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Effects of Licensed and Unlicensed Negation on the Activation of Negated Concepts

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Effects of Licensed and Unlicensed Negation on the Activation of Negated Concepts

Effects of Licensed and Unlicensed Negation on the Activation of Negated Concepts

A dissertation submitted in partial fulfillment
of the requirements for the degree of
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by

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ABSTRACT

Research on the activation of negated concepts has demonstrated situations in which negated concepts are less active than non-negated concepts (e.g., MacDonald & Just, 1989) as well as situations where negated and non-negated concepts are equally active (e.g., Autry & Levine, 2012, in press). Based on the pragmatic inference hypothesis (Levine & Hagaman, 2008), the present experiments tested the hypothesis that the activation level of negated concepts is a function of the context in which they occur. In two experiments, the activation level of target concepts was measured following licensing or non-licensing contexts using lexical decision and reading times. Although Experiment 1 suggested that subjects inferred the target concept in the licensing contexts more than in the non-licensing contexts, Experiment 2 did not find the predicted evidence of a differential negation effect in licensing and non-licensing contexts. These findings suggest that licensing does not affect the activation of negated concepts.

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Effects of Licensed and Unlicensed Negation on the Activation of Negated Concepts

Language comprehension and production are vital cognitive abilities that are involved in nearly every aspect of life. Language allows for the transmission of thought, not only from one person directly to another, but also across space and time. A single thought can travel across the world and persist for thousands of years when transformed from the momentary firing of neurons into a known language, spreading from one mind to the next. But how is it that a person can understand the meaning packaged within a pattern of sounds or images?

Research on the processing of language has suggested that comprehending an utterance involves the construction of multiple mental representations (Johnson-Laird, 1983; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). The *verbatim representation* consists of the specific spoken or written words that comprised the utterance, and the *propositional representation* consists of the individual propositions that give meaning to the utterance. For example, the statement "*The young fisherman caught a swordfish*" would be divided into simple propositions (e.g., *there was a fisherman, the fisherman was young, there was a swordfish,* and *the fisherman obtained the swordfish*) and the sentence could be recalled word-for-word by referencing the verbatim representation or its gist could be recalled by reconstruction of the propositions (e.g., *"A swordfish was caught by a fisherman who was young."*).

The most complex representation, however, is the *situational representation*, or situation model, which consists of the state of affairs described by the utterance. The situation model integrates the propositional representation with general world knowledge to add additional inferred meaning not explicitly provided by an utterance (Johnson-Laird, 1983; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). For the previous example,

the situation model might include information about the event occurring in the ocean, on a boat, during the day time, and that the fisherman was using a fishing rod rather than a net, or a spear-gun, or his hands. None of this information is actually transmitted by the utterance, but the comprehender may assume many details based on their world knowledge (e.g., swordfish are saltwater fish).

Within a given discourse (e.g., a conversation, article, novel, etc.), the comprehender must continually update and attempt to maintain a coherent situation model, or set of situation models (Kaup, Lüdtke, & Zwaan, 2007). Memory and attention are limited resources, so as the topic of a discourse shifts, so too does the accessibility or activation of the various elements within the representation. Focused concepts become more highly activated, while older or less relevant concepts become less active (Glenberg, Meyer, & Lindem, 1987). Maintaining the appropriate activation levels for concepts is essential for determining how new information fits into the situation model.

Negation (e.g., *no, not*) poses an interesting problem for the construction of these situation models; specifically, how do we represent a concept that has been negated (e.g., the car in *Joe has no car*)? The concept could be present in the representation, as if the negation had not occurred, but this is unlikely if we assume that negation serves a purpose (e.g., Giora, Balaban, Fein, & Alkabetz, 2005; Giora, Fein, Metuki, & Stern, 2010; Greene, 1970). The meaning of *Joe has a car* and *Joe has no car* are clearly different, and the situation model should somehow reflect that difference. Alternatively, the concept could be completely absent from the representation as if it had not been mentioned. However, there is evidence that negated concepts can be referred to anaphorically (e.g., *Joe has no car. It was totaled last week*), suggesting that the negated concept is at least somewhat active and available for referential purposes (Cook,

Myers, & O'Brien, 2005; Levine & Hagaman, 2008; Shuval & Hemforth, 2008). Therefore, the most likely explanation is that negated concepts are present in the representation but somehow marked as having been negated. What then is the effect of signaling a concept as negated? For the purposes of the present experiments, I will be focusing on the negation of entities (i.e., nouns) rather than properties or actions. Properties, in particular, may be processed quite differently from entities because they often have a clear opposite (e.g., *not dirty = clean*) whereas entities typically do not.

Research on the activation level of negated concepts has repeatedly produced two seemingly incompatible results. Some studies have shown that the mental representations of negated concepts are less active than non-negated concepts (e.g., MacDonald & Just, 1989), suggesting that negation reduces activation. However, more recent studies have found that negated concepts are represented at roughly the same level of activation as non-negated concepts (e.g., Autry & Levine, 2012, in press), suggesting that negation does not reduce activation. In this paper, I provide a brief review of these studies, followed by a theoretical explanation for why these discrepant results may have emerged, and an empirical test of context's role in the effect of negation on the activation levels of concepts.

The traditional view of negation as a linguistic operator that reduces the mental activation of a concept (Greene, 1970; Johnson-Laird & Tridgell, 1972), referred to here as the *reduced activation view*, is supported by a number of studies that measured the activation level of negated concepts following sentences containing a negation. In an early study (MacDonald & Just, 1989), subjects read sentences with or without a negated concept (e.g., *Elizabeth baked bread and cookies for the children*; *Elizabeth baked bread but no cookies for the children*) followed immediately by a probe (e.g., *cookies*) naming or recognition task. On both measures, a negation

effect emerged: subjects were slower to respond to concepts when they had been negated compared to when they had been non-negated, supporting the reduced activation view. In a similar study (Kaup, 2001), subjects read multi-sentence passages in which the penultimate sentence included a negation (e.g., *Sarah is now building a chair but not a table for her uncle*[1]). Each passage was followed by a probe recognition task 2500 ms after the final sentence. Consistent with the reduced activation view, response times were longer for negated concepts than for non-negated concepts. Furthermore, the presence of a negation effect after such a delay suggests that the reduced activation persists across time.

Cook et al. (2005) found evidence for a negation effect after an even longer delay. In this study, the negation (e.g., *Terry knew she could not afford to buy the cello*) occurred near the middle of an approximately 15-sentence passage. Reading time was measured on the final sentence, which included an anaphoric reference to the target concept (e.g., *Jill asked what instrument she bought*). Subjects also completed probe recognition and naming tasks 500 ms after the end of the passages. Two important results emerged from this design. First, subjects read the final sentence slower when the target concept had been negated than when it had been non-negated. This effect is presumably the result of increased difficulty resolving the anaphor in the negated condition, suggesting that the antecedent (i.e., the negated concept) was less active.[2] Second, subjects responded to recognition and naming probes more slowly when the concept was negated, providing more direct evidence that the negated concepts were less active than non-

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[1] This is translated from the original German.
[2] However, this finding also suggests that the negated concepts were considered during anaphor resolution. So although the activation level of concepts appears to be reduced by negation, it does not completely eliminate the concept from the subjects' mental representations.

negated concepts. The increased distance between the negation and the measurement of the concepts' activation provides even stronger evidence that the negated concepts maintain their reduced level of activation.

Further evidence in support of the reduced activation view was provided by Hasson and Glucksberg (2006), who had subjects read positive and negative metaphors (e.g., *The train to Boston was a/no rocket*) along with neutral metaphors that served as a control. The metaphors were followed by a lexical decision task that presented the affirmative meaning of the metaphor's vehicle (e.g., *fast*) or the negative meaning of the vehicle (e.g., *slow*) either 150, 500, or 1000 ms after the end of the sentence. The comparison of most interest here is the reaction times to the affirmative meaning following the negative metaphors at the three delays; in this case, the probe word is consistent with the counterfactual meaning of the metaphor rather than the intended meaning of the metaphor. Responses to the affirmative meaning of the metaphor (e.g., *fast*) were facilitated relative to the neutral metaphor following the negative metaphor at the early delays of 150 and 500 ms; however, at the 1000 ms delay, the affirmative meaning was no longer facilitated. Consistent with MacDonald and Just (1989), Kaup (2001), and Cook et al. (2005), this result suggests that the affirmative meaning of a negated concept will eventually be reduced in activation. Although the reduction was not immediate in this study, it is possible that the processing of metaphors may take more time than the processing of literal expressions due to the need to process both the literal and non-literal meaning of the metaphor (Giora, 1997).

Despite the many studies which show evidence of negated concepts being less active than non-negated concepts, there are a few studies which provide evidence of equally active negated concepts, referred to here as the *equal activation view*. For example, Giora, Fein, Aschkenazi, and Alkabets-Zlozover (2007) modified Hasson and Glucksberg's (2006) materials by adding a

context sentence after the metaphor. These contexts were either coherent, meaning they stayed on the same topic as the metaphor (e.g., *The train to Boston was no rocket. The trip to the city was fast though*), or incoherent, meaning they shifted to a new topic (e.g., *The train to Boston was no rocket. The old man in the film spoke fast though*). Subjects' reading times were recorded on the target concept (e.g., the word *fast* in the late context). Inconsistent with the reduced activation view, subjects read the target concept faster in the coherent strings than in the incoherent strings, suggesting that when the late context made the previously presented material remain relevant, the concepts maintained their activation regardless of negation. However, this finding should be interpreted with caution because incoherence likely affects reading time independent of the relevance of the target word.

Stronger support for the equal activation view was provided by Levine and Hagaman (2008). In this study, subjects read short passages that introduced a negated and non-negated concept from the same taxonomic category (e.g., *Justin bought a mango but not a pineapple*). The negation sentence either appeared on its own (i.e., the no reference condition) or was followed by an anaphor sentence (i.e., the reference condition) which referred to the non-negated concept using a categorical anaphor (e.g., *He ate the fruit*). After reading all of the passages, subjects were given a surprise cued-recall task (e.g., "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?"). Within the no reference condition, subjects recalled negated and non-negated concepts equally often, providing no evidence that negated concepts were less active. More importantly, negated concepts in the reference condition were recalled significantly more often than non-referenced, non-negated concepts. The finding that negated concepts increased in activation even when the reference was to the non-negated concept suggests that the negated concepts were

being considered during anaphor resolution. These results not only demonstrate a situation where negated concepts have an advantage over non-negated concepts, they also show that negated concepts must be maintaining some degree of activation in order to be considered as a possible antecedent.

Additional evidence that negated concepts are considered during anaphor resolution was presented by Shuval and Hemforth (2008). In this study, subjects read sentence pairs in which the first sentence introduced a negated and a non-negated concept (e.g., *You're going to buy a motorcycle, not a convertible, this year before summer*) and the second sentence unambiguously[3] referred to either the negated concept (e.g., *It can be rented during the vacation*) or the non-negated concept (e.g., *It can be driven during the vacation*). There were no differences in reading times on the second sentence regardless of whether it was referring to the negated or non-negated concept, suggesting that both concepts were equally active and available as antecedents for the pronoun.

The studies reviewed here demonstrate the inconsistent results obtained in studies of the mental representation of negated concepts. Recent work, however, has provided a possible explanation for the different patterns of activation for negated concepts by taking into account the context of the negation, specifically whether the discourse licenses the use of negation, a notion discussed in more detail below.

A common use of negation is to cancel or deny an existing presupposition (i.e., an implicit assumption or background belief). For example, the statement "Michael no longer drives" presupposes that Michael once drove. Encountering negation therefore initiates a process

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[3] The materials in Shuval and Hemforth (2008) were presented in French and the two concepts were always of different grammatical gender. Therefore the pronoun "It" in the second sentence was unambiguous because of its gender marking.

to select a relevant presupposition to deny. According to the pragmatic-inference hypothesis (Levine & Hagaman, 2008), the degree to which a relevant presupposition is available in the discourse or general world knowledge will affect the relative difficulty of processing a negation. In the case of *licensed negation*, when a relevant presupposition is highly available, the necessary processing should be relatively easy (i.e., the presupposition may be explicitly mentioned in the prior discourse or may require a simple inference). However, in the case of *unlicensed negation*, when a relevant presupposition is not readily available, additional processing is necessary to generate a presupposition that would justify the use of the negation, making the overall processing and integration into the situation model more difficult.

For example, in the context of choosing players for a basketball team, the statement *Richard is not tall* is relevant because height is well-known to be an important component of playing ability. The comprehender should be able to quickly and easily relate this statement to the presupposition that good basketball players are usually tall. But in the same context of choosing players for a basketball team, the statement *Richard is not rich* would be relatively more difficult to comprehend. The comprehender would have to engage in some additional processing to determine the statement's relevance to the discourse, for example, that a wealthy player might be able to spend more time practicing or would have access to better equipment. Outside of any context, both *Richard is not tall* and *Richard is not rich* would be even more difficult. Without an identifiable reason for the negation, the comprehender is left with an infinite number of possible presuppositions being denied and no information aside from probability to guide the selection of the correct one.

Another way of conceptualizing this difference in difficulty relies on the concept of questions under discussion (i.e., QUDs), an approach which views discourse as a series of

questions and answers (Clifton & Frazier, 2012; Roberts, 2004). These questions may be raised either explicitly or implicitly, but once accepted by all parties involved in the discourse, the question or set of questions becomes the likely topic of discourse. The relevance of further comments is then based on how well they address the current QUD. For example, the statement "*I am hungry*" would narrow a conversation down to several possible QUDs, such as "*What do you want to eat?*" or "*Why are you hungry?*" Statements that address these implicit QUDs, such as "*Let's go to a restaurant,*" would be easily integrated into the discourse representation, but a statement that departs from the likely QUDs, such as "*Let's book a flight,*" would require the comprehender to find an alternative QUD that is being answered. From this perspective, processing a negation is more difficult when it is unlicensed than when it is licensed, because it does not address a current QUD.

These differences in difficulty should consequently lead to differences in activation for negated concepts in licensing and non-licensing contexts. More difficulty with unlicensed negation means more time spent processing. Because processing a relevant presupposition (or QUD) necessarily includes the concept being negated, it should increase the concept's activation such that it is no less active than it if had been non-negated, or perhaps even more active (Autry & Levine, 2012), depending on the amount of additional processing required. This effect is similar to that described in the ironic processing literature, where the activation of a concept has been shown to increase when people are instructed not to think about it (Wegner & Erber, 1992; Wegner, Schneider, Carter, & White, 1987).

The prediction that unlicensed negation results in equal activation of a negated concept is supported by the results of Autry and Levine (in press), in which the activation level of unlicensed negated concepts was measured while systematically varying the delay between the

end of a sentence containing negation and a probe recognition task (see Table 1). Subjects first read a negation sentence that negated one of two direct objects and then read a second sentence which was presented word by word at a fixed pace so that the probe words could appear at varying delays following the negation sentence: before the first word of the second sentence, after the second word of the second sentence, or after the third word of the second sentence. When the probe task occurred immediately after the negation sentence, a negation effect occurred such that subjects responded faster to the concept when it was non-negated than when it was negated. However, when the probe task occurred two or three words into the second sentence, the negation effect was no longer present. Furthermore, subjects responded more quickly to negated concepts as the delay between the negation sentence and the probe task increased, suggesting that the concepts were gradually increasing in activation as time went on. These results suggest that activation of negated concepts is initially reduced in non-licensing contexts; however, the presupposition processing that occurs for unlicensed negation then reactivates the negated concepts such that they are no less active than if they had been non-negated.

This evidence for a short-lived reduction in activation of negation concepts is inconsistent with the previously discussed studies which demonstrated a relatively long-term reduction in activation. Autry and Levine (in press) found that the negation effect was gone as early as 500 ms after the negation sentence, whereas Kaup (2001) found a negation effect 2.5 seconds after the negation sentence, and Cook et al. (2005) found a negation effect after seven intervening sentences. The most substantial difference between these experiments is the context in which the negation sentences occurred. Autry and Levine (in press) presented the negation sentences in isolation, but both Kaup (2001) and Cook et al. (2005) embedded the negation sentences in much

larger contexts, ranging from approximately 8 - 15 sentences. Although the negation of the target concept was not particularly licensed by the contexts (i.e., the presence of the concept was not implied prior to the negation), it is possible that the longer contexts led to a richer discourse representation which made the presupposition processing less difficult. Easing the presupposition search should reduce the amount of reactivation the negated concept receives, allowing the negation effect to persist. This explanation is consistent with the pragmatic-inference hypothesis, in that the amount of presupposition processing affects the activation level of the negated concept.

Experimental evidence has also supported the hypothesis that licensing is the factor responsible for the different activation levels of negated concepts. Autry and Levine (2012) provided subjects with short passages which either licensed a negation via explicit mention or not (see Table 2). Subjects wrote a one-sentence continuation of the passage, and these continuations were coded for reference to the negated and non-negated concepts in the passage. The results showed that in the non-licensing condition, subjects were more likely to write about the negated concept than the non-negated concepts, but in the licensing condition, subjects wrote about the two concepts about equally often. This suggests that the negated concepts had a higher level of activation relative to the non-negated concept when the negation was unlicensed than when it was licensed. However, this finding should be interpreted with caution because the licensing context involved prior mention of the negated concept. This should have caused the concept to have a higher baseline activation in the licensing condition than in the non-licensing condition, which complicates the comparison across the two conditions. Furthermore, the continuation methodology is an offline measure of production, which may not provide a

completely accurate reflection of the activation level of the concepts during (as opposed to after) reading.

Experiment 3 of Autry and Levine (in press) avoided these limitations with an online comparison of the effects of licensing. In this experiment, licensing of the single-sentence materials from Experiments 1 and 2 (e.g., *Every Friday, Tina prepared a lecture but not an activity for her students*) was manipulated by preceding them with a context sentence that provided a reason why the negated entity was not (cf. Moxey & Sanford, 1986) created, obtained, etc. (e.g., *When she had time, Tina liked to give her students something fun to do*) or no context at all. Following a sentence which did not provide a reason why the negated entity was mentioned, the negated entity was re-mentioned (e.g., *Preparing an activity for her students …*) and reading time was measured on the part of the sentence that included the second mention (see Table 3 for a full sample passage). Consistent with Autry and Levine (2012), a negation effect emerged in the licensing condition, but not in the non-licensing condition, further supporting the hypothesis that licensing is the factor responsible for the variable activation of negated concepts.

To summarize, negation provides a unique situation for investigating the construction of situation models. The negated concept must exist within the representation while preserving the information provided by the negation indicating absence or falseness, and it is therefore unclear how active the concept would be in the situation model. The existing research on the activation level of negated concepts has produced contradictory findings, supporting both the reduced and equal activation views; however, the pragmatic-inference hypothesis predicts that context may account for the variation in activation levels that has been observed such that negation should reduce a concept's activation only when the negation is licensed.

The purpose of the present experiments was to directly test the predictions of the pragmatic-inference hypothesis by comparing the activation levels of negated concepts in licensing and non-licensing contexts, while avoiding the problems associated with Autry and Levine's (2012) research. The licensing conditions in the following experiments were designed such that the target concept was implied, but not explicitly mentioned (cf. McKoon & Ratcliff, 1989a). For example, the target concept *apple* was implied by the use of the phrase *traditional American pie*. By not explicitly mentioning the target concept in the licensing condition, the concept's activation level was able to be measured by a probe task without being influenced by prior mention of the concept. In Experiment 1, subjects completed a lexical decision task following two-sentence passages to determine whether the activation of the concepts differed between the licensing and non-licensing contexts. It was essential that the licensing context led to a higher level of activation of the target concept than the non-licensing context in order for the context manipulation to be useful in Experiment 2. In Experiment 2, a third sentence (i.e., the target sentence) was added to each passage that negated the target concept or not. The lexical decision task occurred both before and after the target sentence to measure how licensing modifies the effect of negation on a concept's activation level, and reading time was measured on the target sentence. It was expected that reaction times to the pre-target sentence probe would replicate the results of Experiment 1. More importantly, in the licensing condition, reaction times following the target sentence were expected to be slower when the target concept was negated compared to when it was non-negated. However, in the non-licensing condition, reaction times were expected to be no different when the target concept was negated compared to when it was non-negated. In addition, target sentence reading times were expected to be longer in the non-

licensing condition than in the licensing condition due to the increased processing predicted for unlicensed negation.

Experiment 1

Experiment 1 was designed to measure the activation level of unmentioned target concepts in licensing and non-licensing contexts and to verify that the licensing contexts to be used in Experiment 2 lead to the target being reliably inferred. That readers will do this has been shown by McKoon and Ratcliff (1989a), who demonstrated that readers reliably infer highly-typical category exemplars when there is a strong semantic association between the exemplar and the text (e.g., *orange* when breakfast juice is mentioned). Subjects in the current experiment read two-sentence passages (see Table 4) in which a target concept (e.g., *apples*) was either implied or not and then completed a lexical decision task to measure the activation level of the target concept. It was expected that subjects would show evidence of greater activation for the target concept when it was implied by the context than when it was not. This finding would suggest that the licensing contexts caused subjects to infer the concept to a greater degree than the non-licensing contexts.

Method

Subjects. Sixty-five students enrolled in a general psychology course at the University of Arkansas participated in the experiment to partially fulfill a research requirement and all were native-English speakers.

Materials and design. Subjects read 60 two-sentence passages (24 experimental and 36 fillers; see Table 3 for a sample passage and Appendix A for a full list of experimental passages). Each experimental passage was two sentence in length and occurred in one of two conditions:

licensing or non-licensing. In the licensing condition, the first sentence strongly implied[4] the target concept (e.g., *apples*) without explicitly mentioning it. In the non-licensing condition, the context sentence very weakly implied the target concept, if at all. Although the non-licensing context was designed not to imply the target concept, it is likely that at least some amount of activation spread from *cake* to other foods such as *apples*, in the same way that *cake* might activate related concepts like *candles*, *birthday parties*, and *ice cream*. Therefore, the claim being made is that the target concept is more strongly implied in the licensing condition than in the non-licensing condition. The second sentence ended with a categorical label which names the target concept's taxonomic category (e.g., *fruit*) and was the same across conditions. The filler passages were similar in form to the experimental passages with various modifications to mask the experimental manipulation. Subjects saw half of the experimental passages in each of the licensing conditions along with all filler sentences. Two counterbalanced lists were created such that half of the experimental passages in each list were of each licensing condition, to allow the target concepts to serve as their own control when comparing activation following licensing and non-licensing contexts.

Each passage was followed by a lexical decision task in which subjects were shown a string of letters and indicated whether the string was a real word or not. For the experimental passages, the letter string for the task was always be the target concept (e.g., *apples*), which required a "yes" response; therefore, a majority of the filler passages included non-word letter

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[4] A norming test was conducted to determine the degree to which the contexts implied the target concepts. Thirty-three subjects were recruited via Mechanical Turk and were asked to list the top three concepts that came to mind when presented with questions containing the critical phrases of the experimenter-generated licensing contexts (e.g., What fruit is used in a traditional American pie?). Only contexts which resulted in more than 90% of subjects responding with the target concept as their first answer were included in the experiment. Furthermore, the non-target concept was selected based on the criteria that no subjects listed it among their top three answers.

strings (e.g., *agglim*) requiring a "no" response such that there were an equal number of "yes" and "no" responses expected across all 60 passages. In addition, each passage had a corresponding comprehension question (e.g., *Did Cecilia bake an apple pie?*) with an equal number of "yes" and "no" responses across all 60 passages.

      Procedure. Before beginning the main experiment, subjects completed three practice tasks. The first practice task familiarized subjects with the yes/no response keys. The word "YES" or "NO" appeared in the center of a computer monitor and subjects responded using the left and right arrow keys on a standard keyboard, labeled "Y" and "N" for "yes" and "no," respectively. If subjects responded correctly, the word "CORRECT" appeared in the center of the screen for 500 ms before initiating the next trial, but if the subjects responded incorrectly, the word "INCORRECT" appeared in the center of the screen for 4000 ms before initiating the next trial to encourage accurate responding. The same feedback method was used for each of the three practice tasks. The second practice task familiarized subjects with the comprehension task in the main experiment. Subjects read two sentences presented one at a time followed by a yes/no question about the sentences and responded using the yes/no response keys. The third practice task familiarized subjects with the lexical decision task in the main experiment. A string of capital letters (4-9 characters in length) appeared in the center of the screen and subjects were instructed to indicate whether the letter string was a word in the English language or not using the yes/no response keys. After completing the three practice tasks, subjects began the main experiment, which did not include feedback about response accuracy.

      At the beginning of each trial in the main experiment, a fixation cross appeared left-justified 15% of the way from the left and halfway down the screen. Pressing the spacebar presented the first context sentence such that the first word appeared in the same location

previously occupied by the fixation cross. Pressing the spacebar again removed the first context sentence from the screen and replaced it with the second context sentence. Pressing the spacebar again removed the second context sentence from the screen and advanced the subjects to the lexical decision task. A string of capital letters (4-9 characters in length) appeared in the center of the screen 500 ms after the subject signaled that they had finished reading the passage. The letter string remained on the screen until the subject responded using the yes/no response keys to indicate whether the letter string is a word. Pressing one of the response keys removed the letter string from the screen and replaced it with the comprehension question. Subjects again used the yes/no response keys to respond to the comprehension question, which removed the comprehension question from the screen and replaced it with the fixation cross to signal the beginning of the next trial. The experiment took less than 30 minutes to complete.

Results

Data exclusion and general analytic considerations. The data from 7 subjects were excluded from further analysis due to having less than 70% lexical decision accuracy, exceptionally fast or slow mean lexical decision times, or exceptionally fast mean reading times. Therefore, the reported analyses included 58 subjects and 24 items. For all experiments reported in this paper, subject and item condition means were analyzed separately; a subscript of 1 indicates that subjects were treated as a random variable, whereas a subscript of 2 indicates that items were treated as a random variable. For all significance tests, an alpha level of .05 was used and all reported effect size measures were based on the subjects analysis.

Lexical decision reaction times and accuracy. Only correct lexical decisions from experimental passages that were greater than 300 and less than 3000 ms were included in the analysis. Additionally, for each subject, relative outliers were identified within each condition

using the procedure recommended by Tukey (1977). These procedures resulted in the removal of 11% of the total correct responses. Mean lexical decision times and accuracy are presented in Table 5. A paired-samples t-test of the lexical decision response times revealed a marginally significant difference between the licensing and non-licensing conditions in the subjects analysis, $t_1(57) = 1.77$, $p = .08$, $d = 0.13$, but not in the items analysis, $t_2(23) = 0.41$, $p = .69$, with faster responses in the licensing context than in the non-licensing context. Additionally, a paired-samples t-test of accuracy revealed a non-significant difference between the licensing conditions, $t_1(64) = 1.33$, $p = .19$, $t_2(23) = 1.74$, $p = .10$, although accuracy was slightly higher in the licensing context than in the non-licensing context.

Discussion

The faster lexical decision times in the licensing condition provide preliminary evidence that subjects were in fact inferring the target concept more than in the non-licensing condition. The 30 ms difference in response times suggests that the licensing context made the target concept slightly more active than the non-licensing context, and thus, subjects were able to respond to it more quickly. Although the effect was non-significant in this experiment, it seems to be reliable given that the same pattern of results appeared in the subset of Experiment 2 that replicated this manipulation. Accuracy was essentially at ceiling and therefore no differences emerged between licensing conditions. Given that the contexts appeared to be implying the target concept (or not) as intended, the paradigm was expanded in Experiment 2 by including a target sentence in which the negation of the target concept was manipulated and by manipulating the position of the lexical decision task.

Experiment 2

Experiment 2 was designed to directly assess the effect of licensing on the activation

level of negated concepts. Subjects read the same two-sentence contexts from Experiment 1 with

an additional third, target sentence appended (e.g., *Cecilia bought* [*peaches but not apples* / *not

peaches but apples*] *for the dessert*) that presented the target concept (see Table 6). The target

sentence always negated one of the two concepts, but manipulated which concept was negated so

that the target concept appeared either negated or non-negated. Reading time was measured on

the target sentence to provide an index of processing difficulty, and subjects also completed a

lexical decision task either before the target sentence to assess the effectiveness of the licensing

context, providing a replication of Experiment 1, or after the target sentence, to measure the

effect of the negation on the target concepts' activation. Therefore, in contrast to Experiment 1 in

which the target concepts were unmentioned and only licensing was manipulated, Experiment 2

also measured the activation level of explicitly mentioned target concepts as a function of both

licensing and negation.

When the lexical decision task was presented prior to the target sentence, it was expected

that the target concepts would show evidence of a higher level of activation (i.e., shorter lexical

decision times) in the licensing context than in the non-licensing context, demonstrating that the

licensing contexts had implied the target concepts more than the non-licensing contexts; this is

simply a replication of Experiment 1. When the lexical decision task was presented after the

target sentence, it was expected that a negation effect (i.e., longer lexical decision times for

negated concepts than for non-negated concepts; cf. MacDonald & Just, 1989) would emerge in

the licensing contexts but not in the non-licensing contexts. The negation effect should only

appear in the licensing contexts because unlicensed negation initiates a search process to locate a

relevant presupposition to deny, a process which occurs to a much lesser extent for licensed negation. This increased processing involving the negated concept in non-licensing contexts should therefore lead to increased activation of the concept such that it is no less active than when it is non-negated. This pattern of results would suggest that the activation level of negated concepts depends on the context in which the negation occurs.

Furthermore, it was expected that when the target concept was negated, subjects would show evidence of greater processing on the target sentence (i.e., longer reading times) when the negation was unlicensed than when the negation was licensed. This should occur because the presupposition search is more difficult when the negation is unlicensed, and should therefore lead to longer reading times in the non-licensing contexts than in the licensing contexts where the presupposition processing is easier. This pattern of results would verify that there is a difference in the amount of presupposition processing that occurs for licensed and unlicensed negation, supporting the presupposition processing explanation for the equal activation levels of negated and non-negated concepts. In addition, because the negation of the alternative concept was always unlicensed[5], no processing differences were expected on the target sentence (i.e., equal reading times) when the target concept was non-negated.

Method

Subjects. Seventy-four students enrolled in a general psychology course at the University of Arkansas participated in the experiment to partially fulfill a research requirement and all were native-English speakers. None of these subjects participated in Experiment 1.

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[5] The licensing contexts were designed to license the negation of the target concept only, so the negation of the alternative concept is unlicensed in both contexts.

Materials and design. Subjects read 60 three-sentence passages modified from

Experiment 1 (24 experimental and 36 fillers; see Table 5 and Appendix A). As in Experiment 1,

the first context sentence appeared in either the licensing condition (e.g., *For the annual bake*

sale, Cecilia wanted to bake a traditional American pie) or non-licensing condition (e.g., *For the*

annual bake sale, Cecilia wanted to bake a delicious tasting cake) and the second sentence was

identical across conditions (e.g., *Before she started cooking, she went to the store to pick up the*

fruit). Each passage was also appended with a target sentence that presented the target concept

(e.g., *apples*) and an alternative concept from the same category (e.g., *peaches*) in one of two

conditions. In the target negated condition, the target concept was negated and the alternative

concept was non-negated (e.g., *Cecilia bought peaches but not apples*). In the target non-negated

condition, the target concept was non-negated and the alternative concept was negated (e.g.,

Cecilia bought not peaches but apples). The inclusion of the alternative concept was necessary

because with only one direct object the negation would negate the verb rather than the noun (e.g.,

Cecilia did not buy apples) or would require an unnatural sentence structure (e.g., *Cecilia bought*

not apples). The alternative concept allowed the negation operator (i.e., *not*) to appear more

naturally with the direct object, consistent with previous research[6]. In either condition, negation

always occurred in the experimental target sentences and the target concept was always the

second direct object.

The filler passages were similar in form to the experimental passages with various

modifications to mask the experimental manipulation. Because the target sentence of the

experimental passages negated the implied target concept half the time, most of the filler

passages presented implied concepts without negation. Additionally, the number of concepts and

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[6] However, I acknowledge that the "not X but Y" structure is still not entirely natural.

presence of negation was varied (non-systematically) in the filler target sentences to avoid drawing too much attention to the target sentences.

Each passage also included a lexical decision task. For the experimental passages, the letter string for the task was always the target concept (e.g., *APPLES*), which required a "yes" response; therefore, a majority of the filler passages included non-word letter strings (e.g., *AGGLIM*) requiring a "no" response such that there were an equal number of "yes" and "no" responses expected across all 60 passages. In addition, the lexical decision task occurred either before the target sentence or after the target sentence, manipulated between subjects.

Each passage also had a corresponding comprehension question. For experimental passages, the comprehension questions measured whether subjects correctly comprehended the violated expectation. For filler passages, the comprehension questions were about other aspects of the sentences. Across all 60 passages, there were an equal number of "yes" and "no" responses.

Subjects saw the experimental passages in one of four conditions, along with all filler sentences. Eight lists of experimental passages were created to fully counterbalance the licensing, probe position, and negation variables within subjects. As in Experiment 1, this allowed the target concepts to serve as their own control in the comparison of negated vs. non-negated concepts in the licensing and non-licensing conditions for both pre-negation and post-negation trials. The manipulation of the factors of theoretical interest in the experiment resulted in a design that was 2 (context: licensing, non-licensing) × 2 (negation: negated, non-negated) × 2 (probe position: pre-target sentence, post-target sentence), with the latter being manipulated between subjects.

Procedure. The procedure of Experiment 2 was similar to that of Experiment 1. Subjects completed the same set of three practice sessions and used the spacebar to advance from sentence to sentence. A third, target sentence was appended to each of the passages used in Experiment 1. For subjects in the pre-target sentence condition, the lexical decision task was presented between the second context sentence and the target sentence. After subjects responded to the probe word, the target sentence was presented, followed by a comprehension question. For subjects in the post-target sentence condition, the lexical decision task was presented after the third sentence. After the subjects responded to the probe word, a comprehension question was presented. The experiment took less than 40 minutes to complete.

Results

Data exclusion and analytic considerations. Data from six subjects were excluded from analysis for having mean reading times less than 50 ms per character, from five subjects for having particularly fast or slow probe reaction times, and from two subjects for having less than 70% comprehension accuracy, resulting in the exclusion of 13 total subjects. Therefore, the reported analyses included 61 subjects and 24 items. The negation variable was only relevant for lexical decisions that occurred after the target sentence due to the manipulation of negation occurring in the target sentence; therefore separate lexical decision analyses were conducted for the pre-target sentence and post-target sentence trials. Additionally, trials in which the lexical decision task occurred before the target sentence were excluded from the reading time analysis because in these trials the target concept was presented before it was read in the target sentence, thus affecting target sentence reading times in a theoretically uninteresting way (see Appendix B for an analysis of these excluded trials).

Pre-target sentence lexical decision reaction times and accuracy. Data were cleaned exactly as in Experiment 1, resulting in the removal of 7.6% of the total data. Mean lexical decision time and accuracy are presented in Table 7. Although responses were faster in the licensing condition compared to the non-licensing condition as in Experiment 1, a paired-samples t-test of the lexical decision response times revealed a non-significant effect of context, $t_1(27) = 1.32$, $p = .20$, $t_2(23) = 1.06$, p = .30. Additionally, a paired-samples t-test of accuracy also revealed a non-significant effect of context, $t_1(27) = 1.44$, $p = .16$, $t_2(23) = 1.00$, $p = .33$.

Because the difference in concept activation between the two licensing conditions is critical for the target sentence reading time and post-target sentence lexical decision time analyses, the pre-target sentence lexical decision times from Experiments 1 and 2 were analyzed together. Mean lexical decision times and accuracy for the combined analyses are presented in Table 8. A paired-samples t-test of the lexical decision response times revealed a significant effect of context, $t_1(85) = 2.58$, $p = .01$, $t_2(23) = 2.48$, $p = .02$, $d = 0.17$, with subjects responding faster in the licensing condition than in the non-licensing condition. This finding suggests that subjects were inferring the target concept more in the licensing condition than in the non-licensing condition. However, because accuracy was nearly perfect in both conditions, the paired-samples t-test of accuracy was still non-significant, $t_1(85) = 1.02$, $p = .31$, $t_2(23) = 1.23$, $p = .23$.

Post-target sentence lexical decision reaction times and accuracy. Only correct lexical decisions from experimental passages that were greater than 300 and less than 3000 ms were included in the analysis. Additionally, for each subject, relative outliers were identified within each condition using Tukey's procedure. This resulted in the removal of 8.7% of the total data. Mean lexical decision time and accuracy are presented in Table 9.

In general, accuracy was nearly perfect in all conditions, and subjects responded to the probe words faster when the target concept had been non-negated than when it had been negated. However, the negation effect was reduced from 98 ms in the non-licensing contexts to only 43 ms in the licensing contexts. A 2 (context: licensing, non-licensing) x 2 (negation: negated, non-negated) repeated measures ANOVA of the lexical decision response times revealed a non-significant interaction between licensing and negation, $F_1(1, 31) = 1.52$, $p = .23$, $F_2(1, 23) = 2.26$, $p = .15$. However, there was a significant main effect of negation in both analyses, $F_1(1, 31) = 5.82$, $p = .02$, $\eta_p^2 = .16$, $F_2(1, 23) = 8.99$, $p = .006$, with faster reaction times when the target was non-negated than when it was negated. There was also a significant main effect of licensing in the subject analysis, $F_1(1, 31) = 6.66$, $p = .02$, $\eta_p^2 = .18$, with faster reaction times in the licensing context than in the non-licensing context, but this effect was not significant the items analysis, $F_2(1, 23) = 2.43$, $p = .13$.

Paired-samples t-tests revealed that licensing did not have a significant effect on the non-negated concepts, $t_1(31) = 0.46$, $p = .646$, $t_2(23) = 0.20$, $p = .840$; however, subjects did respond significantly faster to negated concepts in the licensing condition than in the non-licensing condition in the subjects analysis, $t_1(31) = 2.11$, $p = .043$, $d = 0.23$, but not in the items analysis, $t_2(23) = 1.86$, $p = .076$. This finding suggests that licensing only has an influence on the activation of negated concepts, and that the target concepts were more active when the negation was licensed than when it was unlicensed, which is the opposite of what was predicted. Furthermore, subjects responded significantly slower to negated concepts than to non-negated concepts in the non-licensing condition, $t_1(31) = 2.59$, $p = .015$, $t_2(23) = 2.97$, $p = .007$, $d = 0.38$, but not in the licensing condition, $t_1(31) = 1.21$, $p = .24$, $t_2(23) = 1.44$, $p = .16$. This finding is

again opposite of what was predicted. Additionally, a 2 (licensing) x 2 (negation) repeated measures ANOVA of accuracy revealed no significant effects (all Fs < 1.83, all ps > .18).

Target sentence reading times. Only reading times that were greater than 500 ms and less than 7000 ms were included in the analysis. Additionally, for each subject, relative outliers were identified within each condition using Tukey's procedure. This resulted in the removal of 10.7% of the total data. Mean target sentence reading times are presented in Table 10.

In general, subjects read the target sentence faster when the target concept was negated than when it was non-negated and slightly faster in the non-licensing context than in the licensing context. A 2 (context: licensing, non-licensing) x 2 (negation: negated, non-negated) repeated measures ANOVA of reading time revealed a significant main effect of negation, $F_1(1, 32) = 23.65$, $p < .001$, $F_2(1, 23) = 17.99$, $p < .001$, with faster reading times when the target concept was negated than when it was non-negated. However, the main effect of licensing was not significant, $F_1(1, 32) = 0.76$, $p = .391$, $F_2(1, 23) = 1.13$, $p = .298$, nor was the interaction between licensing and negation, $F_1(1, 32) = 0.06$, $p = .806$, $F_2(1, 23) = 0.36$, $p = .557$.

Post-hoc paired-samples t-tests revealed significant differences between the negated and non-negated conditions in the non-licensing condition, $t_1(32) = 3.89$, $p < .001$, $t_2(23) = 3.27$, $p = .003$, as well as in the licensing condition, $t_1(32) = 3.96$, $p < .001$, $t_2(23) = 3.94$, $p = .001$. However, there were not significant differences between the licensing conditions in the non-negated condition, $t_1(32) = 0.86$, $p = .395$, $t_2(23) = 1.18$, $p = .251$, nor in the negated condition, $t_1(32) = 0.59$, $p = .558$, $t_2(23) = 0.41$, $p = .683$.

Discussion

In general, the results did not support the hypotheses. The means of the pre-target-sentence lexical decision analysis were consistent with Experiment 1, suggesting that subjects

were again inferring the target concept in the licensing condition which resulted in a higher level of activation for the target concept relative to the non-licensing condition and therefore faster responding. The post-target-sentence lexical decision times were counter to predictions: subjects responded to negated target concepts faster in the licensing condition than in the non-licensing condition. It was predicted that the non-licensing condition would initiate a presupposition search that would increase the activation level of the target concept; however, the target concept remained less active even when probed after the target sentence containing the negation.

Furthermore, it was predicted that when the target concept was negated, target sentence reading times would be greater in the non-licensing condition than in the licensing condition due to the construction of a relevant presupposition. Although the difference was non-significant, reading times on the target sentence were faster in the non-licensing condition than in the licensing condition, which is again opposite of what was predicted.

General Discussion

The purpose of the present experiments was to determine whether the inconsistent effects of negation on the activation level of concepts found in previous studies could be explained by the varying degree of presupposition processing that occurs for licensed and unlicensed negation. Because unlicensed negation does not clearly deny a particular presupposition, it was expected to require additional presupposition processing relative to licensed negation. This additional processing should then increase the activation of negated concepts, making them no less active than non-negated concepts. Such a finding would demonstrate that the activation level of negated concepts depends on whether they are properly licensed.

Despite evidence from both experiments that the licensing contexts did imply the target concepts more than the non-licensing contexts, Experiment 2 failed to find the predicted effect of

unlicensed negation. It was expected that the negated target concepts would be more active in the non-licensing context than in the licensing context due to the additional processing predicted by the pragmatic-inference hypothesis (Levine & Hagaman, 2008); however, this hypothesis was not supported.

Given that the predicted licensing effect was expected to occur because of additional activation resulting from presupposition processing only in the non-licensing context, there are several plausible explanations for the present results: (1) subjects engaged in presupposition processing equally in both the licensing and non-licensing contexts; (2) subjects engaged in a greater amount of presupposition processing in the non-licensing contexts, but it did not affect the activation level of the target concept; or (3) subjects did not engage in presupposition processing at all.

The first explanation, that presupposition processing occurs equally for licensed and unlicensed negation, is inconsistent with the pragmatic-inference hypothesis, which assumes that the amount of presupposition processing necessary to comprehend a statement is greater for unlicensed negation than for licensed negation. It is assumed that the target sentence (e.g., *Cecilia bought peaches but not apples for the dessert*) is easier to integrate into the discourse representation when the negation of the target concept is motivated by the expectation for the concept that arises from the licensing context (e.g., *For the annual bake sale, Cecilia wanted to bake a traditional American pie. Before she started cooking, she went to the store to pick up the fruit.*) compared to the non-licensing context (e.g., *For the annual bake sale, Cecilia wanted to bake a delicious tasting cake. Before she started cooking, she went to the store to pick up the fruit.*), in which there is a much weaker expectation for the target concept. It is further assumed that this difference in difficulty is the result of differences in the amount of presupposition

processing necessary to understand why the negation has been used. If, however, the amount of presupposition processing does not differ based on licensing, then any changes in activation would be constant and the pattern of activation seen after the negation would be expected to be the same as before negation (i.e., licensed concepts would be more active than unlicensed concepts), which is consistent with the present results.

If it is correct that subjects engaged in presupposition processing equally in both the licensing and non-licensing contexts, then there are two further possibilities to consider. First, it may be that a set amount of presupposition processing occurs regardless of how difficult it is to construct the presupposition (i.e., presupposition processing is so quick and efficient that the increased difficulty is irrelevant). So, although it is easier to integrate the negation of the target concept in the licensing context when the concept is expected, it may be only marginally more difficult in the non-licensing context to make the assumption that the target concept was expected and to integrate the negation accordingly. Second, it may be that the difference between the licensing contexts in the present materials was simply not large enough to cause a measurable increase in the activation level of the unlicensed concepts. Although it may have been more difficult to construct a relevant presupposition in the non-licensing contexts than in the licensing contexts, the difference may have been negligible. This leaves open the possibility that the predicted licensing effect could be found using a different set of materials in which a relevant presupposition is very difficult to construct in the non-licensing context.

The second explanation, that more presupposition processing occurs for unlicensed negation but does not affect activation, is also inconsistent with the pragmatic-inference hypothesis. Although this explanation and the pragmatic-inference hypothesis both assume that a greater amount of presupposition processing is necessary to comprehend unlicensed negation, the

lack of the predicted effect on the activation of the target concept is incompatible with the pragmatic-inference hypothesis which assumes that this greater processing should lead to an increase in activation for the negated concept. In contrast, this explanation assumes that increased presupposition processing has no effect on the negated concept's activation level. However, this explanation is rather unlikely given the well-established notion that processing increases the activation of related concepts, even when that processing is intended to be suppressive (Wegner & Erber, 1992). Therefore, if presupposition processing is in fact occurring, it would be surprising theoretically to find that it does not affect the activation level of concepts central to that processing.

The third explanation, that presupposition processing was not occurring, is the most congruent with the pragmatic-inference hypothesis. It is possible that upon reading the target sentence (e.g., *Cecilia bought peaches but not apples for the dessert*), subjects did not attempt to fully integrate the negation into the discourse representation. Understanding why the negation was used should be more difficult in the non-licensing context when there was no expectation of the negated concept; however, this difficulty is irrelevant if the subjects were not attempting to integrate the negation at all. Although subjects may not have been processing the presupposition that motivated the negation in the present study, this does not necessarily mean that the predicted processing would never occur. Instead, it is possible that the subjects were simply under-motivated and did not expend the effort necessary to fully comprehend the passages.

The idea that subjects were not making an inference about why the negation occurred is consistent with research demonstrating that some inferential processing is limited or optional. For example, elaborative inferences are not necessary to maintain coherence, so the likelihood of a reader spending the time and effort to draw the inference decreases as the difficulty of doing so

increases (McKoon & Ratcliff, 1989b, 1992). There is also evidence that readers do not always resolve anaphors, particularly when identifying the antecedent is difficult and not essential for maintaining coherence (Klin, Guzmán, Weingartner, & Ralano, 2006; Klin, Weingartner, Guzmán, & Levine, 2004; Levine, Guzmán, & Klin, 2000). These findings support the possibility that subjects in the present experiments chose not to understand why the unlicensed negation was occurring. If this is the case, then the present findings do not contradict the pragmatic-inference hypothesis because the effect of presupposition processing on the activation of negated concepts cannot be measured in the absence of any presupposition processing.

Given that the second explanation is theoretically unfounded, future research should attempt to distinguish between the first and third explanations by testing their predictions. A set of materials that make the presupposition very difficult to construct is necessary to test whether additional presupposition processing occurs for unlicensed negation relative to licensed negation. Furthermore, a more engaging procedure (e.g., more interesting passages, more in-depth comprehension questions, or special instructions) is necessary to test the prediction that subjects were opting not to construct the missing presupposition in the non-licensing contexts.

Finally, given that the predicted effects of licensing were not found, it is worth discussing whether the present materials did, in fact, license the negation in the target sentences. Licensing of negation has occurred in a variety of ways in the literature on negation comprehension. One method of licensing negation has been to introduce into a discourse two alternatives that are incompatible and later negating one (Glenberg et al., 1999; Johnson-Laird & Tridgell, 1972; Lea & Mulligan, 2002). For example, Glenberg et al. provided subjects with short passages that mentioned two alternatives that were under consideration (e.g., *She wasn't sure if a darkly colored couch would look the best or a lighter color*.) prior to a sentence that negated one of the

alternatives (e.g., *The couch wasn't black.*), which led to substantially easier processing than if the prior context did not mention the alternatives. Another method of licensing negation has been to negate what is expected, or the usual state of affairs (Wason, 1961). Wason found evidence that the exceptionality of a state of affairs made its negative easier to process. For example, if the train one takes every morning is usually late, the exceptional event of the train being on time is better described as *the train was not late* than if the train is usually on time. Both of these methods of licensing make the negations more informative (cf. Nieuwland & Kuperberg, 2008).

The licensing in the present experiments was modeled after the latter method. In the licensing contexts, the negation of the target concept was preceded by information implying the presence of the concept, such that subjects should be able to understand that the purpose of the negation was to deny this expectation. However, this technique was complicated by the fact that the present materials negated nouns rather than properties. Whereas properties often have readily available alternatives (e.g., an opposite, as in *tidy* and *messy*; cf. Mayo et al., 2004), the same is generally not true for nouns (e.g., *apple* does not have a clear opposite). This difference affects how informative the negation is. If someone says that their room is *not tidy*, it can be understood that the room is *messy*; however, if someone says that they have *no apples*, it remains unclear what they actually have, if anything at all. So, although the present materials implied the presence of the target concept in the licensing condition, the lack of a clear alternative leads the negation to remain underinformative. An alternative concept was provided in the target sentences (e.g., *Cecilia bought peaches but not apples for the dessert*), but the same amount of information would have been provided in the absence of the negation (e.g., *Cecilia bought peaches for the dessert*); therefore, the negation did not add any additional information to the sentence.

It is possible that the underinformative nature of negating concepts, rather than properties, made it such that presupposition processing was not simplified in the licensing condition as expected. This is similar to the first explanation provided earlier, that the licensing and non-licensing contexts lead to equal amounts of presupposition processing; however, here the assumption is being made that the licensing contexts did not actually license the negation. It may be that although the target concepts were implied more in the licensing contexts, this did not license the negation of the target concepts as intended. Future research should address this issue by conducting a similar manipulation with properties instead of nouns.

Conclusion

Although the hypotheses regarding the activation of negated concepts were not supported, it remains a possibility that an alternative set of materials could produce the predicted effect of licensing. If the unlicensed negation can be made particularly incongruous, or if subjects can be made to fully comprehend the passages, the predictions of the pragmatic-inference hypothesis may yet be supported. It is also possible, however, that the pragmatic-inference hypothesis is incorrect, and that the availability of a presupposition to deny does not have an effect on the activation level of negated concepts. The validity of the pragmatic-inference hypothesis and the licensing explanation for the varying activation levels of negated concepts therefore remain open questions in need of further research.

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Table 1. Sample Materials from Autry and Levine (in press)

Noun1 Negated	Every Friday, Tina prepared not a lecture but only an activity for her students. Usually during lunchtime, she would plan things out.
Noun2 Negated	Every Friday, Tina prepared a lecture but not an activity for her students. Usually during lunchtime, she would plan things out.
Noun1 Probe	LECTURE
Noun2 Probe	ACTIVITY

Table 2. Sample materials from Autry & Levine (2012)

Licensing Context	Justin regularly ate an apple after his morning exercise. He jogged and stopped at a store afterward.
Non-licensing Context	Justin got up early to exercise. He jogged and stopped at a store afterward.
Target Sentences	
AND	Justin bought a mango and an apple.
NOT	Justin bought a mango but not an apple.

Table 3. Sample experimental passage from Experiment 3.

Licensed Negation

When she had time, Tina liked to give / her students something fun to do. Every Friday Tina prepared / a lecture but not an activity for her students. She enjoyed / being a teacher. Preparing an activity for her students / would have to wait till she had more time.

Licensed No Negation

When she had time, Tina liked to give / her students something fun to do. Every Friday Tina prepared / a lecture and an activity for her students. She enjoyed / being a teacher. Preparing an activity for her students / made them much happier.

Unlicensed Negation

Every Friday Tina prepared / a lecture but not an activity for her students. She enjoyed / being a teacher. Preparing an activity for her students / would have to wait till she had more time.

Unlicensed No Negation

Every Friday Tina prepared / a lecture and an activity for her students. She enjoyed / being a teacher. Preparing an activity for her students / made them much happier.

Note. The /s indicate the points at which the sentences were split.

Table 4. Sample Passages from Experiment 1

	Experimental Passage
Licensing Context	For the annual bake sale, Cecilia wanted to bake a *traditional American pie*. Before she started cooking, she went to the store to pick up the fruit.
Non-Licensing Context	For the annual bake sale, Cecilia wanted to bake a *delicious tasting cake*. Before she started cooking, she went to the store to pick up the fruit.
Letter String	APPLES (YES)
Comprehension	Did Cecilia bake an apple pie? (NO)
	Filler Passage
Context	His first year in town, Travis went a little overboard for Christmas. When he finished shopping, the store was completely sold out of decorations.
Letter String	AGGLIM (NO)
Comprehension	Did Travis recently move to town? (YES)

Table 5. Experiment 1 mean lexical decision time and
accuracy with standard error

	Lexical Decision Time	Probe Accuracy
Non-licensing	808 (29.6)	.96 (.015)
Licensing	778 (28.9)	.97 (.012)

Table 6. Sample Passages from Experiment 2

	Experimental Passage
Licensing Context	For the annual bake sale, Cecilia wanted to bake a *traditional American pie*. Before she started cooking, she went to the store to pick up the fruit.
Non-Licensing Context	For the annual bake sale, Cecilia wanted to bake a *delicious tasting cake*. Before she started cooking, she went to the store to pick up the fruit.
Target Sentence	
Target Negated	Cecilia bought peaches but *not apples* for the dessert.
Target Non-negated	Cecilia bought not peaches but *apples* for the dessert.
Letter String	APPLES (YES)
Comprehension	Did Cecilia bake an apple pie? (NO)
	Filler Passage
Context	His first year in town, Travis went a little overboard for Christmas. When he finished shopping, the store was completely sold out of decorations.
Target Sentence	Travis hung the most lights in the whole neighborhood.
Letter String	AGGLIM (NO)
Comprehension	Did Travis recently move to town? (YES)

Table 7. Experiment 2 mean pre-target sentence lexical
decision time and accuracy with standard error

	Lexical Decision Time	Probe Accuracy
Non-licensing	881 (44.5)	1.00 (.003)
Licensing	842 (41.2)	0.99 (.007)

Table 8. Combined Experiment 1 and 2 mean pre-target
sentence lexical decision time and accuracy with standard error

	Lexical Decision Time	Probe Accuracy
Non-licensing	911 (36.3)	0.97 (.009)
Licensing	860 (27.5)	0.98 (.006)

Table 9. Experiment 2 mean post-target sentence lexical decision time and accuracy

	Lexical Decision Time		Probe Accuracy	
	Non-negated	Negated	Non-negated	Negated
Non-licensing	825 (34.1)	923 (54.1)	.99 (.007)	.99 (.007)
Licensing	815 (41.5)	858 (43.1)	1.00 (.000)	.98 (.011)

Table 10. Experiment 2 mean target sentence
reading times with standard error

	Non-negated	Negated
Non-licensing	3193 (111)	2828 (118)
Licensing	3298 (120)	2864 (101)

Appendix A

Full Set of Experimental Items

Passage 1	
Licensing Context	For the annual bake sale, Cecilia wanted to bake a traditional American pie. Before she started cooking, she went to the store to pick up the fruit.
Non-licensing Context	For the annual bake sale, Cecilia wanted to bake a delicious tasting cake. Before she started cooking, she went to the store to pick up the fruit.
Target Sentence	Cecilia bought (peaches but not apples/not peaches but apples) for the dessert.
Probe word	APPLES
Comprehension	Did Cecilia buy vegetables? (NO)

Passage 2	
Licensing Context	Maria called all of the children together to eat at her son's birthday party. She gave each child a plate for their food.
Non-licensing Context	Maria called all of the children together to eat at her son's baseball game. She gave each child a plate for their food.
Target Sentence	Maria served (pizza but not cake/not pizza but cake) to the children.
Probe word	CAKE
Comprehension	Did Maria serve adults? (NO)

Passage 3	
Licensing Context	Fancying himself a chef, Carl wanted to cook a huge feast for Thanksgiving. He paid special attention to pick the perfect bird.
Non-licensing Context	Fancying himself a chef, Carl wanted to cook a huge feast for his birthday. He paid special attention to pick the perfect bird.
Target Sentence	Carl served (chicken but not turkey/not chicken but turkey) at the meal.
Probe word	TURKEY
Comprehension	Did Carl like to cook? (YES)

Passage 4	
Licensing Context	Arnold went to the concession stand to buy something to eat during the movie premier. He was so hungry that he had trouble deciding on a snack.

Non-licensing Context	Arnold went to the concession stand to buy something to eat during the chess tournament. He was so hungry that he had trouble deciding on a snack.
Target Sentence	Arnold bought (nachos but not popcorn/not nachos but popcorn) to hold him until dinner.
Probe word	POPCORN
Comprehension	Did Arnold go to a concession stand? (YES)

Passage 5

Licensing Context	With the money he had been saving, Matt bought a ring for his fiancé. He asked his mother to help him select the stone.
Non-licensing Context	With the money he had been saving, Matt bought a ring for his secret crush. He asked his mother to help him select the stone.
Target Sentence	Matt chose (a ruby but not a diamond/not a ruby but a diamond) for the ring.
Probe word	DIAMOND
Comprehension	Did Matt chose the ring by himself? (NO)

Passage 6

Licensing Context	Marvin the Magnificent recited a spell as he pulled a surprise out of his hat. He had practiced for years to be able to conjure the animal.
Non-licensing Context	Marvin the Magnificent recited a spell as he pulled a surprise out of his sleeve. He had practiced for years to be able to conjure the animal.
Target Sentence	Marvin revealed (a dove but not a rabbit/not a dove but a rabbit) to the astonished crowd.
Probe word	RABBIT
Comprehension	Was Marvin an amateur? (NO)

Passage 7

Licensing Context	After graduating from high school, Anna considered moving to California to chase after her dream career. When she arrived, the first thing she did was look for a job.

Non-licensing Context	After graduating from high school, Anna considered moving to California to chase after her boyfriend. When she arrived, the first thing she did was look for a job.
Target Sentence	Anna was hired (as a model but not an actor/not as a model but an actor) after only a week of searching.
Probe word	ACTOR
Comprehension	Did Anna graduate high school? (YES)

Passage 8	
Licensing Context	In the summer, Joe liked to sit outside and observe the constellations. To peer into the sky, he only needed one tool.
Non-licensing Context	In the summer, Joe liked to sit outside and observe the weather. To peer into the sky, he only needed one tool.
Target Sentence	Joe used (his eyes but not a telescope/not his eyes but a telescope) to view the heavens.
Probe word	TELESCOPE
Comprehension	Did Joe like the outdoors? (YES)

Passage 9	
Licensing Context	The last time she visited the zoo, Carol was allowed to feed the hanging animals. She asked an animal trainer to give her the food.
Non-licensing Context	The last time she visited the zoo, Carol was allowed to feed the colorful birds. She asked an animal trainer to give her the food.
Target Sentence	Carol fed the animals (carrots but not bananas/not carrots but bananas) for their lunch.
Probe word	BANANAS
Comprehension	Did Carol own the animals? (NO)

Passage 10	
Licensing Context	For her first international assignment, Megan went to Egypt to write about the ancient monuments. She was just dying to see the famous tourist attractions.
Non-licensing Context	For her first international assignment, Megan went to Egypt to write about mummification. She was just dying to see the famous tourist attractions.

Target Sentence	Megan visited (the Sphynx but not the pyramids/not the Sphynx but the pyramids) on her first day there.
Probe word	PYRAMIDS
Comprehension	Did Megan visit Rome? (NO)

Passage 11	
Licensing Context	Robert loved to keep his mind sharp with stimulating puzzles. Every Sunday, he purchased a copy of the newspaper.
Non-licensing Context	Robert loved to keep his mind sharp with stimulating challenges. Every Sunday, he purchased a copy of the newspaper.
Target Sentence	Robert would complete (the Sudoku but not the crossword/not the sudoku but the crossword) before church.
Probe word	CROSSWORD
Comprehension	Did Robert buy the newspaper? (YES)

Passage 12	
Licensing Context	Ella's mouth was dry and she needed something to wash down her Oreos. She went to the kitchen to get a cold drink.
Non-licensing Context	Ella's mouth was dry and she needed something to wash down her dinner. She went to the kitchen to get a cold drink.
Target Sentence	Ella poured a glass (of juice but not milk/not of juice but milk) to whet her whistle.
Probe word	MILK
Comprehension	Did Ella go to the kitchen? (NO)

Passage 13	
Licensing Context	Thomas was known as an unbeatable deer hunter. When he went hunting, he only trusted the job to one weapon.
Non-licensing Context	Thomas was known as an unbeatable elephant hunter. When he went hunting, he only trusted the job to one weapon.
Target Sentence	Thomas used (a bow but not a rifle/not a bow but a rifle) as he always had.
Probe word	RIFLE

Comprehension   Did Thomas use many different weapons? (NO)

Passage 14	
Licensing Context	Before the long trip, Richard needed to fill up the tank on his car. He got to the refilling station and selected the proper fuel.
Non-licensing Context	Before the long trip, Richard needed to fill up the tank on his 18 wheeler. He got to the refilling station and selected the proper fuel.
Target Sentence	Richard topped off his vehicle (with diesel but not gasoline/not with diesel but gasoline) after paying.
Probe word	GASOLINE
Comprehension	Did Richard drive a motorcycle? (NO)

Passage 15	
Licensing Context	Daniel wanted to buy a new piece of furniture for his living room. He had trouble deciding on the right item.
Non-licensing Context	Daniel wanted to buy a new piece of furniture for his office. He had trouble deciding on the right item.
Target Sentence	Daniel bought (a recliner but not a couch/not a recliner but a couch) in the end.
Probe word	COUCH
Comprehension	Did Daniel want new furniture? (YES)

Passage 16	
Licensing Context	Chris was recently hired to replace a member of a famous heavy metal band. He was so excited about the new gig that he bought a brand new instrument.
Non-licensing Context	Chris was recently hired to replace a member of a famous orchestra. He was so excited about the new gig that he bought a brand new instrument.
Target Sentence	Chris became well-known for playing (the bass but not the guitar/not the bass but the guitar) in the band.
Probe word	GUITAR
Comprehension	Did Chris play in a band? (YES)

Passage 17	
Licensing Context	Mallory was looking for something to eat during her vacation in Hawaii. She asked a local guide where she could find the best local cuisine.
Non-licensing Context	Mallory was looking for something to eat during her vacation in Montana. She asked a local guide where she could find the best local cuisine.
Target Sentence	Mallory ate (a burger but not seafood/not a burger but seafood) at a pleasant little restaurant.
Probe word	SEAFOOD
Comprehension	Did Mallory find the restaurant herself? (NO)

Passage 18	
Licensing Context	On the first day of summer, Rebecca fell and broke her arm. She went to see her doctor for treatment.
Non-licensing Context	On the first day of summer, Rebecca fell and bruised her arm. She went to see her doctor for treatment.
Target Sentence	Rebecca got (a sling but not a cast/not a sling but a cast) for her arm.
Probe word	CAST
Comprehension	Did Rebecca get in a car accident? (NO)

Passage 19	
Licensing Context	Casey won an award for his 20th year working at the same high school. He was glad to receive recognition for his job.
Non-licensing Context	Casey won an award for his 20th year working at the same hospital. He was glad to receive recognition for his job.
Target Sentence	Casey continued to work (as a janitor but not a teacher/not as a janitor but a teacher) at the institution for many more years.
Probe word	TEACHER
Comprehension	Did Casey receive an award? (YES)

Passage 20	
Licensing Context	Tracy couldn't wait to celebrate her 16th birthday. She was most excited about opening her big present.

Non-licensing Context	Tracy couldn't wait to celebrate her 30th birthday. She was most excited about opening her big present.
Target Sentence	Tracy got (a dog but not a vehicle/not a dog but a vehicle) from her parents.
Probe word	VEHICLE
Comprehension	Was Tracy celebrating her birthday? (YES)

Passage 21

Licensing Context	At the buffet, Peter liked to prepare the ultimate ice cream sundae. He was very serious about his selection of toppings.
Non-licensing Context	At the buffet, Peter liked to prepare the ultimate plate. He was very serious about his selection of toppings.
Target Sentence	Peter used (nuts but not hot fudge/not nuts but hot fudge) to top it all off.
Probe word	FUDGE
Comprehension	Was Peter eating at home? (NO)

Passage 22

Licensing Context	Every morning, Janice would get ready in the shower. She always made sure to use her favorite hair product.
Non-licensing Context	Every morning, Janice would get ready in her apartment. She always made sure to use her favorite hair product.
Target Sentence	Janice put (conditioner but not shampoo/not conditioner but shampoo) in her hair.
Probe word	SHAMPOO
Comprehension	Did Janice shower in the evening? (NO)

Passage 23

Licensing Context	Steve was very proud to have graduated from the police academy. His first day on the job, he was forced to draw his weapon.
Non-licensing Context	Steve was very proud to have graduated from the ninja dojo. His first day on the job, he was forced to draw his weapon.
Target Sentence	Steve used (a baton but not a gun/not a baton but a gun) to defend himself.

Probe word	GUN
Comprehension	Was Steve a novice? (YES)

Passage 24	
Licensing Context	Stephanie wanted to go to a yardsale to buy a large dresser. Because she normally rode a bike, she needed to borrow someone's vehicle.
Non-licensing Context	Stephanie wanted to go to a yardsale to buy a lamp. Because she normally rode a bike, she needed to borrow someone's vehicle.
Target Sentence	Stephanie borrowed (a car but not a truck/not a car but a truck) from her neighbor.
Probe word	TRUCK
Comprehension	Did Stephanie own a bike? (YES)

Appendix B

When the lexical decision task was presented before the target sentence, subjects were exposed to the target concept before reading it in the target sentence. This prior exposure likely influenced reading times on the target sentence; therefore, these trials were not included in the target sentence reading time analysis and were instead analyzed separately and presented below.

Only reading times that were greater than 500 ms and less than 7000 ms were included in the analysis. Additionally, for each subject, relative outliers were identified within each condition using Tukey's procedure. This resulted in the removal of 9.8% of the total data. A 2 (context: licensing, non-licensing) x 2 (negation, negated, non-negated) repeated measures ANOVA revealed no significant differences between conditions. The interaction between context and negation was non-significant, $F_1(1, 27) = 0.16$, $p = .70$, $F_2(1, 23) = .001$, $p = .98$, as were the main effect of context, $F_1(1, 27) = 0.02$, $p = .89$, $F_2(1, 23) = 0.20$, $p = .66$, and the main effect of negation, $F_1(1, 27) = 0.19$, $p = .67$, $F_2(1, 23) = 0.09$, $p = .77$.

Appendix C

MEMORANDUM

TO:	Kevin Autry William Levine
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	11-09-127
Protocol Title:	*Representation of Negation in Licensing and Non-Licensing Contexts*
Review Type:	☒ EXEMPT ☐ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 10/4/2011 Expiration Date: 10/3/2012

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (http://vpred.uark.edu/210.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval.   Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 360 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes.   All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu.