

Activation and Suppression of Antecedents During Reinstatement

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In 3 experiments, the nature of the search for antecedents during reading was investigated by examination of the effects of reinstatement on long-term memory for potential antecedents. Participants read passages that contained 2 possible antecedents; one appearing early in the passages and the other appearing late. Experiment 1 showed that reinstated antecedents were strengthened in long-term memory whereas potential but nonselected antecedents that fell in the path of an antecedent search were suppressed. Experiments 2 and 3 showed that this suppression was restricted to concepts that shared a high degree of featural overlap with the target antecedent and with the anaphoric phrase prompting the search. Results are discussed in terms of antecedent search as a resonance process.

A primary goal of reading comprehension is to construct a coherent representation of the information being read. This is generally accomplished by establishing connections between incoming information and information currently active in memory, that is, information in the active portion of the discourse model (e.g., Fletcher, 1981, 1986; Kintsch & van Dijk, 1978; Sanford & Garrod, 1981; van Dijk & Kintsch, 1983). Generally, texts are written in a manner that facilitates this process by ensuring that current information refers to information that has been recently encountered. However, there are situations in which current information makes reference to something that is no longer active in memory. To maintain a fully coherent representation, the reader must establish a connection between the current information and the information that is no longer active in memory. That is, the reader must conduct a reinstatement search, which involves searching inactive portions of the discourse model for the antecedent information, returning that information to the active portion of the model, and connecting it with the newly read information (e.g., Kintsch & van Dijk, 1978; Lesgold, Roth, & Curtis, 1979; McKoon & Ratcliff, 1980; O'Brien, 1987; O'Brien, Duffy, & Myers, 1986; O'Brien, Plewes, & Albrecht, 1990; van Dijk & Kintsch, 1983). The completion of this reinstatement process generally produces an increase in comprehension difficulty, as measured by a slowdown in reading while the reader searches for the antecedent information. If the search has been successful, there is a subsequent benefit in accessibility for that information (i.e., there is an increase in the level of activation of the antecedent information) and a strengthening of the antecedent information in long-term memory, as measured by an increase in the probability that the

antecedent information will be recalled (e.g., Cirilo, 1981; Dell, McKoon, & Ratcliff, 1983; Lesgold et al., 1979; McKoon & Ratcliff, 1980; Miller & Kintsch, 1980; O'Brien, 1987; O'Brien et al., 1986; O'Brien & Myers, 1985; O'Brien et al., 1990).

Substantial evidence has been provided demonstrating that readers complete reinstatement searches and demonstrating the conditions under which such searches are initiated (e.g., Cirilo, 1981; Dell et al., 1983; Lesgold et al., 1979; O'Brien, 1987). More recent research has focused on the nature of this search process. For example, O'Brien (1987) had participants read texts that contained two antecedents, the first occurring early in the text and the second occurring late in the text. The last line of each text contained a query embedded in the text that prompted reinstatement of either the early or late antecedent. O'Brien found that the time to read the last line was longer when it prompted reinstatement of a more distant early antecedent than when it prompted reinstatement of a more recently read late antecedent. However, this was only true if the early antecedent was of equal or lesser importance than the late antecedent; when the early antecedent was rated as more important, reading times were shorter when the last line prompted reinstatement of the more distant early antecedent than when the last line prompted reinstatement of the more recent, but less important, late antecedent.

On the basis of these results, O'Brien (1987) proposed that the reinstatement search is a backward parallel search that begins with the active portions of the discourse model and proceeds through an integrated network. During a reinstatement search, two types of information are likely to reach a level of activation necessary for further processing. These two types are concepts from the text that have sufficient featural overlap with the anaphoric phrase and contextually relevant information from the text that is related to the anaphoric phrase. When the search activates a candidate antecedent, it is checked against the anaphoric phrase to determine whether it provides an appropriate fit. If it does, the antecedent is connected to the new information and is used in subsequent processing. If it does not, the reader will discard the candidate antecedent and continue the search or possibly abandon the search altogether (e.g., Lesgold et al., 1979; O'Brien, 1987).

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Similarly, if the reader has accumulated sufficient contextually relevant information, a specific antecedent may be inferred. This would also terminate the search, possibly leaving the reader with an incorrect antecedent (e.g., O'Brien & Albrecht, 1991).

Although O'Brien (1987) initially described the search process as a spread of activation, subsequent findings suggest that the process is better characterized as a resonance process (Hintzman, 1986; Ratcliff, 1978). When an anaphoric phrase is encountered, it resonates with candidate antecedents; the candidate that resonates the most or shares the greatest number of features with the anaphoric phrase will be selected (Garrod, O'Brien, Morris, & Rayner, 1990; Gernsbacher, 1989, 1990).

There are several factors other than the amount of featural overlap that will influence the level of resonance of candidate antecedents, including referential distance and elaboration. For example, O'Brien et al. (1990) had participants read passages that contained two possible antecedents: One occurred early in the passage and the other occurred late in the passage. For half the passages, the early antecedent was elaborated and for the other half, the late antecedent was elaborated. Consistent with O'Brien's (1987) results, the more recently occurring late antecedents were retrieved significantly faster than were the less recently occurring early antecedents. More importantly, elaborated antecedents were reinstated more quickly than were nonelaborated antecedents. In fact, when a less recently occurring early antecedent was elaborated, it was reinstated more quickly than was a more recently occurring unelaborated late antecedent. This latter finding is consistent with the assumption that the search proceeds in parallel. Elaboration increased the amount of featural overlap, resulting in greater and faster activation of a less recent early antecedent.

Assuming a parallel search, it should also be the case that any candidate antecedent that shares features with the anaphor should resonate to some degree. There is some evidence from research involving simple anaphoric noun phrases to suggest that this is true. For example, Corbett (1984) had participants read passages that contained an anaphoric noun phrase (e.g., *frozen vegetables*) and an antecedent (e.g., *frozen asparagus*). Corbett found that the time to read an anaphoric noun phrase was significantly longer when the passage contained an antecedent distractor that shared features in common with the anaphoric noun phrase (e.g., *fresh corn*) than when it did not. Consistent with the resonance metaphor, Corbett suggested that both antecedents from the category *vegetable* are accessed initially and then the correct antecedent is selected on the basis of constraining information contained in the anaphoric noun phrase.

Similarly, O'Brien et al. (1990) found that when a passage contained two candidate antecedents that shared features in common with a subsequent phrase prompting a reinstatement search, retrieval of a more distant early antecedent resulted in a reactivation of both that antecedent and a more recently occurring late antecedent. When the late antecedent was changed to eliminate any featural overlap with the phrase prompting reinstatement, retrieval of an early antecedent did not reactivate the late antecedent.

Given that the resonance process can result in the activation of more than one potential antecedent, it is reasonable to assume that the antecedent with the highest level of activation will be considered first. If it is the correct antecedent, there should be little difficulty; the reader simply selects that antecedent and discards the others. However, what happens if the antecedent with the highest level of activation is an incorrect antecedent? One possibility is that the reader simply discards the selected antecedent and chooses another. A second possibility is that the reader does not merely discard the incorrect antecedent, but actually suppresses it. For example, MacDonald and MacWhinney (1990) have shown that after a 500-ms delay, pronouns inhibit nonreferents (see also Gernsbacher, 1989). However, it is unclear whether there is any long-term impact of this initial suppression. Gernsbacher (1989) has suggested that the suppression of nonreferents highlights and thereby facilitates the selection of a correct referent. Thus, it may be that once a correct referent has been selected, any suppression of nonreferents decays rapidly. O'Brien (1987) presented some evidence indicating that the suppression effect may be more long term. He found that reinstatement of one antecedent slowed later retrieval from long-term memory of an alternative antecedent. However, suppression was only evident in a subset of passages and the conditions under which it occurred were not well specified.

Our present experiments were designed to further investigate the impact of reinstatement on long-term memory for candidate antecedents. Specifically, the experiments were designed to determine whether reinstated antecedents are strengthened and whether nonselected antecedents are suppressed and to examine some of the conditions under which suppression occurs. In Experiment 1, we examined whether sentence verification times for early and late antecedents that shared features in common with an anaphoric phrase were affected by reinstatement of the early antecedent. Having established that under some conditions the verification times for statements about the late antecedent were slower following reinstatement of the early antecedent, we designed Experiment 2 to determine whether this effect was due to reinstatement or to some other process at the time of test. In Experiment 3, we replicated the critical patterns of verification times found in Experiments 1 and 2.

Experiment 1

As indicated earlier, when an antecedent is selected, it is reactivated and returned to the active portion of the discourse model (e.g., McKoon & Ratcliff, 1980; O'Brien et al., 1986) and the considered but nonselected antecedents are discarded and possibly suppressed (e.g., Gernsbacher, 1989; MacDonald & MacWhinney, 1990). Although there have been several demonstrations that readers reactivate antecedents, and some evidence that nonselected antecedents are suppressed, it is not clear whether there is any long-term impact of that suppression. Experiment 1 was designed to determine the impact of reinstatement on long-term memory for selected and nonselected antecedents.

Passages from O'Brien et al. (1990) were used. Four examples are presented in the Appendix; the first two are

examples of the passages used in Experiment 1. Each passage contained two candidate antecedents that shared features in common with the subsequent phrase prompting reinstatement: one antecedent occurred early in the text and the other occurred late in the text. Because O'Brien et al.'s results indicated that elaboration increased the likelihood that a target antecedent would be reinstated and that a candidate antecedent would be activated as well, we varied elaboration of the antecedents; for half the passages, the early antecedent was elaborated and the late antecedent was not, and for the remaining half, the late antecedent was elaborated and the early antecedent was not. Also, because O'Brien et al.'s results suggested that a late antecedent may be considered during the search for an early antecedent, only conditions in which the early antecedent is reinstated and no-reinstatement control conditions were used.

Presumably, information concerning the early antecedent is verified more quickly when it has been reinstated than when there has been no reinstatement. However, the advantage for the reinstated early antecedent should be less when it has been elaborated. Elaboration should serve to facilitate retrieval of the antecedent and a single reinstatement may not provide a substantial increase in that facilitation. The critical pattern of results involves verification times for statements about the late antecedent following reinstatement of the early antecedent. When the early antecedent has been elaborated, some activation should reach the late antecedent, causing it to be considered. If it is suppressed, verification times should be slow relative to a control condition in which there is no reinstatement. In contrast, when the late antecedent has been elaborated, reinstatement of the early antecedent should activate the late antecedent; the increase in the amount of featural overlap of the late antecedent should increase its level of activation (see O'Brien et al., 1990). However, the high degree of elaboration should facilitate subsequent recall and minimize any impact of suppression. Also, it may be that on some occasions readers incorrectly select the late antecedent. The result of these processes is that an elaborated late antecedent may show no effects of the reinstatement of an early antecedent.

Method

Participants. Forty University of New Hampshire undergraduates enrolled in Introductory Psychology participated for course credit. Ten participants were randomly assigned to each of four stimulus sets described below.

Materials. Thirty-two passages from O'Brien et al. (1990, Experiment 1) were used. Two passages are presented in the Appendix. Each passage contained two candidate antecedents; one antecedent occurred early in the passage and the other occurred late. To reduce primacy and recency effects, each passage contained three sentences before the first mention of the early antecedent and three to four sentences between the last mention of the late antecedent and the end of the passage. There were three or four sentences that intervened between the last mention of the early antecedent and the first mention of the late antecedent. Both the early and late antecedents had features in common with the phrase prompting reinstatement. Within each passage, one antecedent was mentioned two times (once directly and once indirectly) over two sentences whereas the other antecedent was mentioned four times (once directly and three times indirectly)

over three or four sentences. For half of the passages, the early antecedent received the additional elaboration; for the remaining half, the late antecedent received the additional elaboration. The last line of the passage either prompted reinstatement of the early antecedent or required no reinstatement. In the latter case, the last sentence of the passage was eliminated. This provided a control condition in which verification times that were based completely on recency and elaboration could be obtained. Following each passage, a series of five verification statements was presented. Of these verification statements, one stated a fact about the early antecedent and a second stated a fact about the late antecedent. Examples of the verification statements are presented in the Appendix. Of the remaining statements, two were always false and a third was true for half of the passages and false for the remaining half. This last measure was taken to ensure that the participants could not determine the truth value of the last verification statement. The following restrictions were placed on the presentation order of the verification statements: The early and late statements were either in Positions 1 and 4, respectively, or in Positions 5 and 2, respectively. In addition, the truth value of the statement in the third position was true half of the time and false the remaining half. Both early and late verification statements ranged from 24 to 28 characters in length with a mean of 26.09 characters. Four sets of materials were constructed in such a way that half of the passages prompted reinstatement of the early antecedent and the other half required no reinstatement. These sets were further subdivided so that for half of the passages, the early verification statement was encountered first (Position 1) followed by the late verification statement (Position 4) and for the remaining half, the late verification statement (Position 2) was encountered first followed by the early verification statement (Position 5). Across material sets, each passage appeared once in each of these four conditions.

Procedure. We tested the participants individually in a session that lasted approximately 90 min. All materials were displayed on a video monitor controlled by a Zenith Z100 microcomputer. We instructed the participants to rest their right thumb on a line-advance key, their right index finger on a yes key, and their left index finger on a no key. Each trial began with the word *Ready* on the center of the video monitor. When the participants were ready to begin reading each passage, they pressed the line-advance key, which erased the screen and presented the first line of the passage. We instructed the participants to read each line and to press the line-advance key when they understood it. Each press of the line-advance key erased the current line and presented the next line of text. Comprehension time for a particular line was considered to be the time between key presses. Immediately upon pressing the line-advance key to erase the last line of the passage, the word QUESTIONS was flashed on the screen for 2,000 ms to signal the start of the verification test. Following the signal, the first verification statement was presented. We instructed the participants to decide as quickly and accurately as possible whether the statement about the passage was true or false. On those trials in which the participant responded correctly, another cue (???) was flashed on the screen for 500 ms and then replaced by the next verification statement. Following incorrect responses, the word "ERROR" was presented for 500 ms, followed by the cue (???) and the next verification statement. To break up the long experimental session, there was a short rest period after the 16th experimental passage. Each experimental session began with 3 practice passages to be sure that each participant understood the procedure.

Results

The mean verification times for statements about the early and late antecedents were recorded. Response times that were three standard deviations from the mean were discarded; this

Table 1
Mean Verification Times (in Milliseconds) and Percentage of Errors for Statements About the Early and Late Antecedents

Condition	Probed antecedent			
	Early		Late	
	M	% error	M	% error
Elaborate early antecedent				
Reinstatement (R)	1,479	3.1	1,583	5.6
No reinstatement (N)	1,467	3.4	1,465	4.4
Difference (R - N)	12		118	
Elaborate late antecedent				
Reinstatement	1,549	9.4	1,515	4.4
No reinstatement	1,746	10.3	1,491	5.0
Difference (R - N)	-197		24	

eliminated less than 2% of the data. In what follows, F_1 refers to tests against an error term that was based on subject variability and F_2 refers to tests against an error term that was based on item variability. All planned comparisons used a Bonferroni procedure with a familywise error rate equal to .05 and an error term that was based on subject variability. All analyses are significant at the .05 level unless otherwise indicated.

Verification times. The mean verification times and error rates are presented in Table 1.¹ The influence of reinstatement on sentence verification depended on which antecedent was elaborated, $F_1(1, 36) = 32.15, MSE = 14,334, F_2(1, 24) = 15.36, MSE = 8,869$, and on which antecedent was verified, $F_1(1, 36) = 18.47, MSE = 28,448, F_2(1, 24) = 22.51, MSE = 8,892$. Planned comparisons confirmed the nature of these interactions. When considering those passages in which the early antecedent was elaborated, reinstatement had no impact on the time needed to verify statements about the early antecedent (1,479 vs. 1,467), but significantly increased the time required to verify statements about the late antecedent (1,583 vs. 1,465), $t(39) = 4.17$. In contrast, for those passages in which the late antecedent was elaborated, reinstating the early antecedent decreased the time required to verify statements about the early antecedent (1,549 vs. 1,746), $t(39) = 6.80$, but had no impact on the time needed to verify statements about the late antecedent (1,515 vs. 1,491), $p > .50$. As the planned comparisons suggested there was also a three-way interaction of Elaboration \times Verification Probe \times Reinstatement. However, this interaction only reached significance in an analysis that was based on subject variability, $F_1(1, 36) = 4.77, MSE = 13,963, F_2(1, 24) = 2.69, MSE = 8,892, p = .11$.

In addition, the participants verified statements more quickly when the early antecedent was elaborated. This effect was significant in an analysis that was based on subject variability, $F_1(1, 36) = 30.76, MSE = 15,387$, but failed to reach significance in an analysis that was based on item variability, $F_2(1, 24) = 2.13, MSE = 86,689, p = .15$. The participants also tended to verify statements about the late antecedent faster than statements about the early antecedent. However, this effect was only significant in an analysis that was based on subject variability, $F_1(1, 36) = 9.40, MSE = 18,742, F_2(1, 24) = 1.27, MSE = 47,112, p > .26$.

Error rates. The participants made more errors when the late antecedent was elaborated than when the early antecedent was elaborated. $F_1(1, 36) = 9.07, MSE = .009, F_2(1, 24) = 3.85, MSE = .008, p = .061$. However, this increase in error rates occurred only for statements about the early antecedent. $F_1(1, 36) = 13.42, MSE = .007, F_2(1, 24) = 4.03, MSE = .009, p = .056$. Overall, there was a tendency for the participants to make more errors on statements about the early antecedent. This effect was significant in an analysis that was based on subject variability, $F_1(1, 36) = 4.21, MSE = .006$, but not in one that was based on item variability. $F_2(1, 24) = 1.20, MSE = .004, p > .28$.

Discussion

The finding that the participants took longer to verify statements about the late antecedent when the early antecedent was elaborated and reinstated supports the hypothesis that during the reinstatement search, readers consider potential antecedents and suppress the inappropriate ones. This finding suggests that not only is the nonselected antecedent less available, but also that information about that antecedent is more difficult to retrieve. This was true when the participants were tested after a short delay (Position 2) and when they were tested after a somewhat longer delay (Position 5). For those passages that elaborated the late antecedent, the finding of faster verification times for the early antecedent following reinstatement supports the hypothesis that reinstatement strengthens the long-term memory trace of the selected antecedent. Taken together, these two effects support the predictions about the nature of the search process; readers consider candidate antecedents, strengthen selected antecedents, and suppress nonselected ones.

Finally, the verification times also reflected the influence of elaboration. Verification times for statements about the early antecedent following passages that elaborated the early antecedent were the same regardless of the reinstatement condition. This same pattern of verification times was found for statements about the late antecedent following passages that elaborated the late antecedent. Presumably, elaboration of an antecedent provided additional retrieval routes leading to and from the antecedent that reduced or eliminated any impact of reinstatement. This interpretation is consistent with several findings that have demonstrated that increasing elaboration decreases retrieval time (e.g., Albrecht & O'Brien, 1991; Bradshaw & Anderson, 1982; Myers, O'Brien, Balota, & Toyofuku, 1984; O'Brien & Myers, 1987; O'Brien et al., 1990).

Although the results of Experiment 1 support the predictions of the search process proposed earlier, the results are also consistent with another interpretation that does not involve the suppression of nonselected antecedents. It is possible that the slow verification times for the statements about the late antecedent following reinstatement were due to the participants' focusing on the reinstated antecedent at the time of test and not due to the suppression of the late

¹ In Experiments 1 and 2, we collapsed across position in the verification list. This variable did not interact with elaboration or antecedent.

antecedent during the search process. That is, the results may be due to the participants' focusing on the early antecedent at the cost of the rest of the text information including the late antecedent. According to this interpretation, the slow verification times should be found for all nonreinstated information regardless of whether the antecedents are potential candidates or not. Experiment 2 was designed to determine whether the slow verification times for the late antecedent were due to a general effect for all nonreinstated text information or whether the slowdown was due to the participants' considering and suppressing only potential but nonselected antecedents.

Experiment 2

To distinguish between the different interpretations for the results of Experiment 1, we used passages that contained target antecedents in which the late antecedent could not be a candidate antecedent. Passages 3 and 4 in the Appendix are examples of the passages used in Experiment 2. These passages have the same format as the passages from Experiment 1, but the target concepts changed so that they could not both be candidate antecedents. If the slowed verification times for the late antecedent following passages that elaborate and reinstate the early antecedent constitute a general effect that occurs for all nonantecedents, then the same pattern of verification times found in Experiment 1 should occur again; verification times for the late antecedent should be longer following reinstatement. However, if this slowdown was due to readers' considering the late antecedent and then suppressing it, then reinstatement of the early antecedent should have no impact on the time required to verify statements about the late antecedent because the late antecedent should no longer be a candidate antecedent.

Method

Participants. Forty University of New Hampshire undergraduates enrolled in Introductory Psychology participated for course credit. None of these participants were involved in the previous experiment.

Materials and procedure. The materials were the same 32 passages used by O'Brien et al. (1990, Experiment 2). The third and fourth passages in the Appendix were used in Experiment 2. These were passages from Experiment 1 that were rewritten so that both target concepts could not serve as candidate antecedents to the same anaphoric phrase. In all passages, the elaborated concept was changed and the unelaborated antecedent remained the same. In most cases, rewriting the elaboration portion of the passage required additional changes in the passage to ensure that it read smoothly. Whenever a passage required rewriting, the same constraints that were placed on the materials in Experiment 1 were used. The average lengths of the early and late verification statements were 26.22 and 26.38 characters, respectively. The verification statements ranged in length from 24 to 29 characters. The same constraints on the order of the verification statements used in Experiment 1 were maintained. The procedure was the same as that used in Experiment 1.

Results

The mean verification times and error rates for Experiment 2 are presented in Table 2. Verification times that were three

Table 2
Mean Verification Times (in Milliseconds) and Percentage of Errors for Statements About the Early and Late Antecedents

Condition	Probed antecedent			
	Early		Late	
	<i>M</i>	% error	<i>M</i>	% error
Elaborate early antecedent				
Reinstatement (R)	1,587	3.1	1,586	8.1
No reinstatement (N)	1,608	4.1	1,586	4.4
Difference (R - N)	-21		0	
Elaborate late antecedent				
Reinstatement	1,484	4.4	1,487	2.2
No reinstatement	1,622	6.9	1,488	2.2
Difference (R - N)	-138		-1	

standard deviations from the mean were discarded; this eliminated less than 2% of the data.

Verification times. When the early antecedent was reinstated, there was a tendency for probe statements to be verified faster, $F_1(1, 36) = 12.69$, $MSE = 10,032$, $F_2(1, 24) = 7.73$, $MSE = 7,713$. However, this effect depended on which antecedent was elaborated, $F_1(1, 36) = 4.26$, $MSE = 16,248$, $F_2(1, 24) = 3.46$, $MSE = 7,713$, $p < .08$, and on which antecedent was verified, $F_1(1, 36) = 9.44$, $MSE = 13,175$, $F_2(1, 24) = 4.06$, $MSE = 10,915$, $p < .06$. When the early antecedent was elaborated, reinstatement had no impact on the time required to verify statements about the early antecedent (1,587 vs. 1,608) or about the late antecedent (1,586 vs. 1,586). In contrast, when following passages that elaborated the late antecedent, reinstatement reduced the time required to verify statements about the early antecedent (1,484 vs. 1,622), $t(39) = 5.22$, but had no impact on the time needed to verify statements about the late antecedent (1,487 vs. 1,488). The Elaboration \times Verification Probe \times Reinstatement interaction was only marginally significant, $F_1(1, 36) = 3.92$, $MSE = 17,662$, $p < .06$, $F_2(1, 24) = 3.31$, $MSE = 10,915$, $p < .09$.

Finally, the participants also verified statements more quickly when the late antecedent was elaborated. This effect reached significance in an analysis that was based on subject variability, $F_1(1, 36) = 22.54$, $MSE = 18,223$, but did not approach significance in an analysis that was based on item variability, $p > .25$. Also, the participants verified statements about the late antecedent more quickly than statements about the early antecedent. Again, this effect was only significant in an analysis that was based on subject variability, $F_1(1, 36) = 5.34$, $MSE = 22,194$, $F_2(1, 24) = 1.42$, $MSE = 35,696$, $p = .24$.

Error rates. In the reinstatement conditions, the participants made more errors on the late antecedent than on the early antecedent, $F_1(1, 36) = 4.46$, $MSE = .006$, $F_2(1, 24) = 5.49$, $MSE = .002$. The participants also made more errors in verifying nonelaborated antecedents than in verifying elaborated antecedents, $F_1(1, 36) = 12.36$, $MSE = .006$, $F_2(1, 24) = 6.03$, $MSE = .004$. However, this difference was only true when verification followed a reinstatement. This interaction was significant in an analysis that was based on subject variability, $F_1(1, 36) = 5.17$, $MSE = .003$, but not in one that was based on item variability, $F_2(1, 24) = 2.00$, $MSE = .002$, $p < .18$.

Discussion

The finding of faster verification times for statements about reinstated early antecedents following passages that elaborated the late antecedent demonstrates that readers were completing the reinstatement search and that this strengthened the long-term memory trace of the target antecedent. This replicates the benefit produced by reinstatement in Experiment 1. However, in contrast to Experiment 1, reinstatement of the early antecedent had no impact on the time required to verify statements about the late antecedent following passages that elaborated the early antecedent (1,586 vs. 1,586). The finding that verification times for statements about the late antecedent were the same regardless of the reinstatement conditions suggests that the slowdown in Experiment 1 was due to the search process. In other words, a concept can only serve as a candidate antecedent if it shares featural overlap with the anaphoric phrase prompting the search. Without sufficient featural overlap, a concept will not reach a level of activation necessary to be considered and therefore should not be influenced by reinstatement.

As in Experiment 1, verification times for statements about the elaborated antecedent were not influenced by reinstatement. This was most likely due to the additional retrieval routes leading to and from the antecedent, which eliminated or reduced any benefit of reinstatement.

Taken together, the results of Experiments 1 and 2 suggest that during the search for an antecedent, potential candidates are considered and the appropriate antecedent is strengthened while inappropriate candidates are suppressed. However, the patterns of verification times that support this conclusion depended on between-experiment comparisons. Experiment 3 was designed to provide a within-experiment comparison of the critical conditions from Experiments 1 and 2.

Experiment 3

Method

Participants. Forty University of New Hampshire undergraduates enrolled in Introductory Psychology participated for credit. None of these participants were involved in the previous experiments.

Materials and procedure. The materials consisted of 16 passages from Experiment 1 and 16 passages from Experiment 2. For half of the passages, the early antecedent was elaborated and in the remaining half the late antecedent was elaborated. Four stimulus sets were constructed such that half of the passages prompted reinstatement of the early antecedent and the remaining half required no reinstatement. The passages were further subdivided so that for one half of the passages, the antecedents shared features in common with the phrase prompting reinstatement and in the other half, the antecedents did not. For the conditions in which the early antecedent was elaborated, the early and late verification statements occurred in Positions 3 and 2, respectively, and the false verification statements occurred in Positions 1 and 4. The probe in Position 5 was true half of the time and false the remaining half. For the conditions in which the late antecedent was elaborated, the early and late verification statements occurred in Positions 4 and 1, respectively, and the false verification statements occurred in Positions 2 and 5. The probe in Position 3 was true half of the time and false the remaining half. The procedure was the same as that used in Experiments 1 and 2.

Results

The mean verification times and error rates for Experiment 3 are presented in Table 3. Verification times that were greater than three standard deviations from the mean were discarded; this eliminated less than 2% of the data.

Verification times. As in Experiment 1, the effect of reinstatement on verification times depended on which antecedent was verified, $F_1(1, 36) = 12.80$, $MSE = 36,305$, $F_2(1, 24) = 11.61$, $MSE = 22,616$, and on which antecedent was elaborated, $F_1(1, 36) = 9.98$, $MSE = 45,049$, $F_2(1, 24) = 9.75$, $MSE = 19,907$. A series of planned comparisons provided a clearer picture of these interactions. First, consider conditions in which the late antecedent was elaborated. Replicating the results of Experiments 1 and 2, reinstating the early antecedent reduced the time needed to verify statements about the early antecedent when the potential antecedents had features in common with the anaphoric phrase (1,526 vs. 1,654), $t(39) = 3.78$, and when they did not (1,381 vs. 1,542), $t(39) = 4.49$. However, reinstating the early antecedent had no impact on the time required to verify statements about the late antecedent (features in common, 1,854 vs. 1,842; no features in common, 1,737 vs. 1,744). Next, consider conditions in which the early antecedent was elaborated. When the potential antecedents had features in common, reinstatement had no effect on verification times for statements about the early antecedent (1,497 vs. 1,464) but increased the time required to verify statements about the late antecedent (1,687 vs. 1,578), $t(39) = 2.34$. However, when the potential antecedents did not have features in common with the anaphoric phrase, reinstatement had no impact on the time needed to verify statements about the early antecedents (1,512 vs. 1,547) or late antecedents (1,624 vs. 1,594).

Table 3
Mean Verification Times (in Milliseconds) and Percentage of Errors as a Function of Featural Similarity, Reinstatement, Probe Type, and Elaborated Antecedent in Experiment 3

Condition	Probed antecedent			
	Early		Late	
	M	% error	M	% error
Elaborate early antecedent				
Features in common				
Reinstatement (R)	1,497	5.0	1,687	8.1
No reinstatement (N)	1,464	4.4	1,578	9.4
Difference (R - N)	33		109	
No features in common				
Reinstatement	1,512	1.3	1,624	7.5
No reinstatement	1,547	3.1	1,594	6.3
Difference (R - N)	-35		30	
Elaborate late antecedent				
Features in common				
Reinstatement	1,526	10.0	1,854	6.9
No reinstatement	1,654	11.9	1,842	4.4
Difference (R - N)	-128		12	
No features in common				
Reinstatement	1,381	4.4	1,735	1.3
No reinstatement	1,542	6.3	1,744	3.8
Difference (R - N)	-161		-9	

Finally, the participants also verified statements about the early antecedent faster than statements about the late antecedent, $F_1(1, 36) = 90.96$, $MSE = 64,828$, $F_2(1, 24) = 22.22$, $MSE = 19,907$. This effect was larger when the late antecedent was elaborated than when the early antecedent was elaborated, $F_1(1, 36) = 25.90$, $MSE = 35,883$, $F_2(1, 24) = 5.06$, $MSE = 103,215$, and larger when the antecedents had features in common with the anaphoric phrase than when they did not, $F_1(1, 36) = 20.03$, $MSE = 34,268$, $F_2(1, 24) = 5.67$, $MSE = 54,160$.

Error rates. The participants made more errors when the antecedents had features in common than when they did not, $F_1(1, 36) = 10.85$, $MSE = .172$, $F_2(1, 24) = 7.25$, $MSE = .079$. Also, the participants made more errors verifying statements about nonelaborated antecedents than about elaborated antecedents, $F_1(1, 36) = 18.99$, $MSE = .285$, $F_2(1, 24) = 9.97$, $MSE = .127$.

Discussion

The results of Experiment 3 replicated the pattern of results from Experiments 1 and 2. When an antecedent was elaborated, reinstatement produced little or no advantage in verification times. However, when the late antecedent was elaborated, statements about the early antecedent were verified more quickly following reinstatement. This occurred regardless of whether the target antecedents had features in common with the anaphoric phrase or not.

Verification times for statements about the late antecedent also replicated the results of Experiments 1 and 2. For passages that elaborated the early antecedent, verification times for statements about the late antecedent were slowed following reinstatement of the early antecedent but only when both the target concepts could serve as candidate antecedents. When the two concepts were not candidate antecedents, the late antecedent was unaffected by reinstatement of the early antecedent. Together, these results provide strong support for a search process in which potential antecedents that are considered but rejected are suppressed.

General Discussion

Our goal in the present experiments was to further investigate the nature of the reinstatement search by examining the impact of the search process on long-term memory for potential antecedents. The finding concerning verification times for statements about the late antecedent following passages that elaborated the early antecedent confirms the predictions about the consideration of potential antecedents. When both candidate antecedents had semantic features in common with the subsequent phrase that prompted a reinstatement search, verification times for statements about the late antecedent were significantly slower following reinstatement, whereas verification times were unaffected when the antecedents did not have features in common with the anaphoric phrase. The finding that verification times were slower following reinstatement suggests that when late antecedents were candidates, they were considered and then suppressed. When the late antecedent was not a candidate, verification times for the late antecedent were not affected because the late antecedent did

have a sufficient level of featural overlap with the anaphoric phrase.

The finding concerning verification times for statements about the early antecedent following passages that elaborated the late antecedent confirms that reinstating an antecedent strengthens the long-term memory trace for the antecedent. The participants verified statements about the early antecedent faster following reinstatement regardless of whether both target concepts were candidate antecedents.

However, the results also demonstrate the influence of elaboration on verification times. When an antecedent was elaborated, verification times for the elaborated antecedent were not affected by reinstatement. On the basis of previous research, it seems likely that any benefit from reinstatement was eliminated because of the increased level of accessibility established through elaboration (e.g., Albrecht & O'Brien, 1991; Myers et al., 1984; O'Brien & Myers, 1987).

Although the current experiments defined candidate antecedents as those concepts that share featural overlap with the anaphoric phrase on the basis of general world knowledge, it is also possible that the amount of featural overlap can be determined through the discourse context. For example, consider a passage in which participants read "Billy lost his house key." Later, they learn that Billy broke a window to get into the house. Now when participants read the sentence "Billy knew he would be in trouble when his father returned home," there are two potential antecedent events: losing the key and breaking the window. Rizzella and O'Brien (1995) have found that when participants read passages like these, they considered both candidate antecedents, but only when the first antecedent was more important than the second antecedent. This finding is consistent with and an extension of O'Brien et al.'s (1990) results and provides strong support for the model of reinstatement proposed by O'Brien (1987; O'Brien et al., 1990) by demonstrating that the consideration of antecedents can be based on featural overlap as defined by the text and that candidate antecedents need not share semantic features with the anaphoric phrase prompting the search.

As indicated earlier, several factors influence the resonance process, including referential distance and elaboration. The greater the distance between an anaphor and antecedent, the longer it takes to complete the reinstatement. This may be due to a decay or weakening of the resonance signal over time or due to the possibility that as distance increases, the number of candidate antecedents that resonate with the anaphoric phrase may also increase (e.g., Gernsbacher, 1990). The more elaboration surrounding the antecedent, the higher the degree of resonance or activation and the quicker the reinstatement search can be completed. Presumably, elaboration increases the number of possible features that can resonate with the anaphoric phrase; this may increase the overlap between antecedent and anaphor and increase the probability that at least some feature(s) will resonate with the anaphoric phrase (e.g., Garrod et al., 1990).

When the anaphoric phrase in the last sentence of the passage is encountered, it resonates with other candidate antecedents in the text as well. In the case in which a passage contains an additional candidate antecedent that shares semantic features with the correct antecedent as well as the anaphoric phrase, both candidate antecedents will resonate. In

this way, both candidate antecedents may be considered and the incorrect one can be suppressed. In contrast, when the antecedents do not share features in common with each other or with the anaphoric phrase, the only antecedent that should resonate with the anaphoric phrase is the appropriate one; the other candidate should not resonate because it does not share any features with the anaphoric phrase.

However, the resonance process is not restricted to concepts mentioned in the text; concepts that share semantic and situational features (e.g., Sharkey & Sharkey, 1992) with the text and anaphoric phrase may also resonate. If there is sufficient overlap between an unmentioned concept and the anaphoric phrase, the unmentioned concept may be inferred as the antecedent, even though it may be the incorrect antecedent. For example, O'Brien and Albrecht (1991) had participants read passages that contained phrases like "a small black cat with a white stripe down its back." The last line of the passage prompted reinstatement of the earlier-mentioned antecedent, *cat*. O'Brien and Albrecht found that participants produced the incorrect antecedent, *skunk*, even though the text stated the correct antecedent, *cat*. Presumably, when the reinstatement sentence was encountered, both potential antecedents (*cat* and *skunk*) resonated. However, the incorrect unmentioned antecedent shared more semantic and situational features with the anaphoric phrase than the correct antecedent did. This resulted in the participants' often inferring the incorrect antecedent.

Finally, it is important to note that the reinstatement device used in the present experiments differed from those typically used. The reinstatement search was prompted by embedding an explicit query in the last sentence of the passage (e.g., "He asked Sally what building she had been working on."). This last sentence is an anaphoric phrase in that its full interpretation involves the interpretation of earlier information. However, implicit in this type of phrasing is that there was more than one building to be considered. This may have signaled the reader to engage a more conscious problem solving strategy that might not take place if a simple extended reference had been used (e.g., *He noticed the building Sally had been working on.*). Further research is necessary to determine the extent to which this type of reinstatement device produces unique results. However, to date, most of the research investigating the reinstatement process has produced results that are consistent with the results reported here: The retrieval of antecedent information involves a parallel access of multiple candidates. Our results extend these findings by demonstrating that accessed, but nonselected, antecedent information is suppressed.

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Appendix

Sample Passages From Experiments 1-3

The following passages and verification statements were adapted from "Antecedent Retrieval Processes," by E. J. O'Brien, P. A. Plewes, and J. E. Albrecht, 1990, *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, pp. 241-249. The underlined concepts are the target antecedents.

Early Antecedent Elaborated in Experiments 1 and 3

Mark had grown up in the city but he had always wanted to live in the country. The first chance he got, he bought some land and moved there. It made him very happy not having to live in the crowded and noisy city. On holidays, he would travel by train into the city to visit his parents. While riding in it he liked to watch the countryside as it raced passed him. Sometimes, the clackety clack it made on the tracks, would put him to sleep. He'd wake up quickly though when they came to a crossing and it sounded the horn. Mark couldn't understand why people like his parents preferred to live in the city. Mark really enjoyed living in the country. He loved the open spaces and the clean fresh air. His brother had also moved out of the city and was now living in Colorado. Last summer Mark traveled by plane to visit him. He had loved looking down from it at the countryside and the clouds. Ever since Mark had moved to the country he had made a lot of friends. On Saturdays, he played golf with his neighbor. On the weekends, their families would get together for cookouts. One weekend they'd eat at Mark's and the next they would eat at his neighbor's. One night while they were talking, Mark's neighbor asked him how he had traveled to his parents'.

Mark had traveled by train. (early antecedent)
Mark had traveled by plane. (late antecedent)

Late Antecedent Elaborated in Experiments 1 and 3

It was Saturday morning and Sally got up and dressed in a hurry. She knew that her mother was making blueberry pancakes and that was her favorite breakfast. Sally's mother made them every Saturday morning. As soon as breakfast was over, Sally's entire family got in the car and they went to church. They spent the entire morning working with all their neighbors painting and cleaning it up. After lunch, Sally had hoped to spend the afternoon playing. On her way out the front door, however, her mother stopped her and reminded her that she still had chores left to do. Reluctantly, Sally cleaned her room and dusted and vacuumed the livingroom. When her mother saw how much work she had gotten done though, she told Sally that she could go out and play. Sally decided to play in the barn. It took all of her energy to push open its great big red doors to get inside. When she did, she climbed up into its loft and she spent the next few hours jumping in the hay. From where she was playing she could see a sparrow had built a nest in one of its rafters. Sally was sorry when she heard her mother calling her for dinner. When she walked into the house, her mother sent her straight upstairs to get cleaned up and changed. By the time Sally came back downstairs, everyone was already at the table. She was happy to see that her uncle was visiting and she sat down next to him. He asked Sally what building she had been working on.

Sally cleaned the church. (early antecedent)
Sally played in the barn. (late antecedent)

Early Antecedent Elaborated in Experiments 2 and 3

Mark had grown up in the city but he had always wanted to live in the country. The first chance he got, he bought some land and moved there. It made him very happy not having to live in the crowded and noisy city. Mark had just finished building a shed on his property. It was going to be the home for his newly acquired rakes and hoes. It had taken him a long time to complete, but now that it was finished, Mark felt that he really was an established country resident. Mark couldn't understand why people like his parents preferred to live in the city. He loved the open spaces and the clean fresh air. His brother had also moved out of the city and was now living in Colorado. Last summer Mark traveled by bus to visit him. He had loved looking out of it at the countryside as it passed by. Mark enjoyed seeing the ruggedness of the West, but he really preferred the rolling hills of home. He thought the people who lived near him were among the nicest he had ever met. On Saturdays, he played golf with his neighbor and on the weekends, their families would get together for cookouts. One night while they were talking, Mark's neighbor asked him what he had just finished building.

Mark had just built a shed. (early antecedent)
Mark had traveled by bus. (late antecedent)

Late Antecedent Elaborated in Experiments 2 and 3

It was Saturday morning and Sally got up and dressed in a hurry. She knew that her mother was making blueberry pancakes and that was her favorite breakfast. Sally's mother made them every Saturday morning. As soon as breakfast was over, Sally's entire family got in the car and they went to work on the church. They spent the entire morning working with all their neighbors painting it and cleaning up the area. At home that afternoon, on Sally's way outside to play, her mother stopped her and reminded her that she still had chores left to do. Reluctantly, Sally cleaned her room and dusted and vacuumed the livingroom. When her mother saw how much work she had gotten done, she told Sally that she could go out and play. Sally decided to play with her dolls. She dressed them all in fancy clothes and pretended that they were going to a party. Normally, Sally would spend hours playing with them. Soon Sally's mother called her in for lunch and she went straight upstairs to get cleaned up and changed. By the time Sally came back downstairs, everyone was already at the table. She was happy to see that her uncle was visiting and she sat down next to him. He asked Sally where she had gone with her family.

Sally cleaned the church. (early antecedent)
Sally played with her dolls. (late antecedent)

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