $r^2 = .0007, \, p > .91, \, \text{intercept} = .11$, and deviation from predicted total reading time, $r^2 = .01, \, p > .66, \, \text{intercept} = .03$).

In summary, the results of Experiment 2 were consistent with the results of Experiment 1 in that they showed that the type of verb preceding the tar-
get NPs influenced processing. NP arguments were easier to process than NP adjuncts when sentences contained biased transitive verbs. However, there was no significant difference observed in the processing of NP arguments and adjuncts when sentences contained biased intransitive verbs.

**GENERAL DISCUSSION**

Two reading experiments investigated the role of verb information in resolving temporarily ambiguous NP arguments and adjuncts. Reading time was measured on sentences containing NP arguments and adjuncts that were preceded either by biased transitive or biased intransitive verbs. The results indicated that NP arguments were processed more quickly than NP adjuncts when they followed biased transitive verbs. In contrast, no significant difference was observed between the processing of NP arguments and adjuncts when they followed biased intransitive verbs. Further comparisons revealed that the type of verb preceding the NPs significantly influenced how adjuncts were processed but did not significantly influence how arguments were processed. Adjuncts were processed more quickly when they followed biased intransitive verbs than when they followed biased transitive verbs. Of the four conditions, the condition in which NP adjuncts follow biased transitive verbs was the most difficult to process, and the remaining three conditions were comparable in their processing difficulty. Therefore, it can be concluded that the processing of advantage for argument NPs over adjunct NPs was obtained when the preceding context contained lexical information supporting the preference for an argument NP (i.e., where the verb was biased transitive), but was not obtained when the preceding context did not contain lexical information supporting the preference for an argument NP (i.e., where the verb was biased intransitive).

These results can be viewed as consistent with the two previously discussed types of sentence processing theories. For example, theories in which phrase structure information is consulted during the initial syntactic analysis of a phrase (e.g., the garden path theory, Frazier & Fodor, 1978; Frazier & Rayner, 1982) predict that comprehenders initially analyze the temporarily ambiguous NP as an argument of the preceding verb. The argument of a VP is attached as a sister of $V'$, which is a more recent part of the phrase marker than that involved in attaching an adjunct of VP (as a sister of VP) (see Clifton et al., 1991, for similar late closure analysis of argument/adjunct resolution). In those contexts in which the NP is continued as an adjunct, it is necessary for comprehenders to reanalyze the phrase as an adjunct of the preceding verb. The process of reanalysis may
be influenced by contextual sources of information, such as verb information (Rayner, Carlson, & Frazier, 1983). Consequently, the influence of verb information, if observed, is predicted to occur in cases in which there has been a revision of the initial, structure-based analysis, i.e., adjunct NPs, but it is not predicted to occur in cases in which there has not been a revision of the initial, structure-based analysis, i.e., argument NPs. The only difficulty for this account is explaining why there is a no-cost revision for adjunct NPs following biased intransitive verbs, because reading time did not differ significantly for NP arguments and adjuncts following intransitive verbs. This issue has been discussed in previous reports and advocates of this view have been comfortable with the notion of a no-cost revision (see Adams, Clifton, & Mitchell, 1998, for detailed discussion of the filtering hypothesis).

In contrast, theories claiming that lexical information is consulted during the initial syntactic analysis of a phrase (e.g., partial activation hypothesis, MacDonald, 1994; also constraint satisfaction, MacDonald, Pearlmutter, & Seidenberg, 1994; Spivey-Knowlton & Sedivy, 1995; Trueswell, Tanenhaus, & Kello, 1993) predict that comprehenders initially analyze the temporarily ambiguous NP following a biased transitive verb as an argument. When the NP proves to be an adjunct, comprehenders must reanalyze the initial analysis, resulting in a processing cost. When comprehenders encounter temporarily ambiguous NPs following biased intransitive verbs, they are predicted to prefer neither NP arguments nor adjuncts on the basis of frequency of usage. However, there is a processing difference predicted between argument NPs following biased intransitive verbs and adjunct NPs following biased transitive verbs, because NP arguments are lexically specified. Biased intransitive verbs prefer intransitive usages, but transitive usages remain possible. Consequently, the fact that verb type influenced the processing of adjunct phrases but not argument phrases is also consistent with these types of theories.

The experiments presented here represent a preliminary look into the processing of noun phrase arguments and adjuncts in contexts containing differing types of verbs. Several interesting empirical questions remain. For example, one interesting future direction would be to investigate the effect that the distance between the transitive and the intransitive reading of a verb would have on the processing of a following noun phrase argument or adjuncts. Given that the present results show a role for verb information in the processing of noun phrase adjuncts, it is plausible to imagine that other verb-specific distinctions may also influence processing. A second interesting empirical question relates to how readers diagnose the argument/adjunct status of a postverbal noun phrase. The meaning of the noun phrase must be considered in conjunction with the verb to determine whether the noun
phrase is acceptable in the argument role or in the adjunct role for a specific verb (see Schütze & Gibson, 1999, for discussion of how PP arguments are diagnosed).

As the results of Experiment 2 show, differences between arguments and adjuncts occur relatively late during processing. One may conclude that there is a substantial amount of semantic interpretation occurring to determine the argument status of the noun phrase during on-line processing. Future research could illuminate the processes involved and the sources of information that are used by readers during these stages of processing.

In conclusion, the processing preference for argument phrases over adjuncts phrases cannot be viewed as a general preference that occurs in all types of sentence contexts. The present findings indicate that the preference was observed in contexts in which lexical information supported a preference for an argument (i.e., those contexts containing biased transitive verbs). Further investigation is necessary to determine how different types of sentence contexts can influence the processing of arguments and adjuncts. Understanding the role of sentence context in the syntactic analysis of arguments and adjuncts will likely prove important in evaluating the viability of existing models of sentence processing.

APPENDIX

The following sentences were used in Experiments 1 and 2. Biased intransitive verbs are listed first and biased transitive verbs, second. The estimated percentage of transitive and intransitive usages is listed in parentheses, respectively. NP arguments are listed first and NP adjuncts, second. The “|” indicates presentation regions for Experiment 1 and analysis regions for Experiment 2.

1. Everyone knew that| Meredith| performed (30 69)/read (93 7)| every
 play/week| despite| her busy schedule.| every
2. In Troop 207,| the girl scouts| sang (44 56)/read (93 7)| every
 song/night| during| their free time.| during
3. No one remembered that| Mildred| drove (7 74)/watched (81 15)| the
 whole family/evening| during| the blizzard.| the blizzard.
4. Everyone appreciated that| Gregory| performed (30 69)/taught (85 4)| the
 entire play/week| in the auditorium| in front of all the parents.| in front of all the parents.
5. Late Saturday night| Robert| drove (7 74)/watched (81 15)| several peo-
 ple/minutes| to the airport| and then| went home by himself.| and then
6. It was rumored that| Samantha’s brother| worried (4 98)/visited (67 30)| almost every advisor/semester| at school| because of his failing grades.| almost every advisor/semester| at school| because of his failing grades.
7. To the administrator’s amazement the professor lectured (22 63)/taught (85 4)/most freshmen/Saturdays during the summer session.

8. Friends knew that Samuel studied (19 81)/researched (74 11)/nearly every article/weekend with his brother Jake.

9. Many wondered why Patrick cheated (4 93)/teased (81 0)/the whole class/month even though the teachers were always scolding him.

10. Last summer the German tourists hiked (0 100)/explored (96 0)/every mountain/morning in the National Park.

11. Before the audition the actresses sang (44 56)/read (93 7)/all the lines/time in the rehearsal room.

12. Just for fun the boys scouts hiked (0 100)/explored (96 0)/several trails/hours near the campground.

13. The counselors learned that the children worried (4 98)/called (67 30)/several people/times during the trip.

14. Last week the accountant consulted (19 81)/fought (63 30)/nearly every employee/afternoon during lunch.

15. No one knew that Sue’s father studied (19 81)/researched (74 11)/almost every company/weekend in the city.

16. On the field trip Bobby rushed (4 85)/coaxed (93 0)/all the kids/time to enjoy the amusement park.

17. Late Sunday night the security guard hurried (0 93)/followed (81 0)/nearly every person/minute in the store.

18. At the small college Harold lectured (22 63)/advised (74 4)/every student/Tuesday about recreational drinking.

19. It was true that Maryellen cheated (4 93)/teased (81 0)/all the boys/time despite her mother’s repeated attempts to get her to stop.

20. While the parents watched TV the toddlers stood (0 100)/hid (28 72)/several toys/hours in the closet behind a pile of clothes. [This item was not included in any analysis reported in the paper.]

REFERENCES


