**Original Papers**

*Polish Psychological Bulletin*
2019, vol. 50(4) 293–302
DOI - 10.24425/ppb.2019.131002

*Józef Maciuszek*[*]
*Mateusz Polak*[*]
*Martyna Sekulak*[*]

# Memory effects of implicit and explicit negation in a visual setting: Negation based on implicatures leads to a similar number of false memory alarms as overt negation

***Abstract***: *AIMS: The primary goal of the presented research was to investigate the memory effects of implicit negation, conveyed using implicatures, as compared to explicit negation. We also speculated that implicit negation might require more cognitive effort.*
*METHODS: Three experiments were conducted (total N = 181), in which participants were presented with a description containing implicit or explicit negation, followed by a memory recognition test of items present, negated or not mentioned in the description. We manipulated the pace at which the description was presented (own pace vs. fixed) and whether participants were informed about the upcoming recognition test.*
*RESULTS: We found no differences between explicit and implicit negation in the number of false alarms to negated and not mentioned items, response times or time spent reading the source material. Bayesian analyses indicated a 90% probability that there were no differences in the number of false alarms between explicit and implicit negation.*
*CONCLUSIONS: Implicit and explicit negation lead to a similar quality of recognition, and seem to require a similar amount of time to process, indicating comparable cognitive effort.*

***Keywords***: *implicit negation, explicit negation, negation memory, implicatures, pragmatic inference*

## Introduction

Negation is an important element of everyday communication, in which it performs a diverse array of functions and has different forms of expression. The most important of them include the volitional (e.g. *I do not want to go to the cinema*) and logical-corrective functions (e.g. *That's not true – our players did not lose the game yesterday*). The latter function of negation consists in the reversal of meaning, declaration of falsity of someone's utterance, correction of statements, or contradiction of something (see Maciuszek, 2018). Additionally, in everyday communication one of the primary functions of negation is to inform about the absence of certain objects (e.g. *There are no bookcases in the house*) as well as to deny events and behavior (Maciuszek & Polczyk, 2017).

Negation has many functions and there are numerous ways to express negation, as well as different classifications of negation types (see Dahl, 2011). This paper concerns the distinction between asserted and non-asserted negation, which is defined respectively as *explicit* and *implicit* negation. As noted by Clark (1974), explicit negation (EN for short) is constituted by such words as *no*, *not*, *never*, *nobody*. In addition to negative particles (e.g. *not happy*), overt negation may be expressed by affixes (e.g. unhappy); therefore within explicit negation, a distinction is drawn between morphological (affixal) negation and sentence negation. Clark also includes explicitly negative quantifiers such as *scarcely*, *hardly*, *few*, *seldom*, *little*, *only* which do not contain overt negative morphology, but are considered explicit negation. On the other hand, implicit negation (IN for short) is constituted by pragmatic inferences and it may be conveyed using such words as *forget*, *fail*, *doubt*, *deny* (Xiang, Grove & Giannakidou, 2016; see also Fodor, Fodor & Garrett, 1975). The description of the same facts may be expressed by explicit or implicit negation: *He did not give me my money back* (EN) or *I wish he had given me the money back* (IN). *The teacher was not there* (EN) or *The teacher was absent* (IN).

[*] **Institute of Applied Psychology, Faculty of Management and Social Communication, Jagiellonian University**

Corresponding author: Mateusz Polak, e-mail: mateusz.polak@uj.edu.pl

In this paper, we deal with implicit and explicit negation in the function of informing about the absence of objects, and more specifically – in the context of memory recognition of objects negated implicitly and explicitly. Our research problem concerns investigating the memory effects of informing about the absence of objects by means of asserted and non-asserted negation. Are there differences in cognitive load (processing difficulty) between explicitly negative sentences and sentences containing implicit negation, which are in affirmative form? Thus the main subject of the study is to compare memory effects of IN with EN and to compare select indicators of IN and EN processing in the context of cognitive load.

We will first present a brief introduction to implicit negation and review the theory and existing research on the relationship between implicit and explicit negation. Then we will report on the results of our previous studies on EN and IN memory effects, which have inspired current studies.

## Implicit and Explicit Negation

### Implicit Negation in the Context of Linguistic Opposition

Scientific interest in implicit and explicit negation seems to have been based around the problems of opposites of meaning (particularly the phenomenon of antonymy), the theory of markedness and the question of differences in the difficulty of processing between affirmation and negation. Antonyms are based on semantic negation; one of the segments of the antonymic pair is a denial of the meaning of the other segment. This denial can be visible in the construction of a word carrying an affix (*happy* vs. *unhappy*) or hidden, i.e. invisible in the morphological structure of the word (*bad* is the denial of *good*, and *absent* is the opposite of *present*). In this approach (Clark, 1974; Clark & Clark, 1977), words such as *bad* or *absent* are inherently negative, i.e. contain implicit negation.

Fodor, Fodor and Garrett (1975), using the terms "overt" and „covert" negation, distinguish four classes of negative morphemes: (1) explicitly negative free morphemes, e.g., *not*, (2) explicitly negative bound morphemes (morphological negatives), e.g., *un-*, *in*, *never*, (3) implicitly negative morphemes, e.g., *doubt*, *deny*, *fail*, and (4) pure definitional negatives (PDNs). The last case concerns an observation that some words have a negative implicit meaning in their definition. For example, the word "bachelor" has such an implicit negative, which is equivalent to "not married".

### Implicit and Explicit Negation in the Context of Semantic and Pragmatic Inference

A particular type of source of implicit negation is presuppositions, implications, and implicatures. Presuppositions and implications are two types of semantic information that are provided in a sentence, but are not expressed directly in it. The main difference between them is that if *A* presupposes *B*, then also *not-A* presupposes *B*, while if *A* implies *B*, then *not-A* implies *not-B*. Givón (1973) pointed to a group of verbs related to inception (e.g. *began*) and motion (e.g. *enter*) which carry both presuppositions and implications. For example, the sentences (1) *John began to work at 9:00* includes the presupposition (2) *Sometime before 9:00 John was not working* (implicit negation), and the sentence (3) *John still did not begin to work at 9:00* carries the implication (4) *Sometime after 9:00 John was not working*. The negative meanings contained in sentence (2) and sentence (4) are not asserted in (1) and in (3). These are the implicit negatives. Implication is a reasoning that is based on logical form or semantic content (Levinson, 1983), whereas presuppositions are of a semantic and pragmatic nature.

In everyday communication, the meaning of a statement must often be inferred from non-linguistic factors. Grice (1975) introduced the term "implicature" to describe the inference (which appears during conversation) which goes beyond the semantic content of the spoken words. Implicatures can be affirmative or negative. For example, let us consider a conversation:

A: *Where is my piece of sausage?*
B: *The dog has a satisfied face*.

The answer, depending on the context, means that the dog ate the sausage (affirmative implicature), even though this fact is not directly stated in the sentence. Conversations can also lead to negative inferences:

A: *Will you come to the movies with me tomorrow?*
B: *I have an exam tomorrow*.

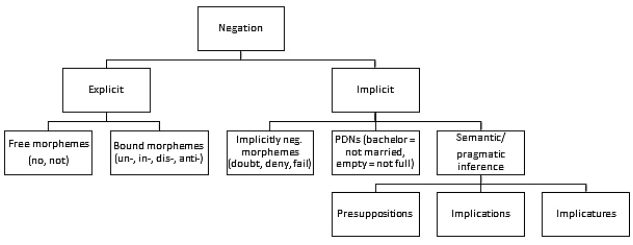
This answer contains implicit negation because it most likely means that the person will not go to the movies. Here are some other examples where the implicature is an implicit negation.

A: *Have you called your doctor?*
B: *I have lost my phone* (it means implicitly that B did not call).

A: *Do you like the green lettuce?*
A: *Am I a cow?* (it means implicitly that B did not like green lettuce).

The various ways of conveying implicit and explicit negation discussed above are presented in Figure 1.

**Figure 1.**




### Review of Select Studies

Empirical studies on implicit negation and its relationship with explicit negation were conducted mainly in the context of the phenomenon of binary opposition, and very few studies concerned IN as a pragmatic inference.

It is well known that negative statements are harder to verify than their affirmative counterparts. It has long been demonstrated that more difficult processing of sentences with negation concerns both EN and IN. In his seminal study, Clark (1974) compared the processing of explicit and implicit negation. In one of the experiments, the participants evaluated the truth or falsehood of sentences referring to the presented pictures. The sentences were affirmative or negative, and contained unmarked or marked words (for example: *The square is present* vs. *The square is not present* vs. *The circle is absent* vs. *The circle is not absent*). Results demonstrated that implicit negatives take longer to process than the corresponding affirmative. It also turned out that an overt sentence negation (e.g. *The square is not present*) was more difficult to process than an inherent (implicit) negation (eg. *The circle is absent*).

In Polish, research was conducted on the semantic complexity of dimensional adjectives (Zagrodzki, 1986). Inherent negation was easier to process than morphological negatives. It was judged more quickly whether a picture has a feature named by an adjective when it contained an inherent negation (e.g. *krótki* / *short*) rather than a morphological one (with affixes e.g. *niekrótki* / *not-short*). A similar result was found when testing the negation processing of adjectives, with recognition of their affective value (Maciuszek, 2008). Adjectives with inherent negation (e.g. *guilty*) were processed significantly faster and more correctly than adjectives negated using a prefix (e.g. *immoral*).

There are few studies on the processing of implicit negation based on pragmatic inferences. Kaup and Zwaan (2003) used explicit and implicit negation to inform about the absence of a certain color, to study the accessibility of the color term. It turned out that the accessibility of the word-probes (color terms) was similar for implicit and explicit negation (i.e. affirmative absent vs. negative absent). Moreover, in the studies carried out by Xiang et al. (2016), it turned out that negative information conveyed using asserted (EN) and non-asserted (IN) content is equally quickly available in online processing.

**Purpose and Subject Matter of the Current Research**

Studies on the relationship between implicit and explicit negation have employed different methods and materials and concerned different cognitive processes. Similarly to explicit negation, implicit negation is also more difficult to process than affirmation. The relationship between implicit and explicit negation is however more difficult to assess. Empirical studies rather seem to indicate that inherent negation is easier to process than sentence negation (Clark, 1976) and affixal negation (Maciuszek, 2008). However, when IN was conveyed using pragmatic inferences, no differences between EN and IN in the availability of negated concepts have been registered (Kaup & Zwaan, 2003).

In our previous studies (Maciuszek, Polak & Sekulak, 2019) we used implicit negation to inform participants about the absence of objects. With implicit negation, objects are not directly denied, but rather their absence needs to be inferred from the statement and the context as a pragmatic inference. The main aim was to compare the memory effects of explicit and implicit negation. The dependent variable was the number of negated items falsely recognized as "present". It turned out that there were no differences in false alarms to negated items between implicit and explicit negation, both after a short (5 minute) and a long (one week) delay. It also turned out that in the group in which the absence of objects was expressed implicitly, a significantly higher number of false alarms occurred concerning objects not mentioned in the source, than in the group with explicit negation (both in the short and long delay of the memory test). We assumed that the higher number of false alarms to not mentioned items was caused by cognitive overload. The source material was an audio recording, so assuming that implicit negation was harder to process than explicit negation, participants in the implicit negation treatment could be less sure if they missed the information about not mentioned objects or if these objects were actually mentioned, which would lead to guessing and therefore to false alarms.

On the other hand, it is also possible that implicit negation requires a deeper level of cognitive processing (to derive meaning) as compared to explicit negation, which could facilitate better memory retention. We were considering whether a combination of the effects of deeper cognitive processing and increased load might lead to a similar level of false recall (recognition of negated items as present in the description) for explicit and implicit negation.

Our current research has two primary goals. The first one is to replicate our earlier results, which showed no difference between implicit and explicit negation in memory performance. The second one is to check whether the processing of sentences containing implicit negation may be associated with a higher cognitive load (i.e. is a more difficult task) than processing of sentences with explicit negation. Therefore, we conducted a series of three experiments aimed at testing whether any differences between implicit and explicit negation would occur (measured as memory quality and reading/response time). The first experiment allowed participants to read the source material at their own pace, to investigate whether the false alarms to not mentioned items, observed in the previous study, are attributable to overload during exposure of the original material containing implicit negation. Experiment 2 was a replication of the previous study using visual stimuli with time constraints. Experiment 3 was constructed ex-post to test whether informing the participants that there would be a memory test would influence the time spent reading the source material depending on the type of negation (IN/EN) used.

## Experiment 1

The aim of Experiment 1 was to compare the effects of explicit and implicit negation in the source material under conditions in which a person has an opportunity to read the material at their own pace. Firstly, due to the fact that

implicit negation is constituted by a pragmatic meaning of a sentence, we assumed that the pace of processing sentences containing implicit negation might be slower as compared to explicit negation, which would indicate higher cognitive requirements of implicit negation. With the intention of testing this assumption, we decided to measure the time required to read the source material consisting of sentences which included implicit or explicit negation, as well as the response time to questions (in a memory test) about objects implicitly or explicitly negated in this material. Moreover, we investigated whether implicit and explicit negation might lead to different numbers of false alarms to negated items. Taking into consideration results from previous research (Maciuszek et al., 2019), we assumed that implicit negation constituted by a pragmatic meaning may be more difficult to process, but on the other hand it may cause deeper processing than explicit negation. Due to the fact that the depth of processing influences memory performance (Craik & Tulving, 1975), we wanted to investigate whether giving participants an opportunity to get familiar with a material at their own pace may result in a lower rate of false alarms to items negated implicitly than explicitly. We also expected that if IN requires more time to process than EN, letting participants process the source at their own pace should mitigate the difference in false alarms to not mentioned items, which was observed in the previous study

## Methods

*Participants*

Fifty-eight Polish undergraduate students voluntarily took part in the experiment upon informed consent. No remuneration was offered for participating. The sample consisted of 39 females and eight males, 11 participants did not indicate their gender. Participants were 22–25 years old ($M_{age}$ = 22.94 years, $SD$ = .95).

*Materials*

***Source material.*** We prepared a written material in which the protagonist describes a newly bought house, which is not yet fully equipped. In the description, the narrator mentions objects, which are present in the building, as well as those which are absent. In the Explicit Negation group, explicit negation is used in order to inform about the absence of objects (e.g. "There is no garage in the building"). In the Implicit Negation group, the protagonist uses implicit negation to express the absence of items (e.g. "I wish there was a garage in the building"). Implicit negation was conveyed by means of implicatures, using nouns pertinent to the protagonist's prospective actions ("In the future I need to add [item]."), wishes ("I wish there were [item].") and/or preferences ("I would prefer if there were [item]."). Eighteen critical items were included in the description – in each variant of the material six of those items were mentioned as present, six objects were mentioned as absent, and six items were not mentioned at all (but were mentioned or negated in other versions of the material, presented to other participants). For counterbalancing purposes, we created 12 versions of the description, so that each item could appear in a different role (Present vs. Negated vs. Not Mentioned) and in both types of negation (Explicit vs. Implicit).

The source material was presented as part of a computerized procedure, and was shown sentence by sentence. Participants could read each sentence separately at their own pace, moving to the next sentence at the push of a button. There was no possibility to go back to the previous sentence. The amount of time spent by a participant reading each sentence was measured (without informing the participants that such a measurement is made, as we wanted to measure their natural pace). Depending on the version, the material contained 20 or 21 sentences (each with an average of 8.22 words). The length of equivalent sentences in Explicit Negation condition and Implicit Negation condition (measured as the number of syllables in the sentence) did not differ significantly ($p$ = .207).

***Memory test.*** Participants were given a computerized recognition test containing questions about the content of the source material. These questions concerned the presence of 18 items in the building. Names of items were presented on-screen. Participants were to decide whether a given item was present or absent in the house, based solely on the source material. They were informed that the item should be classified as *present* only if such an information was directly mentioned in the material. Otherwise, the item should be classified as *not present*. Participants were asked to press the Left Arrow key when they recognized an item as *present*, and the Right Arrow key if an item was *not present*. Each participant was given the same memory test, with a fixed order of items. However, depending on the version of source material, each item from the memory test might have previously appeared as present, negated (explicitly or implicitly) or not mentioned in the description. Regardless of the version of the material, six items included in the memory test were mentioned as present in the building (Present items), so they should have been classified as *present*. The remaining 12 items should have been classified as *not present*. Out of those items, six were mentioned in the description as absent in the building (Negated items) and six items were not mentioned at all (Not Mentioned items). We measured the number of items incorrectly classified as present in the building: false alarms to (Implicitly or Explicitly) Negated items, and to Not Mentioned items. Mentioned items were included primarily to prevent participants from automatically classifying all items as Not Present, since no false alarms to Mentioned items were possible.

*Procedure*

The procedure took place in a computer lab where separated workplaces had been prepared. Participants attended the experiment in groups of 8 to 12. Each person was randomly assigned to one of two conditions (Explicit Negation or Implicit Negation) and randomly assigned one of the 12 versions of the description, reflected by activating one of the 12 versions of the computerized procedure. Individuals were asked to carefully read each sentence in the source material before moving on to the next one.

However, they were not informed of the fact that the source material would be followed by a memory test. Having read the whole description, participants were provided with an unrelated computer task (filler) which took about 5 minutes and required low to moderate cognitive effort. After that, the memory test was run.

**Results**

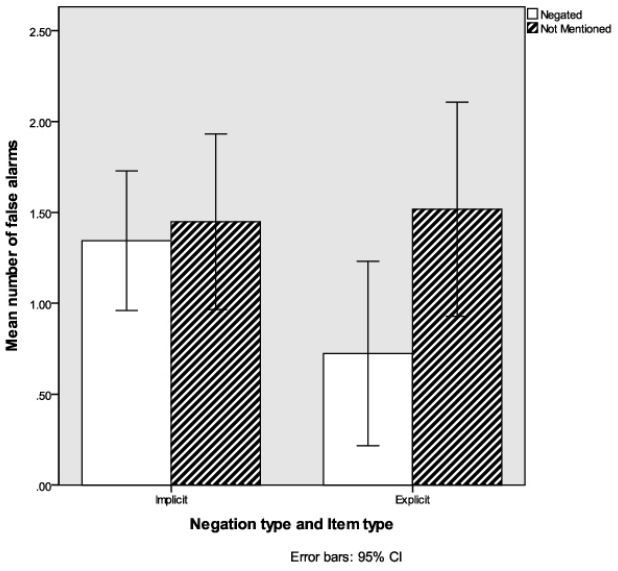
*Number of memory errors*

Two indicators of the quality of recognition were calculated for the Implicit Negation and Explicit Negation groups. The most important one was the number of false alarms to Explicitly Negated items and Implicitly Negated items (i.e. items which were stated as absent in the source material, but were falsely recognized as present by the participants in the memory test). The second one was the number of false alarms to Not Mentioned items (i.e. items which were not mentioned in the source, but recognized as present in the building by the participants).

It turned out that there were slightly more falsely recalled Negated items in the Implicit negation ($M = 1.34$, $SD = 1.00$) than in the Explicit negation group ($M = .72$, $SD = 1.33$). The difference bordered statistical significance at $t(56) = 1.998$, $p = .051$. Please note that additional Bayesian analyses investigating the probability of null hypotheses are conducted for all experiments, presented in Table 1 and further in the manuscript.

There was also a similar number of 'Present' answers to Not Mentioned items in the Implicit Negation group ($M = 1.45$, $SD = 1.27$) and in the Explicit Negation group ($M = 1.52$, $SD = 1.55$; $t(56) = .185$, $p = .854$). Results are presented in Figure 2.

**Figure 2.**




*Reading and response time measures*

There were no differences in mean reading time of individual sentences in the source material between the Implicit and Explicit negation groups ($M = 4.19$, $SD = 2.02$ vs. $M = 4.10$, $SD = 1.71$ seconds per sentence; $t(56) = .160$, $p = .874$). Moreover, there were no correlations between reading time and the number of correct answers to Implicit Negation ($r = .051$, $p = .791$) and to Explicit Negation ($r = .186$, $p = .333$).

There were no differences between the Implicit and Explicit groups in answering time (per item) to Negated items ($M = 1.75$, $SD = .38$ for Implicit negation vs. $M = 1.87$, $SD = .60$ for Explicit negation; $t(56) = .918$, $p = .363$). Moreover, there were no correlations between the number of false alarms to implicitly Negated items and answer time to these items ($r = –.040$, $p = .782$) as well as between the number of false alarms to explicitly Negated items and answer time to these items ($r = –.140$, $p = .348$).

**Summary of Experiment 1**

Experiment 1 yielded a borderline-significant lower number of falsely recognized negated items caused by explicit than implicit negation. The number of falsely recalled Not Mentioned items was similar in both Implicit Negation and Explicit Negation groups. Additionally, we found no differences in reading time and answering time between implicit and explicit negation, which indicates either that implicit negation is not more difficult to process than explicit negation, or that this difficulty is not visible in reading and answering time.

Since the main result was not consistent with expectations, Experiment 2 was planned to limit reading time rather than letting participants control it. The main aim was to replicate previous findings (Maciuszek, Polak & Sekulak, 2019) and to test whether the difference observed in the current experiment between implicit and explicit negation would persist under time pressure.

## Experiment 2

In the Experiment 1, we found that when a person has an opportunity to get familiar with the source material under no time pressure, the explicit negation seems to lead to lower rate of memory errors connected with negated items than the implicit negation. The aim of Experiment 2 was to compare the memory effects of explicit and implicit negation under time constraints, i.e. showing the source material at a fixed, fast rate. We assumed that if implicit negation is more difficult to process (due to the fact that it is constituted by a pragmatic meaning), pace of exposition the material may more strongly affect the processing of implicit negation than explicit negation. The assumption was based on the previous results showing that the implicit negation led to worse memory performance in case of not mentioned items (Maciuszek et al., 2019). When the source material was presented as an audio recording (as in the experiment described in Maciuszek et al.), participants had no opportunity to control the pace of presented information – we assumed that it might have influenced the difficulty of the task in the Implicit Negation group more than the same task in the Explicit Negation group. We found it possible that in the Implicit Negation group participants while filling in the memory test were less sure

if they missed the information about not mentioned objects or if the information about these objects actually was not mentioned in the material (it led to the higher rate of errors in the Implicit Negation group). In Experiment 2 we aimed to replicate the results from the previous paper (Maciuszek et al.) showing no differences between implicit and explicit negation in the number of false alarms to negated items and more false alarms to not mentioned items in the Implicit Negation than in the Explicit Negation group. We also measured the response time to questions related to objects negated implicitly or explicitly. We presumed that if implicit negation is more difficult to process, it might require more time to answer questions related to this type of negation.

## Methods

*Participants*

Sixty undergraduate Polish students (various faculties) voluntarily took part in the experiment upon informed consent. No remuneration was offered for participating. The sample consisted of 39 females and 13 males, eight participants did not indicate their gender. Participants were 22–25 years old ($M_{age}$ = 21.55 years, $SD$ = 1.99).

*Materials*

***Source material.*** The experiment used the same source material as Experiment 1, i.e. 12 versions of a description of a newly bought house, in which the presence / absence of 18 objects was manipulated using explicit or implicit negation.

The description was presented sentence by sentence in a computerized procedure. However, contrary to the previous experiment, each sentence was shown for a fixed time (calculated as 75% of the median reading time of each sentence from the first experiment, and subsequently tested in a pilot study). The memory test and filler task were also identical to the ones in Experiment 1.

*Procedure*

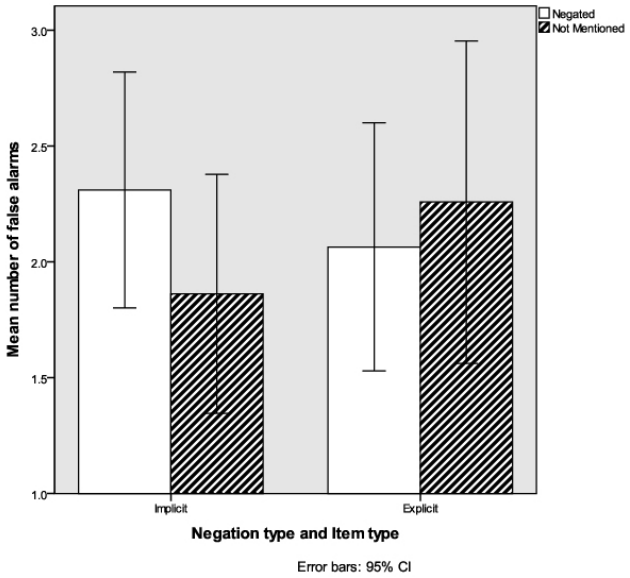
The procedure was identical to the one in Experiment 1: groups of eight to 12 participants were randomly assigned to one of 12 versions of the computerized task, which consisted of presenting the source material (fixed pace), followed by a filler task, and subsequently by the memory test. Answers to Negated and Not Mentioned items were recorded along with answering times.

## Results

*Number of memory errors*

The analysis used the same two false alarm indicators as in Experiment 1. It turned out that the number of false alarms to Negated items was not statistically different between the Implicit ($M$ = 2.31, $SD$ = 1.34) and Explicit negation groups ($M$ = 2.06, $SD$ = 1.46; $t(58)$ = .679, $p$ = .500). The numbers of (incorrect) 'Present' answers to Not Mentioned items was similar in the Implicit negation ($M$ = 1.86, $SD$ = 1.36) and Explicit negation groups ($M$ = 2.26, $SD$ = 1.90, $t(58)$ = .925, $p$ = .359). Results are presented in Figure 3.

**Figure 3.**




*Reaction time measures*

There were no differences between the Implicit and Explicit groups in answering time (per item) to Negated items ($M$ = 1.76, $SD$ = .63 for Implicit vs. $M$ = 1.75, $SD$ = .54 for Explicit; $t(58)$ = .912, $p$ = .951). There were also no differences in general answering time (per item) between the Implicit ($M$ = 1.73, $SD$ = .46) and Explicit group ($M$ = 1.78, $SD$ = .48, $t(58)$ = .379, $p$ = .706). Moreover, there were no correlations between the number of false alarms to Implicit Negation items and answer time to these items ($r$ = .164, $p$ = .394) nor between the number of false alarms to Explicit Negation items and answer time to these items ($r$ = –.007, $p$ = 970).

## Summary of Experiment 2

As predicted, and in line with previous results (Maciuszek, Polak & Sekulak, 2019), we found no differences between implicit and explicit negation on the number of falsely recalled negated items. As in Experiment 1, the number of falsely recalled not mentioned items was similar in both Implicit and Explicit negation groups. We also found no differences in answering times between implicit and explicit negation. These results indicate that there may not be a difference between IN and EN in processing difficulties. It seems that at least under time constraints, implicit and explicit negation have very similar effects on memory. One possible explanation of why the memory of explicit negation was better than of implicit negation in Experiment 1 but not Experiment 2 would be that with no time pressure, participants have time to speculate about the procedure when reading the sentences. Since sentences with explicit negation are clearly divided into two categories (*there were* and *there weren't*), it is easy to notice the difference and predict that subsequent steps of the procedure may be related to presence and absence. Implicit negation (*I wish there were*, *I need to add*) does not create such a clear dichotomy, and may rather lead some participants to focus on the

protagonist's preferences and desires – resulting in a worse distinction of negated items. Therefore in Experiment 3 we decided to clearly inform participants about the presence and form of the memory test which would follow, and especially that it would require knowing which items were present in the house.

## Experiment 3

Experiment 2 did not confirm, but rather weakened, the hypothesis that the processing of IN is more difficult than that of EN. The aim of Experiment 3 was to check whether informing about the memory test before presenting the source material would influence the results of the memory test and reading/response times. We investigated whether the information about the upcoming memory test would make participants process sentences containing implicit negation slower than those with explicit negation (which would indicate them investing more effort to process and remember these sentences). We measured the reading times of the materials containing implicit and explicit negation, as well as the response times to questions about objects negated implicitly or explicitly. We assumed that longer reading and response times would indicate more cognitive effort. As in the previous experiments, we also aimed to compare the numbers of false alarms triggered by both types of negation. Taking into consideration that knowing about an upcoming memory test, participants might classify items as present or absent during exposure to the source material in both the Implicit and Explicit negation groups, we predicted that there would be no differences in the numbers of false alarms to items negated implicitly and explicitly.

### Method

*Participants*

Sixty-three undergraduate Polish students voluntarily took part in the experiment upon informed consent. No remuneration was offered for participating. The sample consisted of 29 females and 13 males, 21 participants did not indicate their gender. Participants were 18–56 years old ($M_{age}$ = 21.79 years, $SD$ = 5.72).

*Materials*

The materials used in Experiment 3 were identical to the ones used in Experiment 1 (the source material was one of the 12 descriptions of a newly-bought house, to be read by participants at their own pace sentence by sentence; the memory test consisted of stating the presence of 18 objects mentioned, negated or not mentioned in the source). In contrast to the previous experiments, in Experiment 3, prior to the presentation of the source material, participants were informed that the description of the building would be followed by a memory test related to the material, and that they would be asked about the presence of certain objects in the building.

*Procedure*

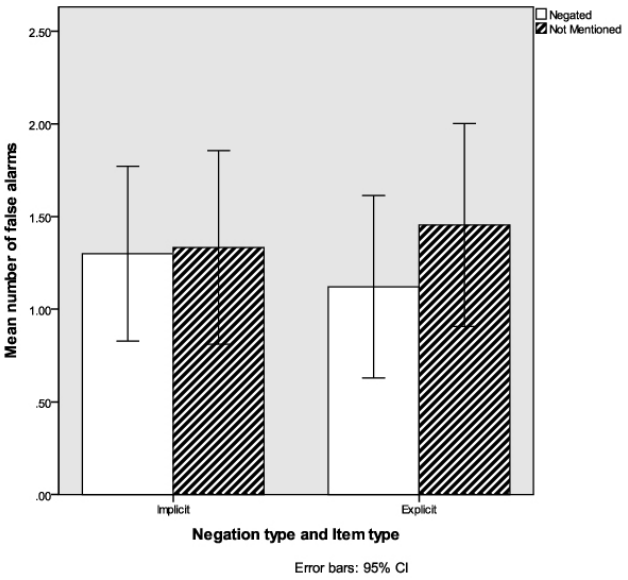
The procedure in the Experiment 3 was identical to the previous experiments. It took place in a computer lab, participants attended the experiment in groups of 8 to 12. Each participant was randomly assigned to one of two conditions (Explicit Negation or Implicit Negation group) and given one of 12 versions of the description. Participants were asked to carefully read each sentence at their own pace. Moreover, they were informed that as part of the procedure, they would be given a memory test (the instruction stated: *Later in the experiment, there will be a test containing questions about the presence of various items in the house*). After reading the source material, participants were given an unrelated filler task (same as in the previous experiments). Then, they filled out the memory test.

### Results

*Numbers of false alarms*

The analysis used the same two indicators of false alarms as in Experiment 1 and 2. Similarly to Experiment 2, there were no differences in the number of false alarms to Negated items between the Implicit and Explicit negation groups ($M$ = 1.30, $SD$ = 1.26 in the Implicit vs. $M$ = 1.12, $SD$ = 1.39 in the Explicit negation group; $t(61)$ = .533, $p$ = .596). The numbers of false alarms to Not Mentioned items were similar in the Implicit negation groups ($M$ = 1.33, $SD$ = 1.40) and Explicit negation groups ($M$ = 1.45, $SD$ = 1.54, $t(61)$ = .326, $p$ = .745). Results are presented in Figure 4.

**Figure 4.**




*Reaction time measures*

Reading time was the same for the Implicit and Explicit negation groups ($M$ = 4.35, $SD$ = 2.39 vs. $M$ = 4.32, $SD$ = 1.20, $t(61)$ = .074, $p$ = .941). Moreover, there were no correlations between reading time and the number of correct answers to Implicit negation ($r$ = .051, $p$ = .791) and to Explicit negation ($r$ = .186, $p$ = .333). There were no differences between the Implicit and Explicit groups in answering time (per item) to Negated items

($M$ = 2.07, $SD$ = .79 for Implicit vs. $M$ = 1.90, $SD$ = .58 for Explicit; $t(61) = 1.004$, $p = .327$).

There was no significant correlation between the answering time and number of false alarms to Implicit Negated items ($r = .264$, $p = .158$) but there was a significant positive correlation between the answering time and number of false alarms to Explicit Negated items ($r = .414$, $p = .016$). This effect was also visible in a significant positive correlation between the total answering time and the total number of false alarms to all Negated items ($r = .334$, $p < .001$).

**Summary of Experiment 3**

Experiment 3 yielded results consistent with expectations. There were no differences in the number of memory errors between implicit and explicit negation. Moreover, even though participants were informed about the upcoming memory test, no differences in reading time were observed. Interestingly, there were positive correlations between answering time and the number of false alarms to negated items. The more memory errors, the slower an answer to whether the items explicitly denied were present in the building (in the case of EN). This seems obvious; if someone does not remember the content, not only does it generate more errors, but also it may take much longer to think about the answer (trying to recall forgotten items). However, this result did not appear in the previous experiments, so shorter reaction times may have meant guessing and therefore more errors. As in the previous experiments, the number of falsely recalled Not Mentioned items was similar in both Implicit Negation and Explicit Negation group.

In general, the results of Experiment 3 indicate that messages with implicit negation do not constitute a greater cognitive load than messages directly informing about an absence (not, no).

## Comparison across Experiments

A multivariate MANOVA was used to analyze the effects of Negation type (Explicit/Implicit), Time constraints (i.e. whether reading time was limited as in Experiment 2 or unlimited as in Experiments 1 and 3) and Informing about memory test (Experiment 3 vs. Experiments 1 and 2) on the numbers of false alarms (FA) to Negated and Not Mentioned items, as well as on response time (RT) to Negated and Not Mentioned items.

It turned out that Negation type did not have a significant effect on any measure across the three experiments (on FA to Negated items: $F(1, 175) = 2.133$, $p = .146$, $\eta^2_p = .012$; on FA to Not Mentioned items: $F(1, 175) = .892$, $p = .346$, $\eta^2_p = .005$; on RT to Negated items: $F(1, 175) = .287$, $p = .593$, $\eta^2_p = .002$; on RT to Not Mentioned items: $F(1, 175) = 1.445$, $p = .231$, $\eta^2_p = .008$).

Warning about memory test also did not have any significant effect (on FA to Negated items: $F(1, 175) = .545$, $p = .461$, $\eta^2_p = .003$; on FA to Not Mentioned items: $F(1, 175) = .103$, $p = .749$, $\eta^2_p = .001$; on RT to Negated items: $F(1, 175) = 2.625$, $p = .107$, $\eta^2_p = .015$; on RT to Not Mentioned items: $F(1, 175) = .018$, $p = .892$, $\eta^2_p < .001$).

Time constraints had a significant effect on the number of false alarms to Negated items ($M = 1.12$, $SE = .12$ without vs. $M = 2.19$, $SE = .19$ with time constraints; $F(1, 175) = 22.838$, $p < .001$, $\eta^2_p = .115$), on the number of false alarms to Not Mentioned items ($M = 1.44$, $SE = .14$ without vs. $M = 2.06$, $SE = .20$ with time constraints; $F(1, 175) = 4.249$, $p = .041$, $\eta^2_p = .024$) and on the response time to Not Mentioned items ($M = 2.21$, $SE = .07$ without vs. $M = 1.90$, $SE = .10$ with time constraints; $F(1, 175) = 4.761$, $p = .030$, $\eta^2_p = .026$) but not on the response time to Negated items ($F(1, 175) = .219$, $p = .640$, $\eta^2_p = .001$).

All of the interaction effects were nonsignificant with $p > .10$ and were omitted for parsimony.

**Bayesian Estimates of the Probability of Null and Alternative Hypotheses**

Since many of the predicted effects in the presented studies concerned a lack of difference, standard NHST analyses were supported with Bayesian testing for null hypotheses (Masson, 2011). The analyses in question convert standard sums of squares generated by ANOVA into a graded level of evidence about which model (null vs. alternative) is more strongly supported by the data (op.cit.). In essence, these sums of squares are converted into Bayes Information Criteria (BIC) for the null and alternative hypotheses (cf. Wagenmakers, 2007). The final result is an estimated probability that the null hypothesis is true (and the leftover probability that the alternative hypothesis is true), without the need to assume arbitrary priors.

While for Experiment 1 the probabilities of the null and alternative hypotheses were not clearly conclusive (although pointing toward the null hypothesis), data from Experiments 2 and 3, as well as the cumulative data from all experiments strongly indicates (all p(H0|D) > .75) that there were no differences between explicit and implicit negation in the numbers of memory errors. Results of these analyses are presented in Table 1.

**Table 1. Bayesian analyses of differences in the number of memory errors between Implicit and Explicit negation**

| Error type | ΔBIC | $p$(H0\|D) | $p$(H1\|D) |
|---|---|---|---|
| FA to NEGATED | | | |
| Experiment 1 | .117 | .51 | .49 |
| Experiment 2 | 3.611 | .86 | .14 |
| Experiment 3 | 3.839 | .87 | .13 |
| All experiments | 2.573 | .78 | .22 |
| FA to NOT MENTIONED | | | |
| Experiment 1 | 4.02 | .88 | .12 |
| Experiment 2 | 3.22 | .83 | .17 |
| Experiment 3 | 4.03 | .88 | .12 |
| All experiments | 4.45 | .90 | .10 |

*Note.* $p$(H0|D) is the probability that the null hypothesis is true based on the data; p(H1|D) is the probability of the alternative hypothesis; ΔBIC is the difference in Bayes Information Criteria between H0 and H1 models.

Most importantly, both the summary of the three experiments and the crucial Bayesian analyses provide strong support that implicit and explicit negation have very similar, if not identical effects on memory. The only inconclusive result was the number of false alarms to negated items in Experiment 1 (with 49/51 odds of the alternative hypothesis being true); all other results strongly favor the assumption that there are no differences between implicit and explicit negation as regards the number of memory errors in general (negated and not mentioned items), as well as the number of false alarms to negated items. While these results do not state that the underlying cognitive processes are the same for implicit and explicit negation, they do show that these two types of negation may result in the same quality of memory.

## General Discussion

The current research concerned the relationship between IN and EN in the context of remembering objects the presence of which was negated either explicitly (sentential negation) or implicitly (implicatures). We checked whether implicit negation messages, which required drawing a conclusion about absence, cause a greater cognitive load than messages directly informing about absence (*not*, *no*). We also wanted to check if there were any differences between implicit and explicit negation in false recognition of negated items as present in the description. It turned out that in two out of three experiments there were no differences in false recognition between implicit negation and explicit negation.

One of the bases for the assumption of greater difficulty in processing implicit negation was the result of a previous experiment (Maciuszek et al., 2019), where in the group where the absence of objects was expressed implicitly, a significantly greater number of false memory alarms to objects not mentioned in the source material occurred than in the group with EN (both with a short and long memory test delay). This led us to the question whether the "effect of unmentioned objects" in this group was due to cognitive overload.

The results of the current study indicate that the assumption that a higher level of false memory alarms for not mentioned items resulted from a higher cognitive load when processing implicit negation than explicit negation should be rejected. In all experiments, the level of false memory alarms for unmentioned items was not significantly different between the group with IN and in the group with EN. Moreover, Bayesian analyses indicated that there is only a 10% chance that this difference exists. This means that the way of processing sentences with implicit and explicit negation probably did not affect the memory of objects that were not mentioned in the narrative (where no mention of the items was to be interpreted as their absence). The effect obtained in the previous study is to be considered an artifact.

In the present studies, we used several indicators to check if there is a difference between IN and EN in processing difficulty: results of the memory test, time spent reading the text, time needed to respond in the memory test. We also introduced additional experimental conditions: shortening the exposure time of the description and providing information about the memory test (as an attempt to evoke motivation for careful reading). In Experiments 1 and 3, the participants decided at what pace they read the text; subsequent sentences appeared on screen at the press of a button. Let us remember that the participants of Experiment 1 and 2, while reading the source material, did not know that there would be a memory test afterwards, while the participants of Experiment 3 were notified of the memory test before reading the description. It turned out that both in Experiment 1 and in Experiment 3, the time spent reading the text, in which descriptions with implicit negation were used, was similar to the time spent reading the text with explicit negation. This may indicate that IN and EN are similarly difficult to process. Moreover, the information about the memory test (Experiment 3) did not extend the reading time at all, indicating that the pace at which the participants read the text in Experiment 1 was sufficient to understand it (i.e. they did not skip over sentences due to a lack of motivation).

The lack of difference in processing difficulties between IN and EN is also indicated by the result of the memory test in Experiment 2, in which we shortened the exposure time of subsequent sentences of the description. It was expected that less time to read the description should result in a worse memory test result (more false memory alarms), especially for material that would be more difficult to process. Still, there was no difference between IN and EN in the memory test under these conditions.

Another variable that could indicate possible differences in the difficulty of IN and EN processing was the time needed in the memory test to respond whether an object was present in the described newly bought house. We assumed that the difficulty of recalling the presence (or absence) of a certain item may result in a longer response time in the memory test. This variable also was not different between these two types of negation. In each of the three experiments, participants exposed to EN and IN did not significantly differ in the time needed to decide whether a negated object (explicitly or implicitly) was present in the described building. This result supports earlier conclusions about the lack of difference in processing difficulty between implicit negation and explicit negation.

We also checked if there is a positive correlation between the response time to memory test questions and the number of false memory alarms (i.e. whether the response time in the memory test can be an indicator of difficulties remembering an item). In Experiment 1 and Experiment 2, the response time to memory test items did not correlate with memory test results, both for IN and EN. However, in Experiment 3, in the EN group, there was a significant positive correlation between the response time in the memory test and the number of false memory alarms (the slower the response, the more memory errors). The longer decision-making time may (but does not have to) point to a problem with item memory. However, shorter response times can also mean guessing and therefore lead to more errors. Thus, our results do not clearly indicate the pattern

of the relationship between the decision time and the memory test results and the response time in the memory test does not indicate processing difficulties.

Propositional theories of comprehension (e.g. Clark & Chase, 1972) state that comprehension of negation requires creating a propositional representation of it. Negation is treated as an explicit operator, which triggers taking the whole sentence into its scope. As a result, processing a sentence with negation is more complex than processing an affirmation. According to the propositional models, the complexity of comprehension of a negation makes the process slower and prone to more mistakes. In contrast, the experiential-simulation model (Kaup & Zwaan, 2003; Kaup, Yaxley, Madden, Zwaan & Lüdtke, 2007) is based on the claim that the comprehension of a negation is connected with non-linguistic cognitive processes rather than operations on sentences. According to the model, processing a negation is based on mental simulations of the states of affairs described in the sentence. In terms of the propositional model, implicit negation based on a pragmatic meaning (the one we examined in the current study) should be treated as an affirmation (because negation is not overtly expressed in the syntax of the sentence). As a result, using an implicit negation to inform about an absence should trigger different effects than the usage of explicit negation. However, in terms of the experiential-simulation model, implicit negation and explicit negation may be similar, because both of them cause a similar simulation of the actual situation. Since we did not find any key differences between the memory effects of implicit negation and explicit negation, it seems that the results of our research are more consistent with the experiential-simulation model than the propositional model. This model is also supported by other research (Kaup & Zwaan, 2003), in which concepts present in the actual state of affairs were more cognitively available than concepts absent from the state of affairs, regardless of the type of negation used to express the absence. It seems that when it comes to memory effects, the simulation of actual state of affairs may be the key process influencing comprehension and remembering the information about absence included in both explicit negation and the implicit negation.

As we noted in the Introduction, most studies have shown that processing negation is more difficult than processing affirmative statements. This also applies to remembering – sentences with negation often turn out to be more difficult to remember than affirmative ones. It should also be stressed that over the last few years, many studies have shown that the difficulty in processing negation can be alleviated by pragmatics and different semantic contexts (Dale & Duran, 2011; Giora, 2016; Tian, Breheny, & Ferguson, 2010; Orenes, Moxey, Scheepers, & Santamaría, 2016). These discoveries seem particularly interesting in the case of the study of implicit negation processing, which is generated by pragmatic inferences. In future studies, we will attempt to study the dependence of IN processing on various pragmatic and semantic factors.

The general conclusion form the present study is that despite the significant linguistic differences between explicit negation and implicit negation, and despite implicit negation requiring pragmatic inference, these two types of negation lead to a very similar quality of memory.

## References

Clark, H. H. (1974). Semantics and Comprehension. In T. A. Sebeok (Ed.), *Current Trends in Linguistics*, *vol. 12* (pp. 1291–1428). The Hague: Mouton.

Clark, H. H. (1976). *Semantics and comprehension*. The Hague: Mouton.

Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentences against pictures. *Cognitive Psychology*, *3*(3), 472–517.

Clark, H. H., & Clark, E. V. (1977). *Psychology of Language: An Introduction to Psycholinguistics*. New York: Harcourt, Brace.

Craik, F. I., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of experimental Psychology: general*, *104*(3), 268.

Dahl, Ö. (2011). Typology of negation. In L.R. Horn (Ed.), *The Expression of Negation* (pp. 9–38). Berlin: De Gruyter Mouton.

Dale, R., Duran, N. D. (2011). The Cognitive Dynamics of Negated Sentence Verification. *Cognitive Science*, *35*(5), 983–996.

Fodor, J. D., Fodor, J. A., & Garrett, M. F. (1975). The psychological unreality of semantic representations. *Linguistic Inquiry*, *6*, 515–531.

Giora, R. (2016). When negatives are easier to understand than affirmatives: The case of negative sarcasm. In P. Larrivée & C. Lee (Eds.), *Negation and negative polarity: Experimental perspectives* (pp. 127–143). Heidelberg, New York, Dordrecht, London: Springer.

Givón, T. (1973). The time-axis phenomenon. *Language*, *49*, 890–925.

Grice, P. (1975). Logic and conversation. In P. Cole, & J. Morgan (Eds.), *Syntax and semantic 3: Speech acts* (pp. 41–58). New York: Academic Press.

Harley, T. A. (2005). *The psychology of language: from data to theory*. Taylor & Francis e-Library.

Katz, J. J., & Fodor, J. A. (1963). The structure of a semantic theory. *Language*, *39*(2), 170–210.

Kaup, B., & Zwaan, R. A. (2003). Effects of negation and situational presence on the accessibility of text information. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *29*(3), 439–446.

Kaup, B., Yaxley, R. H., Madden, C. J., Zwaan, R. A., & Lüdtke, J. (2007). Experiential simulations of negated text information. *Quarterly Journal of Experimental Psychology*, *60*(7), 976–990.

Levinson, S. C. (1983). *Pragmatics*. Cambridge: Cambridge University Press.

Maciuszek, J. & Polczyk, R. (2017). There was not, they did not: May negation cause the negated ideas to be remembered as existing?. *PLoS ONE 12*(4): e0176452.

Maciuszek, J. (2008). Processing Negation in the Context of Adjectival Antonymy. *Psychology of Language and Communication*, *12*(2), 17–43.

Maciuszek, J. (2018). I believe that he didn't do it and I don't believe that he did it. The influence of context on the semantic-communicative relations between sentence negation and performative negation. *Studies in Logic, Grammar and Rhetoric*, *54*(1), 61–76.

Maciuszek, J., Polak, M., & Sekulak, M. (2019). There is no item vs. I wish there were an item: Implicit negation causes false recall just as well as explicit negation. *PLoS ONE 14*(4): e0215283.

Masson, M. E. (2011). A tutorial on a practical Bayesian alternative to null-hypothesis significance testing. *Behavior research methods*, *43*(3), 679–690.

Orenes, I., Moxey, L., Scheepers, C., Santamaría, C. (2016). Negation in context: Evidence from the visual world paradigm. *Quarterly Journal of Experimental Psychology*, *69*(6), 1082–1092.

Tian, Y., Breheny, R., Ferguson, H. J. (2010). Why we simulate negated information: A dynamic pragmatic account. *Quarterly Journal of Experimental Psychology*, *63*(12), 2305–2312.

Wagenmakers, E.-J. (2007). A practical solution to the pervasive problems of *p* values. *Psychonomic Bulletin & Review*, *14*, 779–804.

Xiang, M., Grove, J., & Giannakidou, A. (2016). Semantic and pragmatic processes in the comprehension of negation: An event related potential study of negative polarity sensitivity. *Journal Neurolinguistics*. *38*, 71–88.

Zagrodzki, M. (1986). Semantyczna złożoność antonimów. In I. Kurcz, J. Bobryk & D. Kądzielawa (Ed.), *Wiedza a język. Ogólna psychologia języka i neurolingwistyka*. Wrocław: Ossolineum.