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REACTIVATION OF NEGATED CONCEPTS OVER TIME

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REACTIVATION OF NEGATED CONCEPTS OVER TIME

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Psychology

By

Kevin S. Autry
Hendrix College
Bachelor of Arts in Psychology, 2005

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Abstract

Research on the mental representation of negated concepts in written texts has yet to reach a consensus about the effects of negation. MacDonald and Just (1989) reported that after reading a sentence with a negation, negated words took longer to recognize than non-negated words, which suggests that the negated concepts became less active. However, Hasson and Glucksberg (2006) found that after reading negative metaphors (e.g., *this surgeon isn't a butcher*), lexical decisions about words consistent with the affirmative sense of the negated word (e.g., *clumsy*) took less time than for control words. To reconcile these (and other) incompatible findings, two experiments were conducted to test the possibility that the findings of MacDonald and Just do not persist beyond immediate testing. Experiment 1 used a probe task and materials similar to those used by MacDonald and Just, with the addition that the probe task occurred either 0 ms, 500 ms, or 1000 ms after the end of the sentence. The negation effect was present at 0 ms, replicating MacDonald and Just, but not at 500 ms or 1000 ms. This finding is consistent with the hypothesis that the reduced activation seen from negation out of context is short-lived. Experiment 2 used an eye-tracking procedure to provide converging evidence for the effect of additional processing time. However, the hypotheses were not supported.

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This thesis is approved for

recommendation to the

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Reactivation of Negated Concepts over Time

Language is an indispensable part of what makes us human. Unlike animal communication, which is rooted in non-symbolic signs, human language abstracts thought into symbols that can be combined into an infinite number of utterances. This allows us to communicate about abstract concepts as well as things that have never occurred or could never occur. It frees us from discussing the immediate environment, allowing us to communicate about the past and future just as easily as the present. Where once people were bound by what they could discover in a single lifetime, language made it possible for information to be transmitted across time, enabling people to benefit from those who came before them.

For most of human history, language was exclusively spoken. But once writing was invented, this important tool quickly spread across the world. With a modern worldwide literacy rate around 82% (CIA Factbook, 2010), reading and writing are an integral part of daily life for the majority of modern humans. And although language comes naturally and with seemingly minimal effort, its usefulness is rivaled only by its complexity.

Comprehension of a written text involves the construction of a mental representation of the described state of affairs (van Dijk & Kintsch, 1983; Zwaan, Radvansky, Hilliard, & Curiel, 1998). This mental representation includes information previously presented in the text as well as general knowledge about the world. Importantly, this representation is constantly evolving, with new information being integrated either by adding to the representation if the new information is consistent, or by altering the representation if the new information is inconsistent.

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It is fairly intuitive how information about the presence of some object or attribute would be integrated into a mental representation; however, it is much less clear how the mental representation would incorporate the absence of objects or attributes, as is the case when a text contains negation either explicitly (e.g. *not, never*) or implicitly (e.g. *forget, ignore*). In fact, there are several logical possibilities for how a negated concept is included in the mental representation: (1) it is represented as if it were present, (2) it is represented as if it were present and then suppressed, (3) it is never represented as if it were present and is instead immediately suppressed, or (4) it is never represented. Research on the processing of negation has produced inconsistent results regarding these possibilities, and as such, no overarching theory of negation processing exists. What follows is a review of some of these disparate findings.

Much of the research on the processing of negation suggests that when a word in a sentence is negated, people are slower to recognize it after reading the sentence compared to a sentence in which the same word is not negated (Kaup, 2001; Kaup & Zwaan, 2003; MacDonald & Just, 1989). MacDonald and Just provided subjects with sentences in which either the first direct object was negated (1 above), the second direct object was negated (2), or there was no negation (3). They then used a probe recognition

(1) Almost every weekend, Elizabeth bakes no bread but only cookies.

(2) Almost every weekend, Elizabeth bakes some bread but no cookies.

(3) Almost every weekend, Elizabeth bakes some bread and some cookies.

task to measure the activation level of the representation of the negated and non-negated direct objects. This task involved the subjects being presented with a word and indicating whether or not it had occurred in the previous sentence. They found that subjects were

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slower to recognize the probe words if they had been negated than if they had not been negated in the sentence. The increased time necessary to recognize a negated word is consistent with the hypothesis that the negated concept had been suppressed in the mental representation of the sentence. This would make it less active than a non-negated word and therefore in need of more time for processing. However, based on these findings it is unclear whether the negated concept is ever represented as present.

Hasson and Glucksberg (2006) also provided evidence that a suppression process is occurring for negated concepts. Subjects saw affirmative (4) and negative metaphors (5) and responded to a lexical decision task in which subjects had to decide whether letter

(4) The kindergarten is a zoo.

(5) The kindergarten is not a zoo.

strings were words or not. For critical trials, the strings were words related to the meaning of either the affirmative metaphor (e.g. *noisy*) or negative metaphor (e.g. *calm*). The lexical decision task was presented either 150, 500, or 1000 ms after the metaphor was read. For the lexical decisions occurring 150 and 500 ms after the metaphor, the affirmative meaning of the sentence was facilitated by both the affirmative and negative metaphors, relative to an unrelated control metaphor. However, for the lexical decisions occurring 1000 ms after the metaphor, the negated metaphors no longer facilitated responding to the affirmative meaning. These results show that initially (150 and 500 ms), negated concepts are represented as if present. It is only after enough time has passed for processing to occur (1000 ms) that the negated concepts show evidence of suppression, consistent with the idea that negated concepts are represented as present and then suppressed.

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While it may be true that under certain conditions negated entities are suppressed in the reader's mental representation, there is also evidence that under some conditions negated entities continue to be represented as present over time and do not show signs of suppression. Kaup (2001) presented subjects with sentences containing negation that used either a verb of creation (6) or a verb of destruction (7). She found that subjects

(6) John does not build the church but the castle.

(7) Elizabeth does not burn the photographs but the letters.

responded slower to negated concepts than non-negated concepts on a probe task for sentences containing verbs of creation, but when a sentence contained a verb of destruction (e.g., *burn*), negation no longer reduced the accessibility of the negated concept. Because the photographs were not destroyed, they should be represented as present despite having been negated, as is appropriate for the assertion of the example sentence in this case.

There is also evidence that negated entities are considered during anaphor resolution (Levine & Hagaman, 2008). In this experiment, subjects read sentences like (8) followed by (9). After reading a large number of passages like these and completing

(8) Joe bought a mango but not a pineapple.

(9) He ate the fruit in his kitchen.

a distracter task, subjects were given a surprise cued-recall task. Subjects were first asked "You read about two kinds of fruit—what was one of them?" followed by "You read about two kinds of fruit—what was the other?" Both negated and non-negated entities were recalled at a higher rate than a baseline that did not have a sentence like (9), with no

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difference between the two. The fact that the negated concepts were just as active as the non-negated concepts suggests that suppression did not occur.

These incompatible results highlight our incomplete knowledge of how negated concepts are mentally represented. Both MacDonald and Just (1989) and Kaup (2001) find evidence of early suppression of negated concepts when sentences contained verbs of creation in which the negation signaled the absence of the concept. Hasson and Glucksberg (2006) also found evidence of suppression, but not until 1000 ms after the sentence. On the other hand, Kaup (2001) showed that suppression of negated concepts does not occur when the sentences contained verbs of destruction, and Levine and Hagaman (2008) showed that negated concepts continue to serve as possible antecedents for anaphors. Thus it appears that negated entities can either be represented as present or suppressed in the mental representation of the sentence, depending on specific features of the negation (e.g., verbs of creation/destruction, metaphors, etc.). Therefore, two new experiments were conducted to test an overarching explanation for these disparate findings.

The present experiments were designed to investigate if the results of MacDonald and Just (1989), which showed that negated concepts took longer to recognize than non-negated concepts, can be explained by the fact that the negation in the sentences was unlicensed, meaning that the preceding context provided no need for the negation. Take, for example, the isolated sentence “Carol made a cake but not a pie.” The mention of pie here is unnecessary here because the sentence “Carol made a cake” already licenses the inference that she (probably) did not make pie, nor anything else other than cake. The addition of “but not a pie” only becomes necessary if, prior to the sentence, there was the

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expectation that Carol would make a pie, in which case the preceding context would have licensed the negation.

Unlicensed negation is difficult to process (Glenberg, Robertson, Jansen, & Johnson-Glenberg, 1999) in part because it is a violation of Grice's (1975) conversational maxims. These four maxims, which are based on the assumption that all parties involved in a conversation accept a common purpose or direction for the conversation, are as follows: (1) The maxim of quantity—make your contributions to the conversation as informative as necessary and do not make your contributions to the conversation more informative than necessary; (2) the maxim of quality—do not say what you believe to be false and do not say that for which you lack adequate evidence; (3) the maxim of relevance—be relevant to the current topic of the conversation; and (4) the maxim of manner— avoid obscurity of expression, avoid ambiguity, be brief, and be orderly. Although Grice originally constructed these maxims to explain spoken language, it is reasonable to assume that they also extend to written language because in some sense the writer is "conversing" with the reader.

Unlicensed negation violates both the maxims of quantity and relevance because it makes a sentence overly informative by adding irrelevant information. The violation of a maxim leads the reader to generate an implicature, which is an explanation for why the maxim was violated (Grice, 1975). A violation of one of the conversational maxims is not always an error. For instance, metaphors (e.g. *John has a big head*) can be understood in two ways: either (a) literally, meaning John's head is large, or (b) figuratively, meaning John has a large ego. When used figuratively, the size of John's head appears irrelevant

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until one computes the implicature that the sentence was a metaphor. Importantly, this implicature must be understood for the sentence to be comprehended properly.

Comprehending a sentence involves comparing the current sentence's presuppositions with information already in the mental representation, and testing for consistency between the two. Every sentence presupposes some information and it is easier to test for consistency between the presuppositions and the mental representation when the presuppositions are explicitly stated. The sentence "Carol baked a cake but not a pie" presupposes that there was some reason to believe she was going to bake a pie. Presented out of context, this presupposition is never explicitly stated, which makes the negation unlicensed. Because of this, the reader must construct a presupposition that licenses the negation. Once a valid presupposition has been constructed, it then retroactively licenses the mention, and negation, of pie.

It is this additional processing necessary for the construction of a presupposition that may account for the divergent results of previous studies. But before discussing how this processing may affect the activation of the negated concepts, it is necessary to take a look at the timing of presuppositional processing.

The Given-New strategy (Haviland & Clark, 1974) was an early attempt to explain how information is integrated into a mental representation of an evolving discourse. This strategy proposes that people first identify the given information in a sentence (i.e., what is presupposed) and compare it to the existing mental representation of the preceding discourse, deciding whether or not they are consistent, and that only after this will they alter the model to accommodate the new information (i.e., what is

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asserted). To test this hypothesis, Haviland and Clark had subjects read pairs of sentences in which (10a) or (10b) provided context for (11). Sentence (11) made reference to the

(10a) We got some beer out of the trunk.

(10b) We checked some picnic supplies.

(11) The beer was warm.

direct object in the first sentence using a definite noun phrase (NP), which is usually a marker of things that are presupposed. Half of the first sentences contained direct antecedents like in (10a), such that the word "beer" occurred in both sentences, while the other half contained indirect antecedents like in (10b), such that the word "beer" was present only in the second sentence. Sentence (11), which presupposes the existence of the beer, was read faster when the presupposition was explicitly provided in the first sentence by the direct antecedent pair (10a) than when the presupposition was implicitly provided in the indirect antecedent pair (10b).

This finding suggests that the need to infer a presupposition slows comprehension; however, it does not explicitly test the temporal order of integration into the representation. Because of this limitation, Haviland and Clark (1974) acknowledged the inverse possibility for how information is integrated into a representation: the New-Given strategy. This perspective assumes that readers initially take the truth of presuppositions for granted and therefore focus first on the new information in the sentence to comprehend what is asserted. After processing assertions, if they then have the time and motivation, readers will compare presuppositions to the mental representation.

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In support of this New-Given strategy, Hornby (1974) provided initial evidence that presupposition processing occurs later than assertion processing. Subjects read sentences like “The girl is petting the cat.” This particular sentence presupposes the existence of both the girl and the cat and asserts the girl’s action of petting the cat. After reading, subjects verified whether or not a presented picture matched the sentence. Of the mismatched pictures, the inconsistency was sometimes with the sentence’s presupposition, for instance showing a boy petting the cat, and sometimes with its assertion, for instance showing the girl petting a dog. Subjects made more errors when the pictures were inconsistent with the presupposition than when they were inconsistent with the assertion. Accuracy in responding to the pictures should be a function of whether the processing of the inconsistent component has been completed. Therefore, the more-accurate responding to the assertion-inconsistent pictures suggests that assertion processing was complete by the time the picture was presented, while the less-accurate responding to the presupposition-inconsistent pictures suggests that presupposition processing was not yet complete when the picture was presented. Because the pictures were presented at the same time regardless of the type of inconsistency, these results support the hypothesis that assertions are processed before presuppositions.

A more direct test of the New-Given strategy was provided by Langford and Holmes (1979). In this study, subjects completed a paragraph-sentence verification task. Subjects read one of two context paragraphs, for example about two roommates, Jane and Mary, and then verified the truth of a target sentence, for example “It is Jane who wants to get a television.” The target sentence was preceded by either (a) a false presupposition context which described Jane wanting to buy a radio or (b) a false assertion context

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which described Mary wanting to buy a television. Following the false presupposition context, the presupposition of the target sentence was inconsistent because Jane wanted a radio not a television. Following the false assertion context, the assertion of the target sentence was inconsistent because it was not Jane, but rather Mary who wanted the television. Subjects were slower to verify the falsity of inconsistent presuppositions than of inconsistent assertions. If presuppositions are processed first, as the Given-New hypothesis proposes, subjects should have been faster to identify false presuppositions than false assertions. Here, however, the results were similar to those of Hornby (1974), with subjects showing more difficulty (i.e., slower verification times) processing false presuppositions than false assertions, providing converging support for the New-Given hypothesis.

The timing of presuppositional processing is an important component of the hypotheses under investigation in the present experiments. Because the sentences presented by MacDonald & Just (1989) were without context, the negation should trigger a search for a relevant presupposition against which the negation can be comprehended (Levine & Hagaman, 2008; Nieuwland & Kuperberg, 2008; Urbach & Kutas, 2010). According to the New-Given strategy (cf. Hornby, 1974; Langford & Holmes, 1979), prior to the completion of this presuppositional search, the reader will have finished processing the assertion. This should lead to the negated concept being suppressed. Measuring the activation of the negated concept at this point in time should produce the pattern of results found by MacDonald and Just. However, the presuppositional search should then draw attention back to the negated concept, activating the negated concept such that it is no longer suppressed. It is therefore possible that the contradictory results

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of previous studies may be due to differences in the times at which the activation of the negated concepts was being measured.

Experiment 1

Experiment 1 used similar materials to those used in MacDonald and Just's (1989) experiments, but also systematically varied the delay between the target noun and the probe recognition task. Subjects read single sentences that contained unlicensed negation of Noun 1 (12a) or Noun 2 (12b), or no negation (12c). Following each sentence, subjects

(12a) Every Friday Tina prepared not a lecture but only an activity …

(12b) Every Friday Tina prepared a lecture but not an activity ...

(12c) Every Friday Tina prepared a lecture and an activity ...

(13) Did Tina prepare a lecture?

completed a probe recognition task in which they verified whether or not a given word was presented in the sentence. The probe words were either Noun 1 or Noun 2, and were presented 0 ms, 500 ms, or 1000 ms after the end of the sentence, the latter being manipulated between subjects. Additionally, subjects verified a comprehension statement (like 13 above) to ensure they were fully reading and understanding the statements.

It was hypothesized that if presupposition processing is completed within 1000 ms[1] and if this processing reverses the suppression that occurs during assertion processing, subjects should produce slower recognition times for negated concepts only when the probe recognition task occurs before the completion of presuppositional

[1] 1000 ms was arbitrarily chosen as a delay that was long enough after MacDonald & Just's (1989) probe task that it should provide enough time for the additional presupposition processing to at least begin.

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processing, creating a negation by delay interaction. On this basis, it is expected that in the 0 ms delay condition, subjects will respond slower to probe words when they were negated in the statement than when they were non-negated, replicating the findings of MacDonald and Just (1989). The same should be true of the 500 ms delay condition when presuppositional processing is still incomplete. However, in the 1000 ms condition, if presuppositional processing has run to completion, negated entities should have sufficient time to become reactivated, making them equally if not more active than the non-negated entities.

Method

Subjects. One-hundred and sixty-eight students enrolled in a general psychology course at the University of Arkansas participated in the experiment to partially fulfill a research requirement. All subjects were native-English speakers. A subject's data were excluded from analysis if (a) the subject's response accuracy to the probe words or comprehension statements was less than 70% or (b) if the subject's mean reading time was substantially (i.e., ±3 SDs) faster or slower than the overall mean reading time. These criteria resulted in the exclusion of 17 subjects, leaving data from 151 subjects to be included in the analyses.

Materials and Design. There were 42 experimental sentences which appeared in one of three conditions (see Table 1). Each sentence presented a character by name followed by a past-tense action verb and a compound direct object with two nouns that were selected to be of similar length but not close semantic associates. Negation was manipulated such that it occurred for the first direct object (Noun 1 Negated), the second direct object (Noun 2 Negated), or neither direct object (No Negation). In addition, there

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were 58 filler sentences. About half of these filler sentences had syntactic structures similar to the three experimental conditions, while the rest contained either two negated direct objects, a single negated direct object, or a single non-negated direct object to help mask the manipulation. In addition, each sentence had a corresponding comprehension statement (e.g., *Tina prepared a lecture*), half of which required “yes” responses and half of which required “no” responses.

Each subject saw each experimental sentence in one condition and all filler sentences. Twelve lists of experimental sentences were created with the following constraints: One-third of the experimental sentences in a list were of each condition (Noun 1 Negated, Noun 2 Negated, and No Negation). Half of the nouns probed in each condition were Noun 1, half were Noun 2. Across lists, each sentence appeared in each condition one-third of the time, half the time with Noun 1 being probed, half the time with Noun 2 being probed. The experimental trials never contained a false probe, requiring the majority of the filler trials to contain false probes so that each recognition answer occurred equally often. When the filler trials contained "yes" probes, they were always nouns other than the direct object(s). Finally, a second set of experimental materials were created that reversed the order of the nouns, such that Noun 1 was placed in the Noun 2 position and Noun 2 was placed in the Noun 1 position. These counterbalancing procedures were used within each of the three substantive between-subjects conditions: the 0 ms delay, the 500 ms delay, and the 1000 ms delay. Thus, each subject was presented with 100 total trials, with half of the probes and comprehension statements requiring “yes” responses and the other half requiring “no” responses.

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Procedure. The experiment began with three practice blocks. In the first practice block, subjects familiarized themselves with the response keys by pressing the left arrow key on the keyboard (which was labeled "Y") when the screen read "Yes" and the right arrow key on the keyboard (which was labeled "N") when the screen read "No." They completed ten of these yes-no trials and received feedback about the correctness of their responses. In the second practice block, subjects practiced the probe-recognition task. Each trial began with the words "Press the spacebar when ready" presented in the center of the computer screen in all capital letters. When subjects pressed the spacebar, a sentence was presented in the center of the computer screen. Subjects pressed the spacebar to indicate when they had finished reading, which cleared the screen. After a set delay (either 0 ms, 500 ms, or 1000 ms, depending on the condition the subject had been assigned to), a single word appeared in the center of the screen in all capital letters. Subjects indicated with the yes and no keys whether or not the presented word occurred in the sentence. Again, subjects received feedback about the correctness of their responses. In the third practice block, subjects practiced responding to the comprehension statements. Again, sentences were presented in the center of the screen. When subjects finished reading the sentence they pressed the spacebar which removed the sentence from the screen and replaced it with a comprehension statement. Subjects then indicated with the yes or no keys whether or not the comprehension statement was true. Feedback about the correctness of their responses were again provided.

Subjects then began the experimental session. Each trial consisted of a sentence, a probe word, and a comprehension statement. At the beginning of each trial, subjects were given the instruction "PRESS THE SPACEBAR WHEN READY." When they pressed

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the spacebar, the full experimental or filler sentence appeared centered on the screen and remained until the subject pressed the spacebar a second time to indicate they had finished reading. Following experimental sentences, subjects were presented with a probe word that was either Noun 1 or Noun 2. Following filler sentences, the probe word was a word from the sentence other than Noun 1 or Noun 2 or a false probe. The probes were presented either 0 ms, 500 ms, or 1000ms (manipulated between subjects) after the subject pressed the spacebar, and subjects indicated with a yes or no response whether the probe word had occurred in the sentence by pressing the arrow keys labeled “Y” or “N.” Reaction times for these responses were recorded. After the subjects respond to the probe word, a comprehension statement appeared on the screen and subjects indicated with a yes or no response whether or not the statement was true, again by pressing arrow keys labeled “Y” or “N.” Feedback was no longer provided.

The experimental session consisted of 100 trials (42 experimental and 58 fillers) in four blocks of 25 trials each. The order of the blocks, as well as the the order of the trials within each block, were randomized with the restriction that the first statement of each block was always a filler statement to allow time for the subjects to fully return their attention to the task after the mandatory 10 s breaks between blocks. Subjects were instructed to read the statements as they normally would for comprehension and to respond to the probe words as quickly and accurately as possible. They were free to take breaks between trials. The experiment lasted 30 to 45 minutes.

Results

Analysis. Because subjects and items are both random-effects variables, data were analyzed twice, once with subjects treated as a random-effects variable (averaging

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over items), for which F_1 and t_1 are reported, and once with items treated as a random-effects variable (averaging over subjects), for which F_2 and t_2 are reported. Data analysis was limited to probe responses that were (a) correct, (b) between 400 ms and 3000 ms, and (c) less than 3 SDs away from each subject's mean response time. All tests were evaluated with an alpha level of .05.

All condition means appear in Table 2. A 3 (Delay) × 3 (Sentence) × 2 (Noun) mixed-factor ANOVA, with the first factor being between-subjects and the second and third factors being repeated measures, revealed a significant main effect of delay, $F_1(2, 148) = 5.17$, $p = .007$, $\eta_p^2 = .07$, $F_2(2, 166) = 71.56$, $p < .001$, $\eta_p^2 = .46$. A main effect contrast for this factor showed that response times were significantly faster in the 500 ms delay condition than the combined 0 and 1000 ms delay conditions, $t_1(148) = 3.19$, $p = .002$, $d = 0.55$, $t_2(83) = 11.58$, $p < .001$, $d = 1.37$[2]. Main effects were non-significant for sentence, $F_1(2, 296) = 1.68$, $p = .20$, $F_2(2, 166) = 1.23$, $p = .30$, and noun, $F_1(1, 148) = 0.19$, $p = .66$, $F_2(1, 83) = 0.24$, $p = .63$.

The only significant two-way interaction was between sentence type and noun (see Figure 1), with probe recognition times to the two concepts differing when one was negated (Noun 1 Negated and Noun 2 Negated) but not when both concepts were present (No Negation), $F_1(2, 296) = 12.60$, $p < .001$, $\eta_p^2 = .08$, $F_2(2, 332) = 10.59$, $p < .001$, $\eta_p^2 = .11$. In the two negation conditions, probe recognition times were slower when the concept was negated than when it was non-negated for both Noun 1 ($M_{negated} = 899$, $M_{non-negated} = 856$), $t_1(150) = 3.33$, $p = .001$, $d = 0.27$, $t_2(83) = 3.17$, $p = .002$, $d = 0.35$, and

[2] Effect sizes can be very different between the subject and item analyses because missing data affects the two analyses differently.

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Noun 2 ($M_{negated}$ = 897, $M_{non\text{-}negated}$ = 869), $t_1(150) = 2.101$, $p = .04$, $d = 0.17$, $t_2(83) = 2.040$, $p = .04$, $d = 0.22$.

This result was qualified by a significant three-way interaction (see Table 2) between sentence type, noun, and delay, $F_1(4, 296) = 3.92$, $p = .004$, $\eta_p^2 = .05$, $F_2(4, 332) = 3.73$, $p = .005$, $\eta_p^2 = .04$. To further explore this interaction, paired-samples *t*-tests were conducted to compare the recognition times for Noun 1 probes in the Noun 1 Negated condition to the No Negation condition, separately for each delay. The same comparisons were made between Noun 2 in the Noun 2 Negated condition and the No Negation condition.

In the 0 ms delay condition (see Figure 2), probe recognition times were significantly longer when Noun 1 was negated than when it was non-negated, $t_1(49) = 3.69$, $p = .001$, $d = 0.52$, $t_2(83) = 3.06$, $p = .003$, $d = 0.33$. This difference was significant for Noun 2 in the subject analysis, $t_1(49) = 2.15$, $p = .04$, $d = 0.30$, and nearly significant in the item analysis, $t_2(83) = 1.67$, $p = .098$, $d = 0.18$. In the 500 ms delay condition (see Figure 3), Noun 1 probe recognition times were nearly significantly slower for negated concepts than for non-negated concepts in the subject analysis, $t_1(49) = 1.92$, $p = .06$, $d = 0.27$, and significantly slower in the item analysis, $t_2(83) = 2.20$, $p = .03$, $d = 0.24$.This difference, however, was non-significant for Noun 2 in both analyses, $t_1(49) = 1.15$, $p = .25$, t_2 $(83) = 1.38$, $p = .17$. In the 1000 ms delay condition (see Figure 4), there were no differences in probe recognition times for Noun 1, $t_1(50) = 0.72$, $p = .47$, $t_2(83) = 0.47$, $p = .64$, or Noun 2, $t_1(50) = 0.62$, $p = .54$, t_2 $(83) = 0.65$, $p = .52$.

To get a clearer picture of how this effect changed over time, a negation effect was computed for each noun at each delay condition (see Figure 5). The Noun 1 negation

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effect was computed by taking the difference between Noun 1 in the Noun 1 Negated condition and Noun 1 in the No Negation condition, while the Noun 2 negation effect was computed by taking the difference between Noun 2 in the Noun 2 Negated condition and Noun 2 in the No Negation condition; that is, reaction times for a concept were computed when the concept was negated and compared to when it was not negated. Single-sample *t*-tests revealed a significant negation effect in the 0 ms delay condition for Noun 1, $t_1(49) = 3.69$, $p = .001$, $d = 0.52$, $t_2\ (83) = 3.06$, $p = .003$, $d = 0.33$, and for Noun 2 in the subject analysis, $t_1(49) = 2.15$, $p = .04$, $d = 0.30$, but not the item analysis, $t_2(83) =1.67$, $p = .10$, $d = 0.18$. In the 500 ms delay condition, there was a nearly significant negation effect for Noun 1 in the subject analysis, $t_1(49) = 1.92$, $p = .06$, $d = 0.27$, which was significant in the item analysis, $t_2(83) = 2.20$, $p = .03$, $d = 0.24$, but the negation effect was non-significant for Noun 2 in both analyses, $t_1(49) = 1.15$, $p = .25$, $t_2(83) = 1.38$, $p = .17$. And in the 1000 ms delay condition, the negation effect was non-significant for Noun 1, $t\ (50) = 0.72$, $p = .47$, $t_2(83) = 0.47$, $p = .64$, and Noun 2, $t_1(50) = 0.62$, $p = .54$, $t_2\ (83) = 0.65$, $p = .52$.

Discussion

The results supported the hypothesis that the effect of negation changes over time. When there was no delay (0 ms) between sentence and probe recognition task, concepts were responded to slower when they had been negated than when they had been non-negated, replicating the findings of MacDonald and Just (1989). However, with a 500 ms delay the results were mixed, with a significant difference found for Noun 1, but not for Noun 2. With a 1000 ms delay, there were no significant differences between negated and

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non-negated concepts for either Noun 1 or Noun 2. Thus, it appears that the negation effect diminishes over time.

An explanation for this effect is that the initial assertional processing of the negated concepts leads to suppression by the end of the sentence, as seen in the shortest (0 ms) delay condition. But the additional time in the 500 and 100 ms delay conditions gives subjects a chance to begin processing or possibly completely process the presupposition that makes the unlicensed negation relevant. This processing involving the negated noun causes it to be re-activated such that it counteracts the initial suppression and the negation effect is no longer present. For example, consider the sentence "Tina prepared not a lecture but only an activity for her students." The assertion of this sentence is that Tina prepared an activity and not a lecture. Thus, when the reader processes this assertion, the concept of *activity* increases in activation and, conversely, the concept of *lecture* is suppressed. But when the reader then processes the missing presupposition to make sense of the unlicensed negation, the concept of *lecture* is re-activated such that it is no less active than when *lecture* is non-negated.

If it is true that the resurgence of activation when negation is unlicensed is the result of presuppositional processing, these findings also provide a rudimentary timeline for the process. Because the negation effect is present with a 0 ms delay, but reduced and non-significant with a 500 ms delay, it appears that presuppositional processing has begun somewhere within this timeframe. And because the magnitude of the difference between negated and non-negated concepts continued to decrease from the 500 ms delay to the 1000 ms delay, it seems that some amount of processing continues beyond 500 ms. However, it is unclear whether presuppositional processing is complete within 1000 ms

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or if it is still ongoing. If it is ongoing, it is possible that the continued processing would further activate the negated concept, possibly leading to a level of activation significantly higher than the non-negated concept, as predicted by the pragmatic-inference hypothesis (Levine & Hagaman, 2008).

The probe recognition task may not be suitable for measuring this effect at longer delays because the screen remains blank during the delay. In fact, the analysis of probe recognition times for each delay suggests there may be some concerns even with a delay of 1000 ms. Subjects responded significantly faster in the 500 ms delay than in the 0 ms delay, as would be expected since the noun is increasing in activation. Therefore, it would be expected that responses would be equally fast if not faster in the 1000 ms delay since the ongoing processing should push activation even higher. But responses in the 1000 ms delay were actually roughly equivalent in speed to those at the 0 ms delay, significantly slower than the 500 ms delay, not faster. Since the negation effect continued to diminish in the 1000 ms delay, the slower responses may be taken as evidence that subjects' attention may have drifted from the task. Another task, then, is necessary to evaluate this re-activation on a longer time scale.

A final point of discussion is the use of the No Negation condition as a baseline. To assess the impact of negation, response times for the negated concepts in the Noun 1 Negated and Noun 2 Negated conditions were compared to the concept in the same position in the No Negation condition. This baseline was chosen because it was used by MacDonald and Just (1989). But instead of comparing Noun 1 in the Noun 1 Negated condition to Noun 1 in the No Negation condition, it could also be compared to Noun 1 in the Noun 2 Negated condition. This would provide a less-confounded comparison

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because the concepts would both be in sentences containing negation, while still occurring in the same position in the sentence. This alternative baseline was tested, but the results were not substantially different than the original baseline, and therefore are not reported.

Experiment 2

Despite their heavy usage in the psycholinguistics literature, probe-word tasks may not be the best method of measuring activation. Gordon, Hendrick, and Foster (2000) found evidence that when subjects expect to engage in a probe-word task, they create a "probe-list memory" such that they treat the text like an unrelated list of words to be remembered rather than a cohesive whole. With this probe-list memory in place, subjects then simply check probe words against this probe-list representation to respond to probe words. To the extent that this occurs in probe-word tasks, the results may not reflect comprehension processes, but instead may reflect memory strategies that are unrelated to comprehension.

Thus, to find converging evidence for the results of Experiment 1 using a task that would not induce a special strategy, Experiment 2 assessed the activation levels of negated and non-negated concepts using an eye-tracker to record eye-movements as subjects read sentences containing anaphors, which are expressions, like pronouns, that refer to previously-mentioned concepts. Subjects read sentence pairs that included both a singular and a plural direct object. The negation sentence manipulated the position of the singular object and whether or not it was negated (14a-d) and was always followed by the same reference sentence which contained an anaphor referring to the singular noun (15).

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(14a) Penny did bake a cake but did not bake brownies for dessert.

(14b) Penny did not bake a cake but did bake brownies for dessert.

(14c) Penny did not bake brownies but did bake a cake for dessert.

(14d) Penny did bake brownies but did not bake a cake for dessert.

(15) She had a mix for *one* in her pantry ...

These manipulations created four conditions such that differences between negated and non-negated concepts could be compared both when they are relatively far away from (Position 1) and relatively close to (Position 2) the anaphor in the reference sentence. Several eye-tracking measures were analyzed for the critical regions around the anaphor in the reference sentence to assess the activation level of the concept to which the anaphor was referring. Presumably, the less active the concept of the antecedent is, the more difficulty a subject will have processing the anaphor, as reflected in various measures indicting reading difficulty. This method is more naturalistic than using a probe word task since it more closely mirrors normal reading by having the subjects continue reading instead of switching attention to the probe task.

It was hypothesized that subjects would show signs of processing difficulty on the anaphor (i.e., longer reading times, more regressive eye-movements) when the negated concept to which it refers was in Position 2 compared to when it was in Position 1. The additional time that passes between the negated noun and the anaphor when the noun is in Position 1 compared to when it is in Position 2 should give subjects the opportunity to complete the presuppositional processing necessary to make sense of the unlicensed negation. As in Experiment 1, the presuppositional processing should increase activation

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of the negated concept, which should in turn make it easier for subjects to process the anaphor.

Method

Subjects. Sixty students from the same population as those who participated in Experiment 1 participated in Experiment 2. All subjects were native-English speakers with normal or to corrected-to-normal vision. Data from nine subjects were excluded from the analysis because the subjects correctly responded to less than 60% of the comprehension statements, and an additional two subjects' data were removed for having unusable eye-tracking data[3].

Materials. Subjects read 32 experimental sentence-pairs (see Table 3). The first sentence, referred to as the negation sentence, contained two verb phrases, one with a singular direct object and the other with a plural direct object. The noun of interest was the singular direct object. Four versions of the first sentence were created by manipulating the position of the singular direct object (Position 1 or Position 2) and whether it was non-negated or negated (Present or Negated). The negation sentence was followed by a reference sentence that contained a singular pronoun (e.g.. *it* or *one*) that unambiguously referred to the singular direct object. The distance between the antecedent and anaphor when the antecedent was in Position 1 ranged from 8 to 14 words (M = 10.59, SD = 1.34). When the antecedent was in Position 2, the distance ranged from 4 to 7 words (M = 5.31, SD = 0.92). The reference sentence appeared in one of two versions, depending on whether the singular direct object was non-negated (affirmative reference)

[3] Several factors make subjects' eyes more difficult to track, such as thick glasses frames, excessive eye makeup, dark eyelashes, lazy eyes, etc.

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or negated (negative reference). These two conditions were identical through the first clause, where the anaphor reading times were measured. They differed only in the second clause, which made the statement fit the given scenario, but this occurred after the regions on which analyses were performed; thus, this difference should not affect subjects' processing within the critical regions. The sentence-pairs appeared together on one or two lines, depending on their length, but both the antecedent and the anaphor critical region always occurred on the first line. Each sentence-pair was followed by a comprehension statement which subjects verified as true or false using predefined keys on a game controller to ensure subjects were reading for comprehension. In addition to the experimental sentence-pairs, subjects read 58 filler statement pairs which were syntactically similar to the experimental materials but designed to obscure the experimental manipulation; the fillers were also followed by true-false comprehension statements.

Because the materials were relatively complex and potentially difficult to comprehend, a pilot study was conducted to ensure that subjects were able to correctly identify the antecedent of the anaphor. Ten graduate students from the University of Arkansas were presented the experimental sentence-pairs on a computer screen. Subjects read each sentence-pair and pressed the spacebar to indicate they had finished reading it. The sentence was then removed from the screen and subjects indicated to which of the two direct objects the anaphor was referring. Subjects accurately identified the antecedent at least 70% of the time for all materials.

Apparatus. Eye-movements were was recorded using an EyeLink 1000 desktop-mounted eye tracker manufactured by SR Research (Mississauga, Ontario, Canada).

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Sampling frequency was 1000 Hz; only the right eye was tracked. The stimuli were presented on a 20" CRT monitor with a screen resolution of 1024 x 768 and a refresh rate of 85 Hz.

Procedure. Prior to the start of the experiment, subjects were calibrated on the EyeLink 1000 using a 9-point display. Calibration was repeated until tracking error was less than 0.5° of visual arc on average and the maximum error was less than 1°. Subjects were then given instructions about how to interact with the computer using a game controller with different buttons assigned for each response.

Each trial consisted of a sentence-pair to read and a comprehension statement. At the beginning of each trial, a fixation point appeared on the left side of the screen to indicate the location of the first word of the sentence-pair. While fixating on this point, subjects pressed an assigned button to begin the trial and the negation and reference sentence or filler sentence-pair appeared left-justified at that point of the screen. When finished reading the sentence-pair, subjects pressed an assigned button and the sentences were replaced by a comprehension statement. Subjects indicated whether the comprehension statement was true or false by pressing assigned buttons. The fixation point then reappeared and subjects were free to begin the next trial when ready. Trials were divided into four blocks of 20 trials each, with short breaks in between. Subjects were recalibrated following breaks if necessary, and at any point during the experiment when the subject removed his or her head from the eye-tracker's chin rest, or if the experimenter noticed a calibration problem. An experimenter was present in the room throughout the experimental session.

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Results

Analysis. Two regions of the second sentence of each sentence pair were analyzed. The critical region was defined as the word before the anaphor plus the anaphor itself. Because the anaphors were only two or three letters long (i.e., *it*, *one*), it is possible that it was being read while the subjects were fixating on the previous word (Underwood & McConkie, 1985). The postcritical region was defined as the two words following the anaphor. This region was analyzed to examine any continuing processing of the anaphor, because the processing of a region continues even after the eyes have moved on in the text (Rayner, 1998).

For each item, the regions of analysis were identical across conditions. Fixations less than 80 ms and within 1° of visual angle from the previous fixation were merged with the previous fixation. All other fixations less than 80 ms or greater than 1000 ms (1500 ms for the regression-path duration analysis) were removed. Additionally, the analyses only included trials in which subjects fixated in the region under analysis. All tests were evaluated with an alpha level of .05.

Eye movement measures. Four eye movement measures were assessed for each region of interest: (1) *total reading time* is the sum of all fixations within a region, which is a measure of overall comprehension difficulty for the region; (2) *gaze duration* is the sum of all fixations in a region until the point of fixation moves out of the region either to the left or right, which is a measure of the initial processing of the region; (3) *regression-path duration* is the sum of all fixations from the time that the region is first entered from the left until it is first exited to the right, which is a measure of early processing difficulty; and (4) *first-pass regression ratio* is the proportion of trials in which a

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regressive eye movement is made out of the region, which is another measure of early processing difficulty. Table 4 displays means and standard deviations for all measures as a function of condition and region of interest.

Critical Region. Analysis of the critical region provided weak evidence that subjects had less difficulty processing the anaphor when the antecedent was in Position 2, and stronger evidence that subjects had less difficulty processing the anaphor when the antecedent was negated than when it was non-negated. A 2 (Negation) × 2 (Position) repeated-measures ANOVA was conducted for each eye movement measure.

Analysis of total durations revealed a nearly significant main effect of position in the subject analysis, with reading times on the critical region being shorter when the antecedent of the anaphor was in Position 2 than when it was in Position 1, $F_1(1, 47) = 3.02$, $p = .09$, $\eta_p^2 = .06$ (see Figure 6), but this effect was non-significant in the item analysis, $F_2(1, 27) = 1.19$, $p = .29$. Analysis of regression path duration also revealed a marginally significant main effect of position in the same direction in the subject analysis, $F_1(1, 47) = 2.88$, $p = .096$, $\eta_p^2 = .06$ (see Figure 7), but this effect was non-significant in the item analysis, $F_2(1, 27) = .046$, $p = .83$. Analysis of first pass regression ratios revealed a significant main effect of negation in the item analysis, with subjects regressing out of the critical region more often when the antecedent of the anaphor was non-negated than when it was negated, $F_2(1, 27) = 5.32$, $p = .03$, $\eta_p^2 = .17$ (see Figure 8), but this effect was non-significant in the subject analysis, $F_1(1, 47) = .20$, $p = .66$. Analysis of gaze durations revealed no significant effects (Fs < 1). There were no significant interactions for any of the eye movement measures.

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Postcritical Region. Analysis of the postcritical region again provided evidence that subjects had less difficulty processing the anaphor when the antecedent was negated than when it was non-negated. A 2 (Negation) × 2 (Position) repeated-measures ANOVA was conducted for each eye movement measure. Condition-by-region means for each measure are reported in Table 4.

Analysis of first pass regression ratios revealed a significant main effect of negation in the subject analysis, with subjects regressing out of the postcritical region more often when the antecedent of the anaphor was non-negated than when it was negated $F_1(1, 47) = 4.62$, $p = .037$, $\eta_p^2 = .09$ (see Figure 9), but this effect was non-significant in the item analysis, $F_2(1, 27) = 0.23$, $p = .64$. Analysis of gaze durations, total durations, and regression path durations revealed no significant effects (*F*s < 1). There were no significant interactions for any of the eye movement measures in the post critical region.

Discussion

The hypothesis that processing negated nouns would be more difficult when the they were in Position 2 than when they were in Position 1 was not supported. Although the predicted interaction between negation and position did not occur, several main effects emerged.

The nearly significant main effect of position for both total duration and regression path duration measures in the subject analysis of the critical region revealed that subjects read the critical region faster and referred back to the previous text less often when the antecedent was in Position 2 than when it was in Position 1. This effect is likely the result of the recency effect (O’Brien, Plewes, & Albrecht, 1990), given that the nouns

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in Position 2 were more recently mentioned than nouns in Position 1 and the effect was relatively weak.

Of more theoretical importance, the main effect of negation for first pass regression ratios in the item analysis of the critical region and the subject analysis of the postcritical region revealed that subjects regressed out of the region of analysis less often when the antecedent was negated than when it was non-negated. This indicates that the subjects had less difficulty processing the anaphor when the antecedent had been negated, which suggests that the negated concepts had a higher level of activation than non-negated concepts. It is generally accepted that negated concepts are less active than non-negated concepts, so this result is relatively unsupported by the literature, but fits well with the results of Experiment 1, with negated concepts in unlicensed contexts being no less active than non-negated concepts after a short amount of time has passed. However, these results should be interpreted with some reservation, since none of the effects were present in both the subject and item analyses. This limits the interpretation of the results to the specific subjects in the subject analyses or to the specific materials in the item analyses.

General Discussion

Experiment 1 supported the hypothesis that negated concepts are less active than non-negated concepts immediately after a sentence, but that this difference is no longer present when subjects are given additional processing time. The favored explanation is that the negated concepts are suppressed by assertion processing and then re-activated by presupposition processing. However, it is also possible that the suppression fades over

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time regardless of presupposition processing, an explanation that is impossible to rule out with the current data.

Experiment 2 did not find support for the predicted interaction between negation and position. It was hypothesized that subjects would have more difficulty reading the regions of interest when the negated antecedent was in Position 2 than when it was in Position 1 because there would have been less time for the presupposition processing to occur. However, the results suggest just the opposite, that subjects actually had somewhat less difficulty when the negated antecedents were in Position 2 compared to Position 1.

There are several possible reasons why the hypothesized interaction between negation and position did not occur in Experiment 2. First, the materials may not have created the desired effect of allowing enough time for presuppositional processing to be completed for the nouns in Position 1 but not for nouns in Position 2. The two alternatives are that (1) presuppositional processing was completed for both nouns or (2) that presuppositional processing was not completed for either noun. The first alternative seems more likely, since the negated concepts appeared to be more active than non-negated concepts, suggesting that the presuppositional processing had already occurred.

It may also be that presuppositional processing only needs to begin in order for the negated concepts to increase in activation, rather than being fully completed. In this case, both positions would allow sufficient time for presupposition processing to begin and thus increase the activation of the negated concept. However, the results of Experiment 1 suggest that negated concepts continue to increase in activation over time, at least up to a full second. Taken together, the results from both experiments suggests that activation may initially increase when presuppositional processing begins and then

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continue to increase as the processing continues. It is unclear from either experiment whether presuppositional processing is complete at the time when activation is measured via a probe word or anaphor reading time.

A third possible explanation is that the difference in distance between the noun and the anaphor for Position 1 and Position 2 was not distinct enough. The distance varied across the materials, with as few as eight words between the Position 1 noun and the anaphor and as many as seven words between the Position 2 noun and the anaphor. Further differentiating the distance between conditions could have led to a greater difference between the conditions.

A fourth possibility is that processing of the presupposition is delayed until the end of the sentence. This would explain why significant results were found in Experiment 1 where the distance manipulation started after the sentence ended, but not in Experiment 2 where the distance manipulation started before the end of the sentence. This explanation fits well with a "wait and see" theory of language processing (Bouma & deVoogd, 1974), which argues that processing is delayed until a sufficient amount of information is acquired to fully comprehend it. However, theories of incremental processing, which argue that words are processed immediately upon encountering them, have much more empirical support (e.g., Just & Carpenter, 1980). Therefore, this is an unlikely explanation for the lack of results.

The final potential explanation to be discussed here is that presuppositional processing may not have any effect on the activation level of either negated or non-negated concepts. However, there does appear to be something occurring when subjects

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are given additional processing time, but whether or not this effect is caused by presupposition processing cannot be determined by the present experiments.

Although the hypothesized interaction did not occur in Experiment 2, the main effect of negation is an important result. Unlike Experiment 1, in which negated and non-negated concepts were found to be at roughly equal activation levels, Experiment 2's results provided evidence for a higher level of activation for negated concepts than for non-negated concepts as predicted by the pragmatic-inference hypothesis (Levine & Hagaman, 2008). Therefore, both experiments suggest that the activation level of negated concepts increases to a level equal to or possibly greater than non-negated concepts if subjects are given sufficient time between the presentation of the concept and a subsequent probe task or anaphor.

The effect of presupposition processing on the activation level of negated concepts in unlicensed contexts may help explain the discrepancies within the literature. This presupposition processing model proposes that two factors, time and whether the negation was licensed or unlicensed, should interact such that additional processing time will increase the activation of negated concepts only when the negation is unlicensed. The existing literature fits well within this framework.

Several previous studies that have found negated concepts to be less active than non-negated concepts presented subjects sentences with licensed negation. The target sentences in Kaup (2001) were preceded by context passages several lines long which provided details that licensed the negation. These contexts set up the idea that the passage's protagonist was choosing between alternatives, as in (16), which licenses the negation that occurs in (17).

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(16) John is reading the [Lego] booklet and is wondering what he could build next.

(17) After a while, he decides to build the castle but not the church.

By introducing a decision between multiple alternatives, the addition of "but not the church" becomes relevant. Thus, it should be expected that negated concepts would be less active than non-negated concepts. This is indeed what was found, even with the probes being presented 2500 ms after the target sentence.

Kaup and Zwaan (2003) also preceded their target sentences with context passages, and again the negation was licensed. However, the negation was not licensed because of the context, but rather because the negation was about the assertion of the sentences. Take, for example, the target sentence "Susan thought that they would buy the bike, and she only wished the bike didn't have a blue frame." This sentence asserts that the bike is blue. The negation is involved in this assertion, rather than a presupposition. It is not necessary for the subjects to already have a representation of the bike being a color other than blue for the sentence to be comprehended, therefore no presupposition search is required to comprehend the negation. It should again be expected that negated concepts would show less activation than non-negated concepts, since no presupposition search will occur to reactivate the negated concept. With probes presented 500 ms after the target sentence, this is precisely what was found.

The negation in the sentences presented by Hasson and Glucksberg (2006) was also licensed because it was related to the sentence's assertion. For example, consider the sentence "The kindergarten is not a zoo." This sentence asserts that the kindergarten was a calm place. Again, it is not necessary for the subjects to already have a representation of

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the kindergarten being a noisy place. As expected following licensed negation, negated concepts were found to be less active than non-negated concepts at 1000 ms after the target sentence.

Thus, it appears that when negation is licensed, either by preceding context or by virtue of being part of the sentence's assertion, negated concepts are less active than non-negated concepts. This finding is consistent across time, having been found at 500, 1000, and 2500 ms, suggesting that additional processing time does not have an effect on licensed negation.

Conversely, when negation is unlicensed, the relative levels of activation between negated and non-negated concepts varies as a function of time. MacDonald and Just (1989) presented subjects with single sentences like "Elizabeth baked some bread but no cookies." Unlike the previous cases where the negation was part of the sentence's assertion, in this case it seems to be part of a missing presupposition. The assertion here is that Elizabeth baked bread. The function of "but no cookies" is not to add new information, but rather to disconfirm a prior expectation. Unless there was reason to expect that Elizabeth would bake cookies, there is an infinite number of other items that could have been included, since Elizabeth also did not bake a cake, a pie, a telephone, etc. Because the mention of cookies seems irrelevant to the reader, the negation is unlicensed, and they must create the missing presupposition themselves.

Presenting the probe task at 0 ms, MacDonald and Just (1989) found evidence of negated concepts being less active than non-negated concepts. Experiment 1 of the present paper, which used materials modeled after MacDonald and Just, replicated this

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result at 0 ms, but found no such difference when the probe task was presented at 500 ms or 1000 ms.

Levine and Hagaman (2008) and Experiment 2 of the present paper both measured reading times on anaphors following sentences with unlicensed negation similar to the previous example. Based on the number of words between the end of the target sentence and the anaphor, subjects first read the anaphor about 1500-2000 ms after the target sentence in both experiments. Levine and Hagaman found no difference in the activation levels of negated and non-negated concepts and Experiment 2 found some evidence that negated concepts might actually become more highly activated than non-negated concepts. Thus, it appears that after reading unlicensed negation, the activation level of negated concepts is initially lower than non-negated concepts and gradually increases over time, possibly even to a higher level than non-negated concepts.

Although a comparison of licensed and unlicensed negation in the existing literature supports the presupposition processing model, future research examining the reduction of the negation effect over time in both licensed and unlicensed contexts will be necessary to determine if the increase in activation is indeed the result of presuppositional processing or if, instead, it is a gradual decrease in suppression of the negated concept over time. Future research should also utilize methodologies other than probe tasks, such as anaphor reading times, to allow the investigation of the level of activation of negated concepts at longer delays than 1000 ms, to find the point at which additional processing time no longer leads to increases in activation, which would be indicative of the completion of presuppositional processing.

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Table 1

PROBES: lecture, activity
Noun1 Negated: Every Friday Tina prepared not a lecture but only an activity for her students.
Noun2 Negated: Every Friday Tina prepared a lecture but not an activity for her students
No Negation: Every Friday Tina prepared a lecture and an activity for her students.

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Table 2

Descriptive Statistics for Experiment 1

		0ms	500 ms	1000 ms
		M (SE)	M (SE)	M (SE)
Noun 1	Present	891 (21.6)	786 (19.0)	891 (30.3)
	Negated	964 (24.4)	822 (21.4)	911 (31.7)
Noun 2	Present	904 (24.4)	806 (19.7)	898 (30.1)
	Negated	944 (20.4)	833 (25.1)	913 (30.3)

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Table 3

Position 1 Present (Affirmative Reference)

Penny did bake a cake but did not bake brownies for dessert. She had a mix for *one* in her pantry, and had been planning to make it all week.

Position 1 Negated (Negative Reference)

Penny did not bake a cake but did bake brownies for desert. She had a mix for *one* in her pantry, but was not in the mood for one.

Position 2 Present (Affirmative Reference)

Penny did not bake brownies but did bake a cake for dessert. She had a mix for one in her pantry, and had been planning to make it all week.

Position 2 Negated (Negative Reference)

Penny did bake brownies but did not bake a cake for dessert. She had a mix for one in her pantry, but was not in the mood for one.

Comprehension Statement:

Penny had a cake mix. YES

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Table 4

Descriptive Statistics for Experiment 2

		Negated		Non-Negated	
		Position 1	Position 2	Position 1	Position 2
Region	Measure	M (SD)	M (SD)	M (SD)	M (SD)
Critical	Gaze Duration (ms)	363 (16.1)	355 (14.5)	370 (15.5)	364 (14.7)
	Total Duration (ms)	456 (12.8)	434 (13.2)	463 (15.9)	443 (13.3)
	Regression Path Duration (ms)	469 (27.6)	422 (21.1)	467 (25.9)	451 (20.5)
	First Pass Regression Ratio	.165 (.024)	.124 (.022)	.154 (.024)	.152 (.022)
Postcritical	Gaze Duration (ms)	339 (15.0)	352 (15.1)	344 (13.7)	348 (16.5)
	Total Duration (ms)	432 (15.7)	429 (14.8)	438 (15.1)	411 (14.4)
	Regression Path Duration (ms)	450 (22.2)	460 (20.8)	474 (22.1)	471 (24.7)
	First Pass Regression Ratio	.195 (.027)	.249 (.030)	.269 (.037)	.290 (.036)

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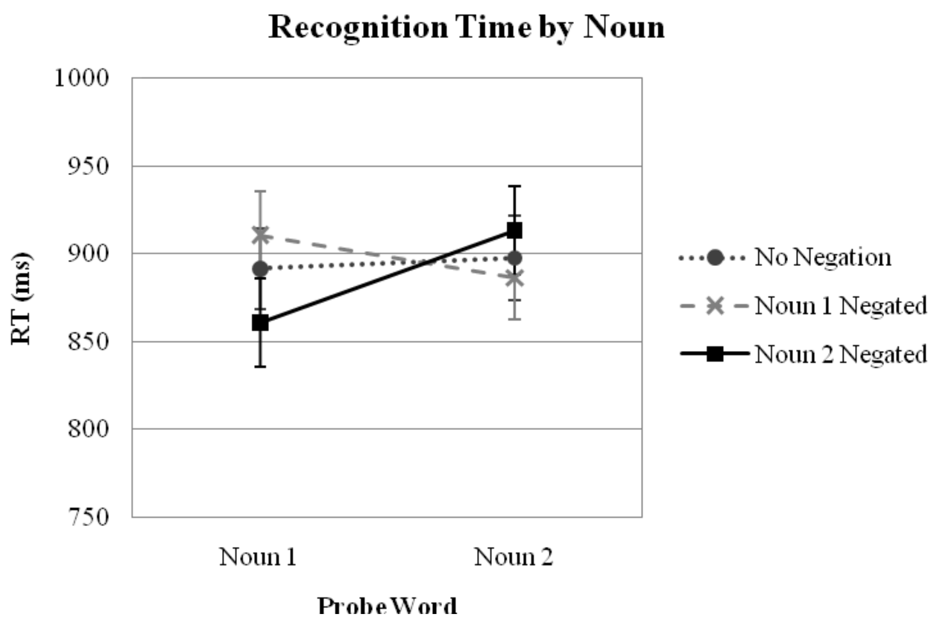

Figure 1. Mean probe recognition times and standard errors for each sentence type at each noun.

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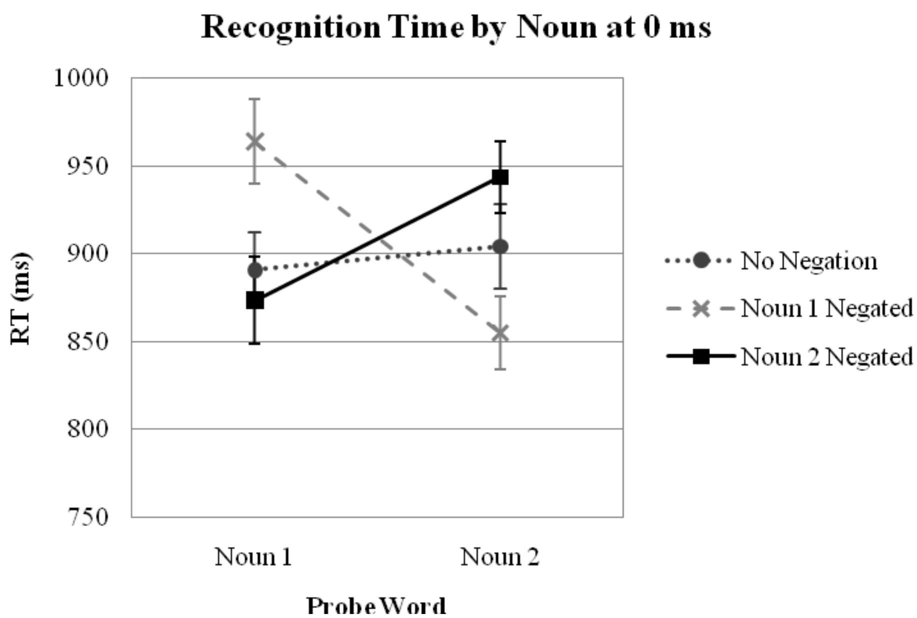

Figure 2. Mean probe recognition times and standard errors for each sentence type at each noun in the 0 ms delay condition.

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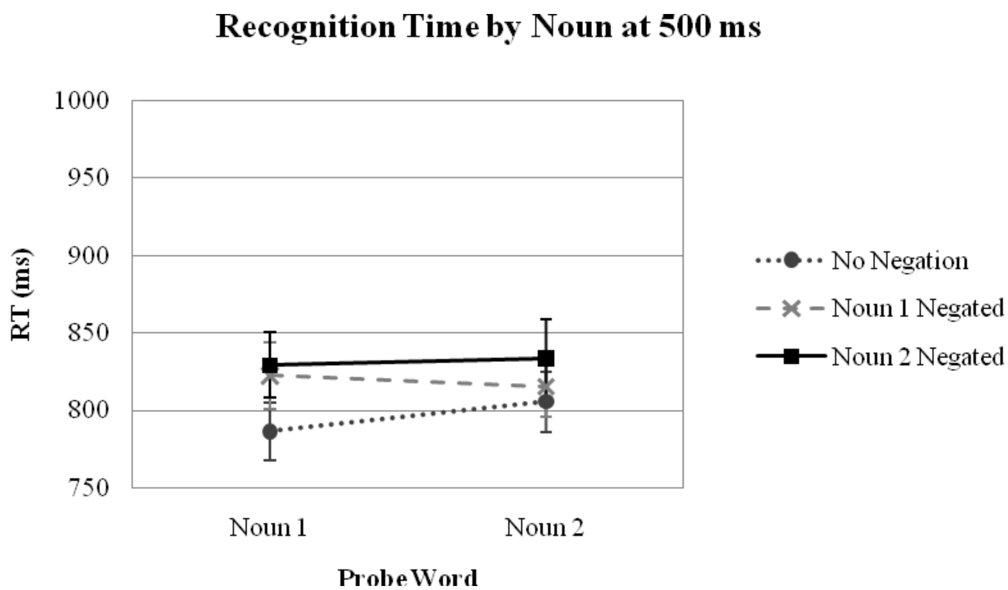

Figure 3. Mean probe recognition times and standard errors for each sentence type at each noun in the 500 ms delay condition.

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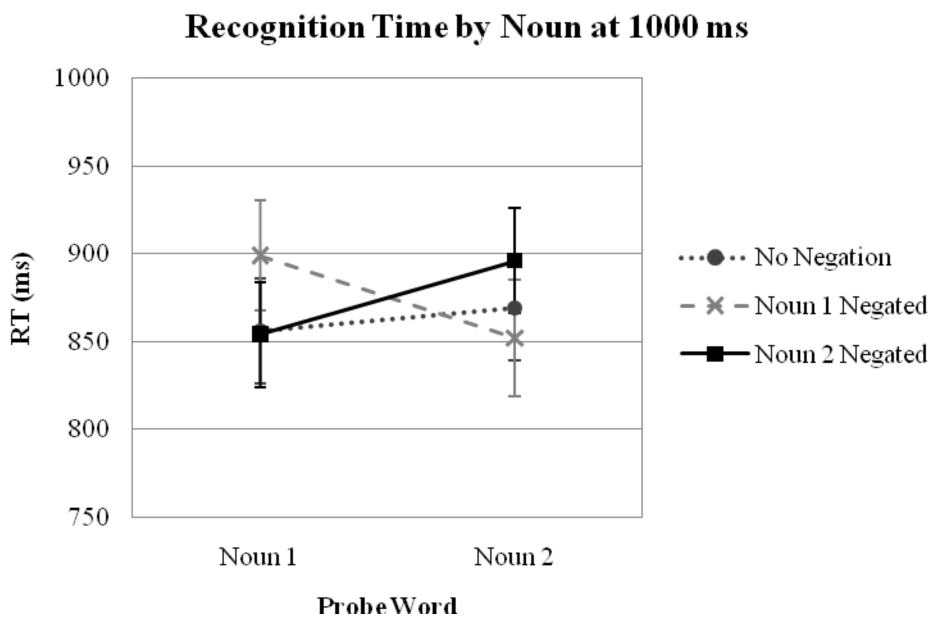

Figure 4. Mean probe recognition times and standard errors for each sentence type at each noun in the 1000 ms delay condition.

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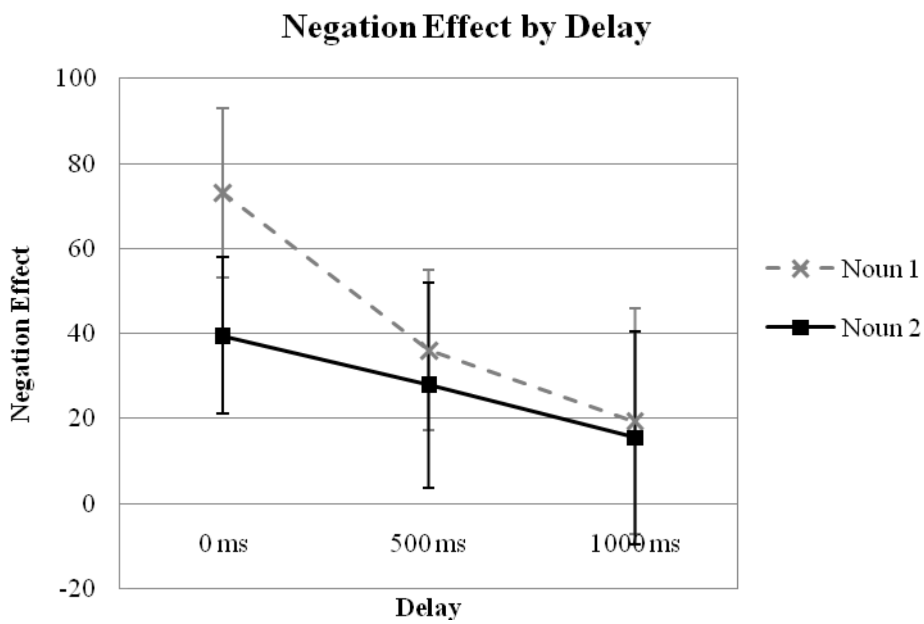

Figure 5. Negation effect for each noun at each delay condition in the subject analysis.

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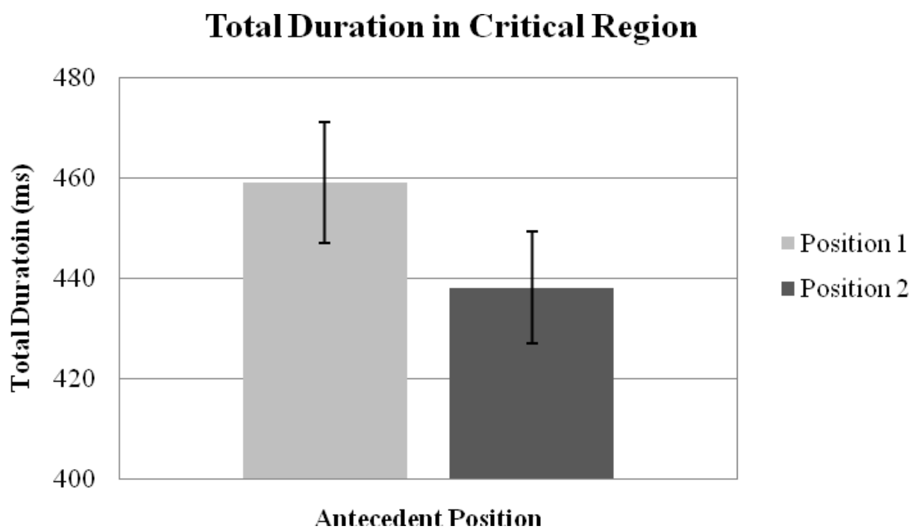

Figure 6. Total duration in the critical region for each position

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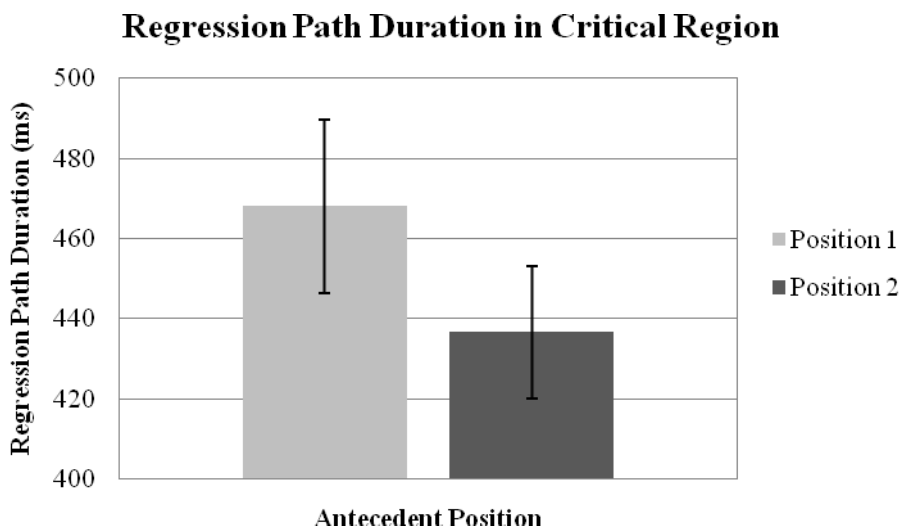

Figure 7. Regression path duration in critical region for each position.

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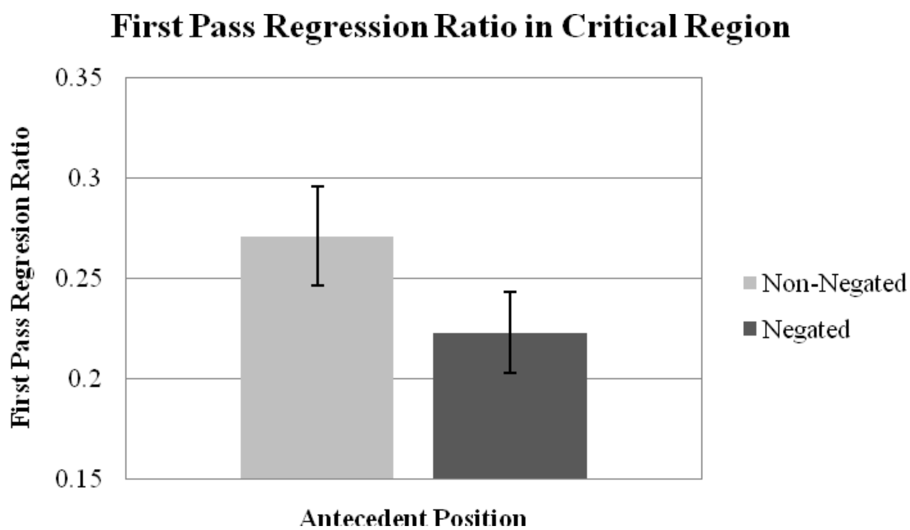

Figure 8. First pass regression ratios in the critical region for negated and non-negated nouns.

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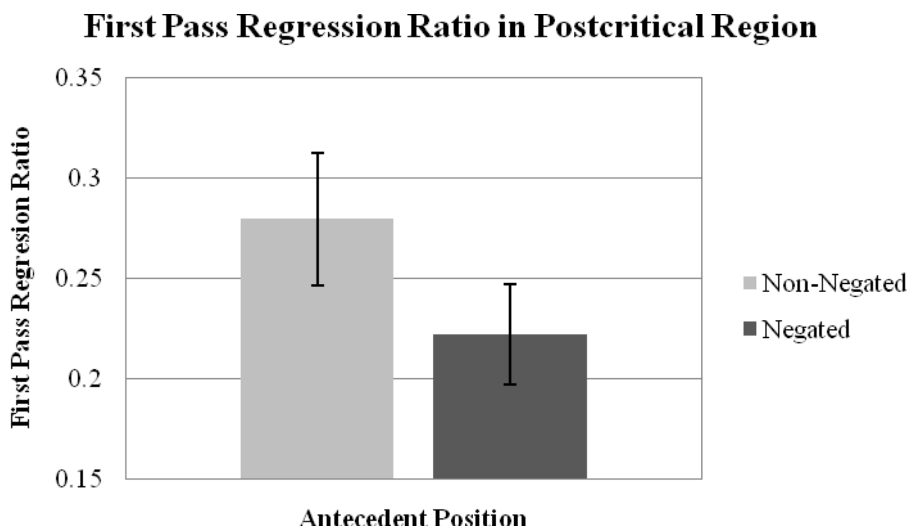

Figure 9. First pass regression ratios in the postcritical region for negated and non-negated nouns.

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