Exploring a Decrease in Recognition Performance for Non-antecedents Following the Processing of Anaphors

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Recognition judgments to the non-antecedents of a repeated-noun anaphor are slower and less accurate after than before the processing of the anaphor. Disagreement exists as to whether this pattern of performance reflects a bias shift carried out by a memory process associated with the recognition of a word that has occurred previously in the discourse, or an accessibility reduction carried out by a comprehension process specifically tied to the resolution of anaphors. The results of three experiments supported the memory-based account.

Each time an entity is mentioned following its introduction in a discourse, the entity is identified with an anaphor. When an anaphor is encountered in a discourse, an *antecedent* must be located in the preceding material. When an antecedent is located, the anaphor is said to be *resolved* (Almor, 1999; Cacciari, Carreiras, & Cionini, 1997; Garnham, 2001; Garnham, Oakhill, & Cain, 1997; Garrod, Freudenthal, & Boyle, 1994; MacDonald & MacWhinney, 1995).

In studying anaphor resolution, researchers have often drawn a distinction between noun and pronoun anaphors. This distinction has been justified on the grounds that the two kinds of anaphor function differently (Greene, McKoon, & Ratcliff, 1992; Sanford & Garrod, 1981). The present study explored the resolution of noun anaphors. The study extended work by Gernsbacher (1989, 1990).

Gernsbacher (1989) conducted a series of experiments using the probe recognition methodology with short, two-clause sentences as stimulus material. In the first clause of each sentence, two characters were introduced, identified with proper nouns. At the beginning of the second clause, an anaphor occurred that referred to one of the characters. On the trials that will be crucial here, the anaphor consisted of the proper noun that had originally been used to identify the referent character (e.g. Ann predicted that Pam would lose the track race, but Pam came in first very easily). The participant read the sentence and responded to a recognition probe that was presented at a range of points before and after the anaphor. When the test word was the anaphor's antecedent (Pam in the earlier example), indices of difficulty for the probe response (response time and/or

error rate) were greater when the probe occurred before as opposed to after the anaphor (we will call this the antecedent effect). When the test word was the noun that was not the anaphor's antecedent (Ann in the earlier example), indices of difficulty were greater when the probe occurred after as opposed to before the anaphor (we will call this the non-antecedent effect).

Gernsbacher (1989) attributed the pattern of recognition performance that she observed to an anaphor comprehension process. In Gernsbacher's conception, the object in resolving an anaphor is an increase in the accessibility of the anaphor's antecedent, which will make possible the incorporation of the antecedent and its corresponding referent into the discourse structure (Dell, McKoon, & Ratcliff, 1983; O'Brien, Duffy, & Myers, 1986; O'Brien, Plewes, & Albrecht, 1990). According to Gernsbacher, the relative accessibility of a repeated-noun anaphor 's antecedent is increased through a two-part process in which the antecedent is activated and non-antecedents are suppressed. Resolution of the anaphor is thereby promoted.

Gernsbacher's (1989) interpretation of the non-antecedent effect was called into question, however, by results that Dopkins and Ngo (2002) subsequently observed. Dopkins and Ngo scrambled the order of the words in sentences similar to Gernsbacher's and used the resulting lists in a task on each trial of which the participant 1) read a list, 2) made a recognition judgment to a test word, and 3) indicated whether the list contained any repeated words. The results for the recognition judgment were crucial. In the critical *repeated noun* condition, the test word was a noun from the list and the last word in the list was another noun that was repeated from earlier in the list, e.g. "Robert more Jim be

honest urged to at tax time but Robert [PROBE: *Jim*]". Indices of difficulty for the recognition judgment were greater in this condition than in conditions for which 1) a new noun was inserted in place of the repeated noun, 2) an adverb was inserted in place of the repeated noun, or 3) the list ended immediately before the point at which the repeated noun would otherwise have occurred.

Notice the correspondence between the Gernsbacher (1989) and Dopkins and Ngo (2002) results. For Gernsbacher, the stimulus items were sentences, recognition performance was assessed before and after the processing of a repeated-noun anaphor, and the test word was a non-antecedent of the anaphor. For Dopkins and Ngo, the stimulus items were lists derived from scrambled sentences, recognition performance was assessed after the processing of a repeated noun and in control conditions, and the test word was a different noun than that which was repeated. Notwithstanding this correspondence, Dopkins and Ngo concluded that their results could not reflect an anaphor comprehension process such as Gernsbacher (1989) proposed. The key consideration was that the lists in the Dopkins and Ngo study were derived from scrambled sentences, and therefore had minimal discourse properties. Thus, they should not have evoked a comprehension process. Instead, Dopkins and Ngo suggested that their results reflected a memory process. Specifically, they suggested that, in the repeated noun condition, participants made a recognition decision to the last word in the list to evaluate it for purposes of the repeated-word question, and that, as a byproduct of this decision, indices of difficulty for the recognition judgment to the test word increased.

Dopkins, Ngo, and Sargent (2006) conducted a series of experiments seeking to understand the memory process underlying the Dopkins and Ngo (2002) results. On the basis of the results of these experiments, Dopkins et al. (2006) concluded that the results reflected a shift in response bias. They reasoned as follows: A given participant made a recognition decision to the last word in the list in the service of the repeated-word question. The participant's response bias for the subsequent recognition judgment to the test word was shifted consequent to the recognition decision to the last word. In the repeated noun condition, the decision to the last word was positive; in the control conditions, the decision to the last word was negative. The participant's response bias was more conservative following the positive decision that occurred in the repeated noun condition than following the negative decision that occurred in the control conditions. Because the test word in the crucial conditions always belonged to the list, so that a positive response was required, indices of difficulty were greater in the repeated noun condition than in the control conditions. Dopkins, Sargent, & Ngo (2010) later confirmed the conclusions of Dopkins et al. (2006).

On the basis of another series of experiments, Dopkins and Ngo (2005) proposed that the Dopkins et al. (2006) bias shift was responsible for the non-antecedent effect that Gernsbacher (1989) observed. Dopkins and Ngo reasoned as follows: In order for a repeated-noun anaphor to be resolved, it must first be identified as an anaphor. The requisite process of *anaphor identification* depends on recognition memory: The reader or listener remains alert to the occurrence of words that are repeated from earlier in the discourse. When a repeated word is recognized as such, it

is classified as a potential anaphor and the earlier occurrence of the word is retrieved. Further processing then determines whether or not the repeated word is in fact an anaphor. This anaphor identification process was operative in Gernsbacher's experiments. The anaphoric noun was consequently recognized as having been repeated from earlier in the discourse. Indices of difficulty for the recognition judgment to the non-antecedent test word increased consequent to the positive recognition decision to the anaphoric noun, through a bias shift such as Dopkins et al. (2006, 2010) proposed. (The antecedent effect that Gernsbacher (1989) observed reflected a different process. Indices of difficulty for the recognition judgment to the antecedent test word decreased following the processing of the anaphoric noun because the antecedent test word was the same as the anaphoric noun; thus a positive response could be emitted simply on the basis of immediate memory; there was no need for a longer-term recognition judgment such as occurred to the non-antecedent test word; response bias was therefore not a factor).

Thus, we have two possible accounts of the Gernsbacher (1989) non-antecedent effect. The comprehension-based account proposes that, when a repeated-noun anaphor is resolved, the accessibility of non-antecedent nouns is reduced. The accessibility reduction reflects a suppression process that promotes the accessibility of the anaphor's antecedent. The process is specifically tied to anaphor resolution. The memory-based account proposes that, as part of the process whereby a repeated-noun anaphor is resolved, the repeated noun is recognized as having occurred previously in the discourse, and the response bias for subsequent recognition judgments

consequently becomes more conservative. This bias shift is not specifically tied to anaphor resolution (and, in fact, occurs whenever a word is repeated in a discourse). The present study sought to choose between the comprehension-based and memory-based accounts of the non-antecedent effect.

Experiment 1

Experiment 1 explored the situation in which a non-antecedent of a repeated-noun anaphor appears together with the anaphor's antecedent in a compound noun phrase. The passages for the experiment resembled the sample shown in Table 1. Notice that the sample passage includes three proper nouns, each of which identifies a different character. The first and second nouns (Penny and Agnes) appear toward the beginning of the passage in a compound noun phrase and the third noun (Wendy) appears later in the passage. Still later in the passage, the first noun (Penny) re-appears as an anaphor. Primary interest focused on the second noun (Agnes), which appeared in the compound noun phrase as *companion* to the anaphoric noun's antecedent. The experiment asked whether the non-antecedent effect would occur for this companion noun following the processing of the anaphoric noun.

Under the comprehension-based account, we would expect the non-antecedent effect to occur for the companion noun. According to this account, the effect reflects a suppression process that operates at the level of discourse content. The process overrides activity in the mental representation of the discourse to reduce the accessibility of non-antecedents and thereby increase the accessibility of the antecedent. In the present case, the companion noun should be interpreted as a non-

antecedent when the anaphoric noun is processed. Convention dictates that ‘they’ would be used to refer jointly to the first and second characters if a statement were about be made jointly about them. Thus, the re-appearance of the first noun should be taken as indicating that a statement is about to be made about the first character alone (this expectation was confirmed with norming data), and, thus, that the companion noun is a non-antecedent of the anaphor. Given that the companion noun is a non-antecedent, the companion noun should be suppressed. Although the memory record for the companion noun may become more highly activated when the anaphoric noun is processed, given that the companion noun appeared in the same phrase as the anaphoric noun’s antecedent (Dell, McKoon, & Ratcliff, 1983), the suppression process should override this activation, because the suppression process operates at a higher level (the discourse level) than the activation process (which operates at the word level). Thus, the non-antecedent effect should occur for the companion noun.

The memory-based account, in contrast, does not predict the non-antecedent effect for the companion noun. According to this account, the non-antecedent effect reflects a shift in the recognition response bias. The bias shift is a memory process initiated when the anaphoric noun is recognized as having occurred previously in the discourse. Thus, in the present case, the bias for the recognition judgment to the companion noun should become more conservative when the anaphoric noun is processed. At the same time, the recognition judgment to the companion noun should be influenced by other memory processes that occur when the anaphoric noun is processed. In particular, the judgment should reflect the fact that the companion noun becomes more highly activated when

the anaphoric noun is processed, for the reasons given earlier. Thus, the recognition judgment to the companion noun should be subject to two opposing influences following the processing of the anaphoric noun. On one hand, indices of difficulty for the judgment should be increased given that the bias for the judgment has become more conservative. On the other hand, indices of difficulty for the judgment should be decreased given that the memory record for the companion noun has become more highly activated. Because we cannot say which of these influences will be stronger, we cannot predict the non-antecedent effect for the companion noun under the memory-based account.

Insert Table 1 about here

On each trial of the experiment, the participant read a passage and responded to a recognition probe. On the crucial trials, the passage had the structure described earlier. In the After condition, a probe was presented immediately after the anaphor and the passage was discontinued (… Penny and Agnes loudly accused Wendy of committing a big robbery and Penny PROBE). The Before condition was identical to the After condition except that the anaphor was removed (… Penny and Agnes loudly accused Wendy of committing a big robbery and PROBE). In the Antecedent condition, the test word was the first noun in the passage – that is, the antecedent of the anaphor (Penny). In the Companion condition, the test word was the second noun in the passage – that is, the non-antecedent that appeared with the antecedent in the compound noun phrase (Agnes). In the Non-antecedent condition, the test word was the third noun in the passage – that is, the non-antecedent that did not appear with the antecedent in the compound noun phrase

(Wendy). Thus, two independent variables were manipulated in the experiment: 1) whether the probe was presented after the anaphor or after the word that preceded the anaphor, 2) whether the test word was the antecedent of the anaphor, the non-antecedent that appeared in the compound noun phrase (the companion noun), or the non-antecedent that did not appear in the compound noun phrase.

Because it seemed possible that recognition performance would vary with the processing of the anaphor, a response signal procedure was used to assess performance at a range of points subsequent to the appearance of the anaphor (Dopkins, 1996; McKoon & Ratcliff, 1986). This procedure makes possible strict temporal control of participant responding. If the task is to make a recognition response to a probe word, as in the present study, the word is presented on the computer screen, a certain temporal interval is allowed to elapse, and a signal is presented which indicates to the participant that a response should be emitted. With processing times thus controlled, the error rates in the different conditions are compared. In order to get as complete a picture as possible of participant responding, several different intervals were used. Thus, a third independent variable was manipulated in the experiment: whether the probe - signal interval was relatively Short, Medium, or Long.

On the basis of Gernsbacher's results, it was expected that the error rate in the Antecedent condition would be greater in the Before than in the After condition, and that the error rate in the Non-antecedent condition would be greater in the After than in the Before condition. Performance in the in the Companion condition was of primary interest. The comprehension-based account of the non-antecedent effect predicted that the error

rate would be greater in the After than in the Before condition. In contrast, the memory-based account of the effect made no such prediction.

Method

Participants. The participants were 36 students at the George Washington University. They received extra credit in a psychology course in exchange for their efforts.

Design. The Probe Position and Probe Type variables were manipulated within participants and items. The Probe - signal Interval variable was manipulated between participants and within items.

Materials. Forty-eight experimental passages were used. The passages were rotated through the six conditions that were obtained by crossing the Probe Position and Probe Type variables. In this way six presentation sets were produced. The experimental passages were randomly intermixed with 61 filler passages for which the probe words were verbs, adjectives, and words from earlier passages.

A norming study was conducted to verify that participants understood the passages in the manner intended under the design of the experiment. The study sought to confirm that the anaphoric re-appearance of the first noun would be interpreted as indicating that a statement was about to be made about the first character alone and not about the first and second character jointly. Forty participants were tested in this study. Each participant was presented with sheets of paper on which all of the experimental passages were printed in their entirety (including the anaphoric noun). The participant wrote continuations for all of the passages. In all cases, the continuations that participants wrote involved statements about the first character. In no case did a

continuation involve a statement about the first and second character jointly. Thus, the study confirmed that participants understood the passages in the manner intended under the design of the experiment.

Procedure. Each participant was randomly assigned to a presentation set and a probe - signal interval. The passages were presented on a computer monitor, according to a procedure derived from Gernsbacher (1989). The participant started the presentation of each passage by pressing the space bar of the computer. The passage was presented word by word, with each successive word appearing alone in the middle of the screen for an amount of time determined according to the following formula: Presentation Time = (450 ms) + ((16.667 ms)*(number of letters)). Gernsbacher used the same procedure except that the constant base was 300 rather than 450 ms and an inter-word interval of 150 ms occurred between each successive pair of words. Thus, the difference between the two procedures is that the participant saw each word for an extra 150 ms in the present procedure whereas he/she saw an extra 150 ms of blank screen between words in Gernsbacher's procedure. Notice, however, that the rate of presentation was the same in the two cases.

At the probe point, the probe appeared at the top of the screen, in capital letters. A row of asterisks appeared below the probe either 400, 700, or 1000 ms after it appeared. The participant was instructed to respond immediately after the asterisks appeared on the screen. The probe remained on the screen until the participant responded. If the participant responded before the asterisks appeared or more than 200 ms after they appeared, a message appeared at the bottom of the screen for 1000 ms indicating that the response

was too fast or too slow, respectively. After the participant responded, the passage was discontinued and a yes/no comprehension question, pertaining to the portion of the passage that had so far been presented, appeared at the bottom of the screen. This again remained on the screen until the participant responded. The participant was instructed to respond as accurately as possible to the comprehension question. When the participant responded incorrectly to either the probe or the comprehension question, he/she was given feedback to that effect.

Notice that the passage was discontinued after the probe was presented. This was done so that participants did not develop ad hoc expectancies, based on the materials for the experiment, as to what would follow the anaphoric noun. One might be concerned that participants would not be motivated to process the anaphors under this procedure, given that they were not dealing with complete sentences. In fact, participants did process the anaphors; this will be clear from the results of the experiments. The key here was probably that there were many filler passages that were both longer and shorter than the experimental passages. As a result, participants could not anticipate when the probe and subsequent passage discontinuation would occur. Nordlie, Dopkins, & Johnson (2001) have shown that similar results are observed with the Gernsbacher procedure regardless of whether or not the stimulus passages are discontinued following the presentation of the recognition probes.

Results

The results are presented in Table 2. There was a significant effect of Probe Type in the error-rate data, $F1(2,36) = 14.91$, $MSe = .01$; $F2(2,84) = 10.01$, $MSe = .02$; the error

rate was lower in the Antecedent and Non-antecedent conditions than in the Companion condition (F1 and F2 represent the results of tests conducted against the variability due to participants and items, respectively). The interaction of the effects of Probe Position and Type was significant $F1(2,36) = 13.28$, $MSe = .02$; $F2(2,84) = 13.55$, $MSe = .02$. The interaction reflects the fact that the error rate in the Antecedent condition was lower in the After than the Before condition, whereas the error rate in the Non-antecedent condition was lower in the Before than the After condition, while the error rate in the Companion condition was more or less the same in the Before and After conditions. Finally, the interaction of the effects of Probe Type and Interval was significant when tested against participant variability, $F1(4,36) = 4.31$, $MSe = .01$;. The interaction reflects the fact that the error rate in the Short condition was fairly similar for the three probe type conditions, whereas the error rate in the Medium and Long conditions was lower for the Antecedent and Non-antecedent conditions than for the Companion condition.

Insert Table 2 about here

The effects of Probe Position, $F1(1,18) < 1$; $F2(1,42) < 1$, and Interval, $F1(2,18) = 1.69$, $MSe = .07$, were non-significant, as were the interaction of the effects of Probe Position and Interval, $F1(2,18) < 1$, and the three-way interaction of the effects of Probe Position, Probe Type, and Interval, $F1(4,36) = 1.09$, $MSe = .02$. (There were too few cases to perform item analyses on the effect of Interval and the interactions of this effect with the effects of the other independent variables).

The response time for a given trial was the amount of time elapsing between the response signal and the participant's response. There was a significant effect of Interval in

the response-time data, $F1(2,18) = 8.26$, $MSe = 141{,}387$; response time was shorter at the longer intervals. The interaction of the effects of Probe Position and Probe Type was significant, $F1(2,36) = 8.11$, $MSe = 14{,}347$; $F2(2,84) = 3.22$, $MSe = 61{,}349$. The interaction reflects the fact that response time for Antecedent probes was shorter in the After than the Before condition, whereas response time for Non-antecedent probes was shorter in the Before than the After condition, while response time for Companion probes was more or less equivalent in the Before and After conditions.

The effects of Probe Position, $F1(1,18) < 1$; $F2(1,42) < 1$, and Probe Type, $F1(2,36) = 1.83$, $MSe = 26{,}872$; $F2(2,84) < 1$, were non-significant, as were the interaction of the effects of Probe Position, $F1(2,18) = 2.14$, $MSe = 27{,}786$; and Probe Type, $F1(4,36) = 1.53$, $MSe = 26{,}872$, with Interval and the three-way interaction of the effects of Probe Position, Probe Type, and Interval, $F1(4,36) = 1.63$, $MSe = 14{,}347$.

Discussion

The crucial results under the response signal procedure are the error rates. As was expected on the basis of Gernsbacher's (1989) work, the error rate in the Antecedent condition was greater in the Before condition than in the After condition. As was also expected, the error rate in the Non-antecedent condition was greater in the After condition than in the Before condition. More important, the error rate in the Companion condition did not vary as a function of the position of the probe, in spite of the fact that the companion word was a non-antecedent of the anaphor. Thus, the companion noun was not subject to the non-antecedent effect. These results are consistent with the memory-based but not the comprehension-based account of the non-antecedent effect.

Several other aspects of the error-rate data deserve comment. We can account for the superiority of the Antecedent and Non-antecedent conditions over the Companion condition by noting that the first condition benefited from the fact that recognition performance was substantially better in the After condition than in the Before condition, and that the second condition benefited from a recency effect, whereas the third enjoyed neither of these advantages. The interaction of the effects of Probe Type and Interval evidently reflects the fact that the aforementioned advantages did not have time enough to express themselves at the short interval.

As was noted earlier, the assumption under the response signal procedure is that processing time will be held constant across conditions. This assumption was not completely fulfilled here but the failures do not appear to complicate interpretation of the error-rate results. The superiority of the Medium and Long conditions over the Short condition reflects the fact that participants had difficulty emitting timely responses in the Short condition. The chief significance of this result is that processing time in the Short condition was not as short as was intended. The interaction of the effects of Probe Position and Probe Type paralleled the interaction of these effects in the error-rate data. There was no speed-accuracy tradeoff. Thus, the interaction does not invalidate the error-rate results.

Experiment 2

Experiment 2 explored the situation in which two repeated-noun anaphors appear in close succession. The passages for the experiment resembled the sample shown in Table 3. Notice that the sample passage includes three proper nouns, each of them identifying a different character, with the first (Jane) and second (Faye) nouns appearing at

the beginning of the passage and the third noun (Meg) appearing later in the passage. In the ‘But’ condition, the first and second nouns reappear anaphorically later in the passage, separated by the conjunction ‘but’, with the first noun holding the object position of a phrase or clause and the second noun holding the subject position of a subsequent clause. In the ‘And’ condition, the first and second nouns reappear anaphorically later in the passage, linked with the conjunction ‘and’ so as to form a compound noun phrase that holds the object position of a phrase or clause. The passage is written so that, in the ‘And’ condition, the third character performs an action with respect to a unit comprising the first and second characters (Meg asks for Jane and Faye). The experiment asked whether the non-antecedent effect would occur for the first noun (Jane) following the anaphoric re-appearance of the second noun (Faye). It was expected that the non-antecedent effect would occur for the first noun in the ‘But’ condition. The first noun would be a non-antecedent of the anaphor in question. Gernsbacher’s work implied that the non-antecedent effect would therefore occur for the first noun. The important question was whether the non-antecedent effect would occur for the first noun in the ‘And’ condition.

Insert Table 3 about here

Under the comprehension-based account, we would not expect the non-antecedent effect to occur for the first noun in the ‘And’ condition. According to this account, the effect reflects a suppression process that reduces the accessibility of non-antecedents, thereby increasing the accessibility of the antecedent and promoting resolution of the anaphor. A crucial aspect of an anaphor’s resolution is the

incorporation of the anaphor's antecedent and its corresponding referent into the discourse structure. In the present case, the crucial integration process would be impeded if the first noun were suppressed. The entity jointly comprising the first and second characters is the object of the third character's action. If the first noun were suppressed following the processing of the anaphoric second noun, then the joint entity would not be effectively integrated as the object of the third character's action; the fact that this action applies to the two characters as a unit would be lost. In the sample passage, the fact that Meg was asking for Jane and Faye would be lost. Suppressing the first noun would therefore be inconsistent with effective resolution of the two anaphors. Thus, the non-antecedent effect should not occur for first noun in the 'And' condition.

Under the memory-based account, in contrast, we would expect the non-antecedent effect to occur for the first noun in the 'And' condition. According to this account, the non-antecedent effect reflects a shift in the recognition response bias. The bias shift is initiated when a noun is recognized as having occurred previously in the discourse. The same bias shift should occur when the second noun is recognized, regardless of whether the second noun is preceded by 'but' or 'and'. Thus, the non-antecedent effect should occur for the first noun in the 'And' condition.

On each trial of the experiment, the participant read a passage and responded to a recognition probe. On the crucial trials, the passage had the structure that was described earlier. In the After condition, a probe was presented immediately after the second anaphor and the passage was discontinued (… called Faye after her trip around

the lake. Meg was gravely ill and asking for Jane and/but Faye PROBE). The Before condition was identical to the After condition except that the second anaphor was removed (… called Faye after her trip around the lake. Meg was gravely ill and asking for Jane and/but PROBE). The test word was always the first noun (Jane). Because Experiment 1 did not demonstrate differences as a function of probe – signal interval, a response signal was not used. It was expected, therefore, that the crucial effects would be strongest in the response-time data, as in previous work with the Gernsbacher task (Gernsbacher, 1989; Nordlie et al., 2001).

In summary, two independent variables were manipulated in the experiment: 1) whether the probe was presented after the final anaphor or after the word that preceded this anaphor, and 2) whether the anaphors were linked by ‘and’ or ‘but.’ Interest focused on the condition in which the anaphors were linked by ‘and’. The comprehension-based account of the non-antecedent effect predicted that response time for the recognition judgment would not differ in the Before and After conditions. In contrast, the memory-based account predicted that response time would be greater in the After than in the Before condition.

Method

Participants. The participants were 76 students at the George Washington University. They received extra credit in a psychology course in exchange for their efforts.

Design. Probe Position and Conjunction Type were manipulated within participants and items.

Materials. Forty-eight experimental passages were used. The passages were

rotated through the four conditions that were obtained by crossing the Probe Position and Conjunction Type variables. In this way four presentation sets were produced. The experimental passages were randomly intermixed with 63 filler passages for which the probe words were verbs, adjectives, and words from earlier passages.

Fifty-two of the participants took part in a norming study seeking to verify that the passages were understood in the manner intended under the design of the experiment. The key question concerned the interpretation of third character's action in the 'And' condition ('asking for Jane and Faye' in the sample passage). The experiment was designed under the assumption that the object of this action was a compound entity comprising the first and second character ('Jane and Faye' in the sample passage). Under this interpretation, the 'and' that appeared between the two anaphoric nouns linked the nouns in a compound noun phrase. An alternative interpretation of the action was possible, however. Under this interpretation, the object of the third character's action was the first character alone (Jane in the sample passage); the 'and' that appeared between the two anaphoric nouns linked the clause describing the action involving the third and first characters to a subsequent clause that began with reference to the second character and was then discontinued. To verify the intended interpretation, the participants were asked to continue the experimental passages in any way that seemed appropriate. Each participant wrote continuations for all of the passages that the participant saw in the 'And' condition. Ninety-seven percent of the continuations that participants produced were consistent with the intended interpretation.

Procedure. The procedure was the same as for Experiment 1 except that a

response signal was not used.

Results

The results are presented in Table 4. The effect of Probe Position was significant in the response-time data, $F1(1,75) = 15.57$, $MSe = 20{,}109$, $F2(1,47) = 11.32$, $MSe = 19{,}527$; response time was longer in the After than the Before condition. The effect of Conjunction Type was non-significant, $F1(1,75) < 1$, $F2(1,47) < 1$, as was the interaction of the effects of Probe Position and Conjunction Type, $F1(1,75) < 1$, $F2(1,47) < 1$. No significant effects were present in the error-rate data (Probe Position, $F1(1,75) < 1$, $F2(1,47) < 1$; Conjunction Type, $F1(1,75) < 1$, $F2(1,47) < 1$; Probe Position X Conjunction Type, $F1(1,75) = 1.98$, $MSe = .002$, $F2(1,47) = 1.19$, $MSe = .002$).

Insert Table 4 about here

Discussion

As was expected, response time was greater in the After than in the Before condition when the anaphors were linked with ‘but’. Of greater interest, the same pattern was present when the anaphors were linked with ‘and’. The effect of probe position was as strong when the anaphors were linked with ‘and’ as when they were linked with ‘but’. These results are consistent with the predictions of the memory-based but not the comprehension-based account of the non-antecedent effect.

No effects were observed in the error-rate data. This is not particularly surprising, given that a response signal was not used, so that the effects were expected to be strongest in the response-time data. Nonetheless, error-rate effects have sometimes been observed in the Gernsbacher task in the absence of the response-signal procedure

(Nordlie et al., 2001). Observation of such effects probably depends on the particular trading relationship that exists in participant performance between speed and accuracy (Luce, 1986).

Experiment 3

Experiment 3 sought to test the memory-based account more directly. The account proposes that, when a repeated-noun anaphor is resolved, the response bias for subsequent recognition judgments becomes more conservative. Indices of difficulty for the recognition judgment to the non-antecedent test word consequently increase, because the test word is present in the current passage, so that a positive response is required. A crucial corollary prediction, as yet untested, is that indices of difficulty for recognition judgments to test words not present in the passage should decrease, because a negative response is required. The comprehension-based account, in contrast, does not predict such a decrease because the suppression process is directed at non-antecedents of the anaphor and should have no effect on words not present in the passage.

Experiment 3 sought to test the prediction of the memory-based account. The critical stimulus materials for the experiment were passages such as were used in the original Gernsbacher (1989) experiments, as described in the Introduction. A recognition probe was presented after the final anaphor of each passage (After condition) or after the word that preceded this anaphor (Before condition). The test word was either the anaphor's non-antecedent (Positive condition) or a character name not present in the passage (Negative condition). As in Experiment 2, a response signal was not used; the

crucial effects were therefore expected in the response-time data. The memory-based account predicted that response time for the recognition judgment would be greater in the After than in the Before condition for positive probes, and greater in the Before than in the After condition for negative probes. The comprehension-based account predicted that response time would be greater in the After than in the Before condition for positive probes but predicted no response-time difference for negative probes.

Method

Participants. The participants were 40 students at the George Washington University. They received extra credit in a psychology course in exchange for their efforts.

Design. Probe Position and Probe Type were manipulated within participants and items.

Materials. 48 experimental passages were used. The passages were rotated through the four conditions that were obtained by crossing the Probe Position and Probe Type variables. In this way four presentation sets were produced. The experimental passages were randomly intermixed with 73 filler passages for which the probe words were verbs and adjectives that were either present in or absent from the passages.

Procedure. The procedure was the same as for Experiment 2.

Results

The results are presented in Table 5. The effects of Probe Position, $F1(1,36) < 1$; $F2(1,44) < 1$, and Probe Type, $F1(1,36) = 1.85$, $MSe = 59{,}778$; $F2(1,44) < 1$, were not significant in the response-time data, but these effects interacted in those data, $F1(1,36) = 7.56$, $MSe = 100{,}571$; $F2(1,44) = 9.21$, $MSe = 81{,}183$. Response time was longer in the

After than the Before condition for positive probes, *F1(1,36)* = 6.26, *MSe* = 75,655; *F2(1,44)* = 4.13, *MSe* = 68,383, and longer in the Before than the After condition for negative probes, *F1(1,36)* = 4.00, *MSe* = 75,397; *F2(1,44)* = 6.74, *MSe* = 70,911. The effects of Probe Position, *F1(1,36)* = 3.10, *MSe* = .02; *F2(1,44)* = 1.19, *MSe* = .02, and Probe Type, *F1(1,36)* = 1.15, *MSe* = = .02; *F2(1,44)* = 2.57, *MSe* = .02, were not significant in the error-rate data, but these effects interacted in those data, *F1(1,36)* = 8.05, *MSe* = .04; *F2(1,44)* = 12.59, *MSe* = .01. Error rate was higher in the Before than the After condition for negative probes, *F1(1,36)* = 8.51, *MSe* = .04; *F2(1,44)* = 9.21, *MSe* = .017, and showed a trend toward being higher in the After than the Before condition for positive probes, *F1(1,36)* = 2.77, *MSe* = .021, *p* = .105; *F2(1,44)* = 3.02, *MSe* = .013, *p* = .09.

Insert Table 5 about here

Discussion

The response time for the recognition judgment was greater in the After than in the Before condition when the test word was the anaphor's non-antecedent and greater in the Before than in the After condition when the test word was not present in the passage. Parallel but weaker effects were present in the error-rate data. These results are consistent with the predictions of the memory-based but not the comprehension-based account of the non-antecedent effect.

General Discussion

The present study sought to determine the relative viability of two accounts that have been proposed for the increase in response time that Gernsbacher (1989) observed for recognition judgments to non-antecedents of repeated-noun anaphors

following the processing of those anaphors. According to the comprehension-based account, originally proposed by Gernsbacher, this non-antecedent effect reflects a suppression process that increases the accessibility of the antecedents of repeated-noun anaphors and thereby promotes resolution of these anaphors. According to the memory-based account, the non-antecedent effect reflects a shift in response bias that occurs when the anaphoric noun is recognized as having occurred previously in the discourse.

The results of the study were consistent with the memory-based account and inconsistent with the comprehension-based account. In Experiment 1, the non-antecedent effect did not occur for a companion noun that appeared with the antecedent of a repeated-noun anaphor in a compound noun phrase. This result is consistent with the memory-based account because the recognition judgment to the companion noun should be subject to opposing influences following the processing of the anaphor. Activation of the memory record for the companion noun should tend to decrease indices of difficulty for the judgment at the same time that the bias shift increases indices of difficulty for the judgment. In contrast, this result is not consistent with the comprehension-based account because the suppression process should override the activation of the companion noun. In Experiment 2, when two anaphoric nouns were linked in a compound noun phrase, the non-antecedent effect occurred for the first noun following the processing of the second noun. This result is consistent with the memory-based account because a shift in response bias should occur following recognition of the second noun, regardless of whether or not the first and second nouns are linked in a

compound noun phrase. In contrast, this result is not consistent with the comprehension-based account, because suppression of the first noun following the processing of the second noun would impede integration of new material in the current discourse with the joint entity corresponding to the first and second nouns, with the result that the anaphors would not be effectively resolved. In Experiment 3, the non-antecedent effect was accompanied by an opposing effect for test words not present in the passage; negative responses to such words were faster after than before the processing of a repeated-noun anaphor. This result is consistent with the memory-based account, because negative responses to such words should be easier with a more conservative response bias. In contrast, this result is not consistent with the comprehension-based account, because the suppression process should not affect words unless they are present in the passage.

The present results have implications for our understanding of anaphor processing. The bias shift that is apparently responsible for the non-antecedent effect occurs as a byproduct of a simple recognition process. This recognition process may play a role in anaphor comprehension by flagging nouns as potential anaphors, with further processing then occurring to conclusively identify the nouns as anaphors. By implication, simple recognition processes may play a larger role than has sometimes been acknowledged in anaphor comprehension.

If recognition processes are important in identifying anaphors, and if these processes produce bias shifts such as were studied here, what is the relevance of these bias shifts for comprehension? One implication of present results is that the bias shift

that occurs when a word is recognized as having occurred previously in a discourse will render immediately subsequent words less capable of being recognized as having occurred previously, and by implication, less capable of being identified as potential anaphors. A larger question, as yet unresolved, is whether such a bias shift will affect the accessibility of other discourse information. Such a bias shift is an aspect of a recognition process and will have a clear effect on recognition judgments. Outside of anaphor processing, however, recognition judgments may have little role in comprehension. In contrast, recall processes are much more important to comprehension; at each step of the way in a discourse, the comprehender must recall information that was previously given in the discourse. Further research is needed to determine whether the bias shift that occurs consequent to the recognition of a word affects the availability to recall of other discourse information.

Finally, the present results suggest a cautionary note regarding interpretation of results from probe recognition tasks. Gordon, Hendrick, & Foster (2000) have presented evidence that performance in probe recognition tasks can be based on simple list memory for the words in the stimulus passages. The present results suggest that, even granting probe recognition performance to be based on more complex discourse memory, such performance may reflect bias shifts that, while they occur consequent to discourse-relevant processes (the recognition of anaphoric nouns), have their primary effects on probe recognition performance rather than on more general aspects of discourse comprehension (e,g, reducing the accessibility of discourse information). Dopkins and Ngo (2002) provided the original impetus for this line of thinking when they observed results

resembling the non-antecedent effect with scrambled passages. On the basis of further results with intact passages, Dopkins and Ngo (2005) argued that the Dopkins and Ngo (2002) results and the Gernsbacher non-antecedent effect both reflect a recognition process rather than the suppression process that had previously been proposed. On the basis of work with recognition tasks, Dopkins et al. (2006, 2010) argued that the recognition process in question is a shift in response bias. The present results argue that this response-bias shift is responsible for the non-antecedent effect.

In sum, the present results suggest that the non-antecedent effect that occurs following the processing of a repeated-noun anaphor reflects a shift in response bias associated with recognition that the anaphoric noun has appeared previously in the discourse rather than a process of suppression associated with the resolution of the anaphor.

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Table 1

Sample stimulus passage from Experiment 1

Over the loud protestations of the detective at the precinct, Penny and Agnes loudly accused Wendy of committing a big robbery and ^ Penny ^

PROBE WORDS:	Penny	(**Antecedent condition**)
	Agnes	(**Companion condition**)
	Wendy	(**Non-antecedent condition**)

Note. ^ indicates a probe point.

Table 2

Results of Experiment 1

	Antecedent		Companion		Non-antecedent	
	ER	RT	ER	RT	ER	RT
			Error Rate			
			Short Interval			
Before Anaphor	.28	(.18)	.25	(.27)	.14	(.20)
After Anaphor	.21	(.23)	.19	(.15)	.25	(.26)
			Medium Interval			
Before Anaphor	.21	(.14)	.22	(.21)	.08	(.12)
After Anaphor	.04	(.08)	.25	(.14)	.15	(.13)
			Long Interval			
Before Anaphor	.17	(.14)	.21	(.15)	.05	(.08)
After Anaphor	.01	(.04)	.25	(.18)	.16	(.12)
			Response Time			
			Short Interval			
Before Anaphor	467	(282)	362	(225)	310	(201)
After Anaphor	305	(209)	390	(209)	329	(221)
			Medium Interval			
Before Anaphor	108	(64)	161	(150)	56	(45)
After Anaphor	61	(84)	248	(342)	244	(326)
			Long Interval			

Before Anaphor	152	(152)	162	(101)	80	(59)
After Anaphor	145	(160)	134	(59)	133	(61)

Note. Response time (RT) was the time elapsing between the response signal and the participant's response. Standard deviations are given in parentheses.

Table 3

Sample stimulus passage from Experiment 2

‘But’ Condition

Jane called Faye after her trip around the lake. Meg was gravely ill and asking for Jane but ^ Faye ^

PROBE WORD: Jane

‘And’ Condition

Jane called Faye after her trip around the lake. Meg was gravely ill and asking for Jane and ^ Faye ^

PROBE WORD: Jane

Table 4

Results of Experiment 2

	‘But’		‘And’	
		Response Time		
Before Anaphor	915	(240)	911	(232)
After Anaphor	980	(287)	975	(251)
		Error Rate		
Before Anaphor	.04	(.10)	.04	(.12)
After Anaphor	.05	(.11)	.04	(.11)

Note. Standard deviations are given in parentheses.

Table 5

Results of Experiment 3

	Positive		Negative	
	Response Time			
Before Anaphor	1252	(345)	1337	(478)
After Anaphor	1405	(461)	1215	(332)
	Error Rate			
Before Anaphor	.09	(.10)	.21	(.27)
After Anaphor	.14	(.20)	.08	(.11)

Note. Standard deviations are given in parentheses.