

# N-words and Sentential Negation\*

—Evidence from polarity particles and VP ellipsis—

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## Abstract

Sentences involving n-words, such as “No student stepped forward”, have been treated either as involving sentential negation taking the n-word in its scope or as involving a negative quantifier occurring in an otherwise positive sentence. This paper provides novel experimental evidence for the former view based on data involving polarity particles and VP ellipsis, offering new tools for detecting the presence of sentential negation.

## 1 Introduction

This paper is concerned with the proper treatment of n-words, such as *no* and *never*, illustrated in (1).

- (1)    a. No student stepped forward.  
      b. Susan *never* saw this movie.

Within the vast literature on the subject one can distinguish two major approaches. In what we call here the negative quantifier (NQ) analysis n-words are treated as negative quantifiers occurring in an otherwise positive sentence, as in (2) (Zanuttini 1991, Haegeman 1995: a.o.)

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$$(2) \quad Nx(\text{student}'(x) \wedge \text{step-forward}'(x))$$

In the competing approach, which we call the negative operator analysis, sentences like (1) are treated as involving the negation operator found in ordinary negative sentences. We consider here a particular version of the negative operator view which we call the negative indefinite (NI) approach. On this approach, n-words are treated as special indefinites marked for occurring within the scope of sentential negation, as in (3) (Penka 2007, Zeijlstra 2004, Tubau 2008 a.o.).<sup>1</sup>

$$(3) \quad \neg\exists x(\text{student}'(x) \wedge \text{step-forward}'(x))$$

The main goal of this paper is to help differentiate between these two approaches by offering two new tools for detecting the presence of sentential negation. The first test is based on the observation that sentential negation affects the distribution of polarity particles (*yes, no*) in confirming responses to a previously made assertion:<sup>2</sup>

- (4)    A: Paul stepped forward.  
      B: Yes / \*No, Paul stepped forward.
- (5)    A: Paul did not step forward.  
      B: Yes / No, Paul did not step forward.

Without any further complications, the NI approach predicts that sentences with n-words like (6) pattern with negative sentences like (5) above rather than with positive sentences like (4). The NQ approach makes the opposite prediction.

- (6)    A: No student stepped forward.  
      B: Yes / No, no student stepped forward.

We report here on two experiments that test (i) whether sentential negation indeed affects the distribution of polarity particles as indicated in (4) and (5) and (ii) whether the prediction made by the NI theory concerning cases like (6) is indeed borne out.

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<sup>1</sup>The account of negation and n-words in de Swart and Sag (2002) falls under the negative operator approach because in it the same polyadic negative quantifier occurs in both ordinary negative sentences and sentences involving n-words, the only difference between them being the addicity of this quantifier. We are concerned here with differentiating analyses where n-words and sentential negation are treated as involving essentially the same operator from analyses in which they are not, and not with distinguishing between the polyadic quantification view and the negative indefinite view. For the purposes of the data presented in this paper the polyadic quantification analysis and the NI approach fall in the same category.

<sup>2</sup>See Kramer and Rawlins (2009) for discussion related to this point.

The second way to detect sentential negation we discuss here arises from the following contrast:

- (7) A: Mary visited some of the children.  
B: I agree, she did / \*didn't.
- (8) A: Mary didn't visit any of the children.  
B: I agree, she \*did / didn't.

Again, the NI approach predicts that sentences with n-words like (9) pattern with negative sentences like (8) rather than with positive sentences like (7), while the NQ approach predicts exactly the opposite.

- (9) A: Mary visited none of the children.  
B: I agree, she \*did / didn't.

We present below an experiment that tests whether cases like (9) behave indeed differently from cases like (7), as expected on the NI approach.

The paper is organized as follows. Section 2 provides a brief outline of the grammar of polarity particles in English setting the stage for section 3, which describes an experiment designed to establish the basic pattern of polarity responses to positive and negative sentences without n-words. We turn to an experiment that tests polarity particle patterns in responses to sentences with n-words in Section 4, which differentiates between the predictions made by the two major approaches we contrast here. Section 5 describes an experiment testing responses involving VP ellipsis to initiatives with and without n-words where NI and NQ make different predictions, and Section 6 concludes. The appendix provides further details about the statistical modeling of the data.

## 2 The grammar of polarity particles

This section summarizes the account of polarity particles in [Farkas and Roelofsen \(2011\)](#), to which the reader is referred for full details. This account provides the theoretical background for our first two experiments but its details are not crucial to differentiating the NI and NQ approaches.

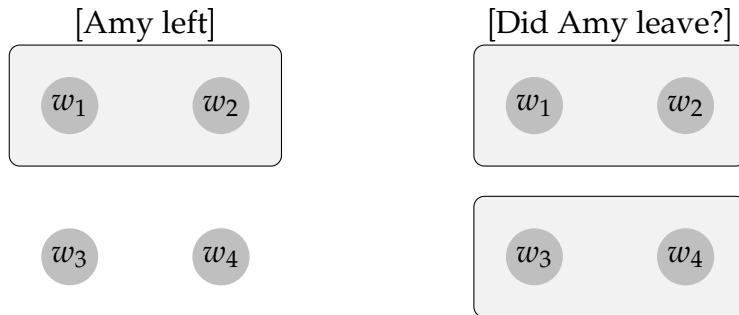
Polarity particles are used in responses to assertions and polar questions, as exemplified in (10) and (11):

- (10) A: Amy left.  
B: Yes, she did / No, she didn't.

- (11) A: Did Amy leave?  
 B: Yes, she did / No, she didn't.

We take both assertions and polar questions to express proposals to update the common ground of a conversation in one or more ways (Groenendijk and Roelofsen 2009, Farkas and Bruce 2010: a.o.). Polarity particles in turn are seen as marking certain types of responses to a given proposal.

To flesh out this basic idea, we need to formally characterize a suitable notion of proposals and specify how polarity particles are interpreted given the proposal they address. We work within the framework of inquisitive semantics, which takes the proposition expressed by a sentence to capture not simply its informative / truth-conditional content, but more generally, the proposal made when uttering that sentence. Sentences express propositions, which are defined as sets of possibilities, where each possibility is a set of possible worlds. Each possibility in a proposition represents a potential update to the common ground. The figures below exemplify the propositions expressed by an assertion and a question, where  $w_1$  and  $w_2$  are the worlds where Amy left and  $w_3$  and  $w_4$  are the worlds where Amy did not leave. The proposition expressed by a sentence  $\varphi$  is denoted by  $[\varphi]$ .

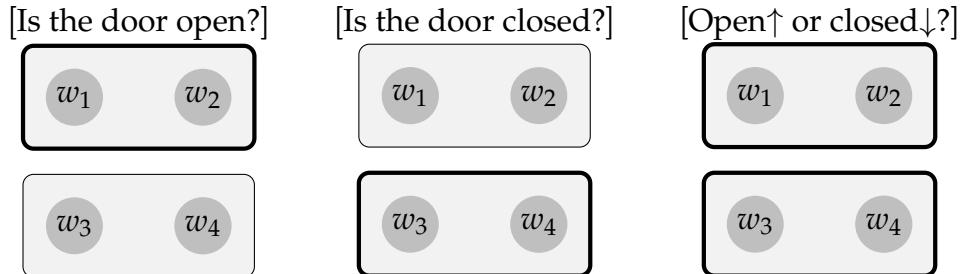


In uttering a sentence  $\varphi$ , a speaker (*i*) provides the information that the actual world is contained in at least one of the possibilities in  $[\varphi]$ , and (*ii*) requests a response from other participants that provides enough information to establish at least one of the proposed updates.

For many purposes, it is sufficient to simply represent proposals as sets of possibilities. But to account for the distribution and interpretation of polarity particles, we need a more fine-grained representation. To see this, consider the following three questions below. The propositions expressed by these questions consist of the same two possibilities, the possibility that the door is open and the possibility that the door is closed. However, polarity particles used in responses to these questions have a different distribution and interpretation, as seen below.

- (12) Is the door open? Yes  $\Rightarrow$  open / No  $\Rightarrow$  closed  
 (13) Is the door closed? Yes  $\Rightarrow$  closed / No  $\Rightarrow$  open  
 (14) Is the door open $\uparrow$  or closed $\downarrow$ ? # Yes / # No

In order to capture these contrasts, we make a distinction between highlighted and non-highlighted possibilities (Roelofsen and van Gool 2010, Pruitt and Roelofsen 2011, Farkas 2011). Intuitively, highlighted possibilities are the ones that are explicitly mentioned and thereby foregrounded: (12) highlights the possibility that the door is open, (13) highlights the possibility that the door is closed, and (14) highlights both of these possibilities. This is depicted in the figures below, where  $w_1$  and  $w_2$  are the worlds where the door is open while  $w_3$  and  $w_4$  are the worlds where the door is closed; highlighted possibilities are displayed with a thick border.



Highlighted possibilities serve as antecedents for subsequent anaphoric expressions, and polarity particles are such anaphoric expressions. As a first step then, we assume that a *yes* answer to an initiative  $\psi$  presupposes that there is exactly one highlighted alternative for  $\psi$  and if this presupposition is met, *yes* confirms the highlighted alternative. A *no* answer simply rejects all the highlighted possibilities for  $\psi$ .<sup>3</sup>

This enables us to account for the contrast between (12), (13), and (14). In the case of (12), there is exactly one highlighted alternative so *yes* is licensed and the *yes* response confirms the highlighted alternative, conveying that the door is open; *no* is also licensed, and the *no* response denies the highlighted alternative conveying that the door is closed. In the case of (13), there is again exactly one highlighted alternative and the reasoning goes through just as before except that the highlighted alternative is different in this case. Finally, in the case of (14), there are two highlighted alternatives so *yes* is not licensed because its presupposition is not met; *no* is infelicitous because it signals that the door is neither open nor closed, which is contradictory.

<sup>3</sup>The characterization of the effect of *no* above is motivated by the fact that a *no* response is possible in open disjunctive questions exemplified below. Such questions highlight two alternatives; the *no* response rejects them both:

(i) A: Did Sally bring beer $\uparrow$  or juice $\uparrow$ ? B: No, she brought neither.

Treating polarity particles as anaphoric to highlighted possibilities makes two additional correct predictions: (i) they can only be used in responses, not ‘out of the blue’, and (ii) they cannot be used in response to *wh*-questions, assuming that such questions do not highlight any possibilities.

Note next that the distinction between highlighted and non-highlighted possibilities is not sufficient for a full account of polarity particles in responses. The two sentences below are entirely equivalent in the system considered so far: they express the same proposition and highlight the same possibility. And yet, they do not license the same polarity particles.

- (15) A: Susan failed the exam.  
B: Yes, she failed. / \*No, she failed.
- (16) A: Susan didn’t pass the exam.  
B: Yes, she didn’t pass. / No, she didn’t pass.

This contrast can only be accounted for semantically if we make our notion of propositions / proposals even more fine-grained so as to distinguish between positive and negative antecedent possibilities.<sup>4</sup> We assume here that positive and negative possibilities are indeed distinguished. Negative possibilities are introduced by sentences involving sentential negation; positive possibilities are the default case.<sup>5</sup> More specifically, the proposition expressed by a negative sentence, [not  $\varphi$ ], consists of a single highlighted, negative possibility: the complement of  $\cup[\varphi]$ . For instance, (16) above expresses a proposition consisting of a single  $[H, -]$  possibility. In contrast, (15) express a proposition consisting of a single  $[H, +]$  possibility.

Once this distinction is in place, the type of responses we are interested in may be distinguished along two parameters: (a) the response may *confirm* or *reject* the antecedent, and (b) the response may be sensitive to the positive or negative nature of the antecedent. Consequently, we claim that polarity particles in English do double duty: they may be used to signal whether the response is confirming or rejecting, and they may be used to signal whether the antecedent possibilities are supposed to be positive or negative.<sup>6</sup> In (15), *yes* signals that the response is

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<sup>4</sup>See [Ginzburg and Sag \(2000\)](#) for a concurring argument that the semantic value of positive and negative polar questions needs to be distinguished to account for the distribution of polarity particles in their responses.

<sup>5</sup>See [Cooper and Ginzburg \(2011\)](#) and references therein for a situation semantics framework in which this distinction is reflected at the level of type theory.

<sup>6</sup>The issue of whether the response signals information relevant to the polarity of the antecedent or the response itself is immaterial for English and therefore we ignore it here. For data showing that the polarity of the response is relevant, see [Farkas](#)

confirming or that the antecedent is positive; *no* is not licensed because it can only be used to signal that the response is rejecting or that the antecedent is negative, and neither is the case here. In (16), *yes* can be used because it signals confirmation, while *no* can be used because it signals that the antecedent is negative.

To make these observations concrete, we assume that polarity particles may realize two bivalent features, a relative polarity feature and an absolute polarity feature (see [Pope 1976](#), [Farkas and Bruce 2010](#), [Farkas 2010](#)). The absolute polarity feature of a response marks it as being positive ([+]) or negative ([−]). The relative polarity feature marks a response as being confirming, and thus having the same absolute polarity as the antecedent ([SAME]) or as being rejecting, and thus having the reverse absolute polarity of its antecedent ([REVERSE]). The four possible feature value combinations are summarized below:

	response	relation with antecedent
[SAME, +]	+	same
[SAME, −]	−	same
[REVERSE, +]	+	reverse
[REVERSE, −]	−	reverse

We take polarity features to be hosted by a syntactic node PolP, which always attaches to a clausal node that we call its prejacent. The prejacent may be partially or fully elided. Alternatively, a fully elided prejacent can be treated as a null pro-sentence.

We take the semantic contribution of features in PolP to be purely presuppositional. If the presuppositions of PolP are met, it contributes the identity function  $\lambda p. p$ . The presuppositions of the four possible feature combinations are given below:

- (17) a. [SAME, +] presupposes a unique [H, +] alternative  $\alpha$  on the Table<sup>7</sup> and presupposes that its prejacent confirms this alternative: [prejacent] =  $\{\alpha_{[+]}\}$
- b. [SAME, −] presupposes a unique [H, −] alternative  $\alpha$  on the Table and presupposes that its prejacent confirms this alternative: [prejacent] =  $\{\alpha_{[-]}\}$

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(2010).

<sup>7</sup>We assume a discourse model of the kind specified in [Farkas and Roelofsen \(2011\)](#), building on [Farkas and Bruce \(2010\)](#). In this model, a discourse context includes a stack of propositions called the Table representing the proposals under consideration. We refer to alternatives that are contained in the *first* proposition on the Table simply as the ‘alternatives on the Table.’

- c. [REVERSE,+] presupposes a non-empty set of [H,−] alternatives A on the Table and presupposes that its prejacent rejects all these alternatives: [prejacent] = { $\overline{\cup A}_{[+]}$ }
- d. [REVERSE,−] presupposes a non-empty set of [H,+] alternatives A on the Table and presupposes that its prejacent rejects all these alternatives: [prejacent] = { $\overline{\cup A}_{[-]}$ }

Now that we have specified the semantic contribution of the polarity feature combinations, the next question to address is which particles can be used to realize which features. Our proposal about *yes* and *no* is given in (18), which captures the ability of these particles to discharge the double duty mentioned above:

- (18)    a. The features [SAME] and [+] may be realized by *yes*  
          b. The features [REVERSE] and [−] may be realized by *no*

We also assume that given a particular feature combination, features that are more marked have higher ‘realization needs’ than features that are unmarked in the sense that other things being equal, the realization of a marked feature by a particle is preferred over the realization over an unmarked feature by a particle. This preference may be strengthened to a requirement in some cases or manifest itself simply as a preference. We assume here that (i) [−] is marked relative to [+]; (ii) [REVERSE] is marked relative to [SAME]; and (iii) the absolute polarity of [REVERSE] responses is marked because it contrasts with the polarity of the antecedent. Under these assumptions, having one and the same particle realizing [SAME] and [+] and another single particle realizing [REVERSE] and [−] is not surprising given that [SAME] and [+] are the unmarked values of their respective features and [REVERSE] and [−] are the corresponding marked values.

The sketched account makes the following predictions for English:

- (19)    a. [SAME,+] can only be realized by *yes* because both features can be realized by *yes* and because none of them can be realized by *no*  
          b. [REVERSE,−] can only be realized by *no* because both features can be realized by *no* and none of them can be realized by *yes*  
          c. [SAME,−] can be realized by *yes* or *no* because [SAME] can be realized by *yes* and [−] can be realized by *no*  
          d. [REVERSE,+] can be realized by *yes* or *no* because [REVERSE] can be realized by *no* and [+] can be realized by *yes*
- (20)    a. In the case of [SAME,−], we expect a preference for *no* over *yes* because [−] is more marked than [SAME].

- b. In the case of [REVERSE,+], both features have high realization needs; across languages we see different strategies to satisfy these needs

In English, [REVERSE,+] polarity phrases must have an explicit preagent with verum focus, reflecting the contrastive positive polarity of the response:

- (21) A: Peter didn't call.  
 B: Yes, he DID. / No, he DID.

In sum, the two points directly relevant for our current purposes are as follows. First, the theory sketched here predicts that particle distribution is sensitive to whether the initiative is positive or negative. In [SAME] responses to positive initiatives, only *yes* can be used. In [SAME] responses to negative initiatives, both *yes* and *no* can be used. Second, the polarity of the initiative is predicted to correlate with the presence of sentential negation rather than with lexical negativity – recall the contrast between (15) and (16) above. Under this view then, polarity particles can be used as a probe to detect sentential negation in the initiative: initiatives introducing negative possibilities and therefore involving sentential negation are predicted to contrast with initiatives that introduce positive possibilities and do not involve sentential negation in that only the former should allow *no* in a [SAME] response.

### 3 Experiment 1: basic distribution of polarity particles

Experiment 1 is designed to test two basic predictions of the theory specified above: (*i*) in [SAME] responses to positive assertions, only *yes* can be used; and (*ii*) in [SAME] responses to negative assertions, both *yes* and *no* can be used. Once these basic facts are established we use them in the next two experiments, which contrast sentences with and without n-words.

**Method.** We used online questionnaires to test people's preferences for the particle *yes* or *no* when they agree with a previously made assertion. Two typical experimental items are provided below:

- (22) This substance will prevent the clay from twisting. [stimulus]
- |   |                     |
|---|---------------------|
| a. <input type="checkbox"/> Yes, it will. | [response option 1] |
| b. <input type="checkbox"/> No, it will.  | [response option 2] |

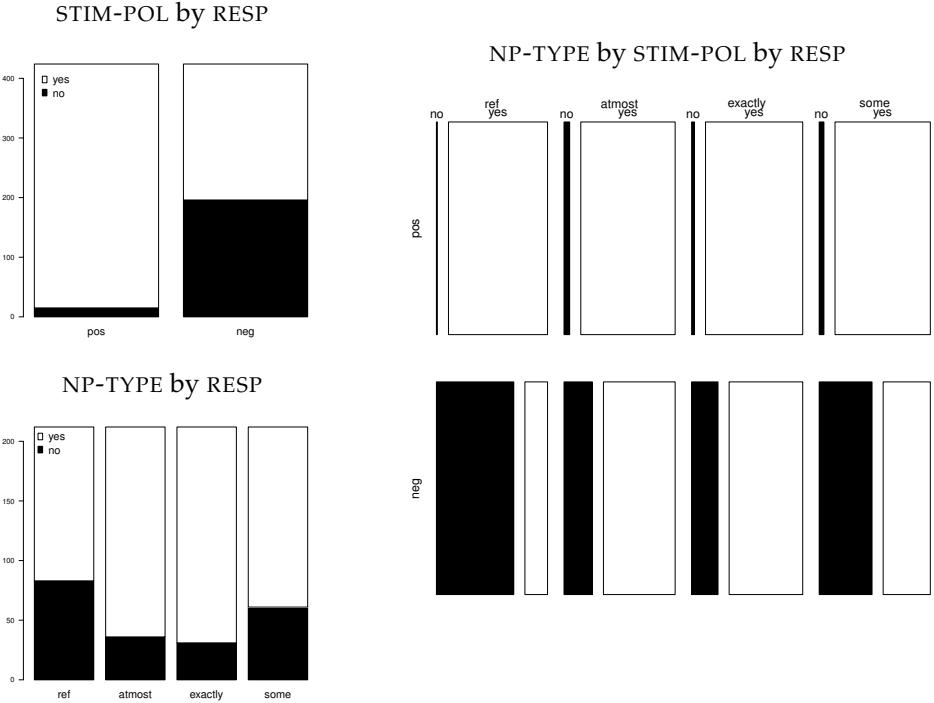
- (23) At most six volunteers did not sign up for  
 free housing. [stimulus]
- a.  Yes, at most six of them didn't. [response option 1]
  - b.  No, at most six of them didn't. [response option 2]

The dependent variable RESP encodes the choice of polarity particle in responses (factor with 2 levels: **yes**, **no**; ‘success’ level: **yes**). The three independent variables are as follows. First, STIM-POL encodes the polarity of the stimulus (factor with 2 levels: **pos**, **neg**; reference level: **pos**). If the stimulus is positive, we expect the subjects to overwhelmingly signal agreement with the particle *yes*; if the stimulus is negative, we expect the subjects to signal agreement with either *yes* or *no*. Second, NP-TYPE encodes the type of subject NP in the stimulus (factor with 4 levels: **ref**, **atmost**, **exactly**, **some**; reference level: **ref**). All stimuli have the structure ‘subject + predication’; the subject NPs are referential or quantificational with 3 possible determiners: *some*, *at most n* and *exactly n*. We are interested in whether the referential vs. quantificational nature of the subject and their monotonicity properties affect particle choice. Finally, PART-POS encodes the position of the polarity particle in the response (factor with 2 levels: **ini**, **fin**; reference level: **ini**). The particle is placed either at the beginning of the response or at the end.

Item (22) above exemplifies the combination STIM-POL = **pos**, NP-TYPE = **ref**, PART-POS = **ini**, while item (23) exemplifies the combination STIM-POL = **neg**, NP-TYPE = **atmost**, PART-POS = **ini**.

For each of the  $16 = 2 \times 4 \times 2$  combinations, 3 stimulus sentences were generated for a total of 48. The sentences were randomly selected from the Brown Corpus and the Corpus of Contemporary American English and simplified in various ways (shortened etc.). A total of 53 subjects in an undergraduate class completed the online experiment for extra-credit. For each subject, we randomly selected 1 sentence for each of the 16 combinations. Total number of observations:  $N = 53 \times 16 = 848$ . We randomized both the order of the stimuli and the order of the two possible responses for each stimulus. Experiments 2 and 3 presented in the following two sections plus 7 items in which the responses disagreed with the stimulus were used as fillers.

**Results.** Barplots of STIM-POL by RESP and NP-TYPE by RESP are provided below, as well as a mosaic plot of NP-TYPE by STIM-POL by RESP.



The main observation confirms our overall expectation: when the stimulus is positive, the response particle is overwhelmingly *yes* and when the stimulus is negative, the response particle is either *yes* or *no*.

We also see that when the stimulus is negative and the subject NP is referential, there is a preference for *no*; in contrast, when the stimulus is negative and the subject NP is *at most n* or *exactly n*, there is a preference for *yes* while a negative stimulus with a *some* subject NP exhibits no particular preference for either *yes* or *no*. At this point, we do not have an explanation for these fine-grained differences between the different kinds of subject NPs. Since these differences are not directly relevant to the goals of this paper, we will not discuss them further here.

Finally, the position of the particle in responses, e.g., *Yes, it will* versus *It will, yes*, was irrelevant for the choice of polarity particle, so we did not depict it graphically. This is as expected: particle choice was not predicted to depend on position. Appendix A.1 provides the details of the statistical analysis.<sup>8</sup>

<sup>8</sup>The pattern of responses to negative initiatives is in principle consistent not only with a preference for *no* responses but also with the existence of two dialects, one in which both *yes* and *no* are equally acceptable in such responses and a dialect that accepts only *no*. We attempted to assess whether there was any evidence for the two dialects hypothesis by estimating a model in which subjects could be grouped into a ‘bias for *no*’ dialect and a dialect with no bias one way or the other. We found no evidence for the existence of two dialects and therefore assume that speakers accept both particles, with a preference for *no*, in line with what our theory would lead us to expect.

## 4 Experiment 2: polarity particles and n-words

Experiment 2 investigates whether sentences with n-words behave like negative sentences or like positive sentences with respect to the distribution of polarity particles in responses.

**Method.** Just as for experiment 1, we used online questionnaires to test whether people prefer to use *yes* or *no* in agreeing responses to a previously made assertion. Three examples of experimental items are provided below:

- (24) None of the local bookstores are hiring full-time. [stimulus]  
a.  Yes, none of them are. [response option 1]  
b.  No, none of them are. [response option 2]
- (25) The Neanderthals never crossed the Mediterranean. [stimulus]  
a.  Yes, they never did. [response option 1]  
b.  No, they never did. [response option 2]
- (26) Infants sometimes do not learn to speak before  
the age of four. [stimulus]  
a.  Yes, they sometimes don't. [response option 1]  
b.  No, they sometimes don't. [response option 2]

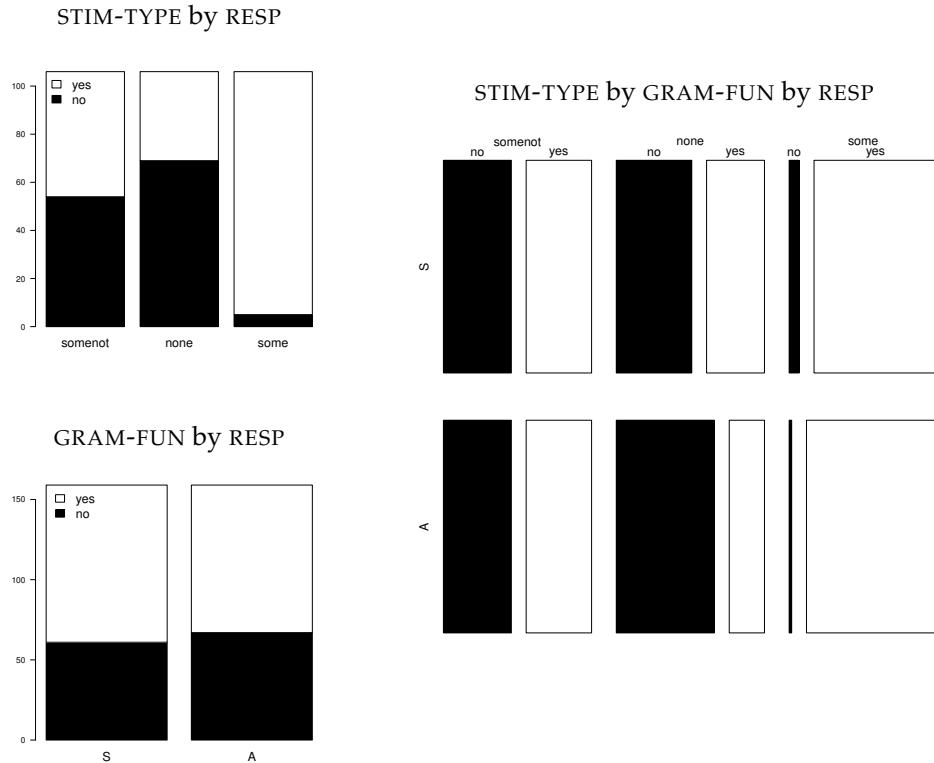
Just as before, the dependent variable RESP encodes choice of polarity particle in responses (factor with 2 levels: **yes**, **no**; ‘success’ level: *yes*). We have two independent variables. First, STIM-TYPE (factor with 3 levels: **some**, **none**, **somenot**; reference level: **somenot**) encodes the three types of stimuli we considered: (i) sentences with n-words but without sentential negation (**none**); (ii) sentences with an existential and sentential negation (**somenot**); and finally (iii) sentences with an existential and without sentential negation (**some**). If the stimulus is positive (STIM-TYPE = **some**), we expect that agreement is generally signaled with the particle *yes*. If the stimulus is negative (STIM-TYPE = **somenot**), we expect that agreement can be signaled with both *yes* and *no*. Crucially, we want to see whether sentences with n-words (STIM-TYPE = **none**) license both *yes* and *no* in agreeing responses – like negative sentences – or only *yes* – like positive sentences. The second independent variable is GRAM-FUN (factor with 2 levels: **S**(ubject), **A**(dverb); reference level: **S**) encoding the fact that we considered both nominal and adverbial n-words.

Item (24) above exemplifies the combination STIM-TYPE = **none**, GRAM-FUN = **S**. Item (25) exemplifies the combination STIM-TYPE = **none**, GRAM-FUN = **A**. Finally, item (26) exemplifies the combination

STIM-TYPE = **somenot**, GRAM-FUN = **A**.

For each of the resulting  $6 = 3 \times 2$  combinations, 3 stimulus sentences were generated for a total of 18. The sentences were randomly selected from the Brown Corpus and the Corpus of Contemporary American English and simplified in various ways (shortened etc.). A total of 53 subjects in an undergraduate class completed the online experiment for extra-credit. For each subject, we randomly selected 1 sentence for each of the 6 combinations. Total number of observations:  $N = 53 \times 6 = 318$ . For each subject, we randomized both the order of the stimuli and the order of the two possible responses for each stimulus. Experiment 1 and 3 plus 7 items in which the responses disagreed with the stimulus were used as fillers.

**Results.** Barplots for STIM-TYPE by RESP and for GRAM-FUN by RESP are provided below, as well as a mosaic plot of STIM-TYPE by GRAM-FUN by RESP.



The main observation is that sentences with n-words license both *yes* and *no* in agreeing responses, just like negative sentences. In contrast, positive sentences only license *yes* in agreeing responses.

In addition, the mosaic plot indicates that the association between stimulus type and response particle does not vary by grammatical function: the pattern observed when aggregating over both subjects and

adverbs is the same as the patterns we observe when we look at them separately.

Finally, we note that n-words induce a stronger preference for *no* than neg+existentials, while positive existentials have a much stronger preference for *yes* than neg+existentials. These preferences are more pronounced for adverbs than for subjects. An explanation of these finer differences is a matter for further research. Appendix A.2 provides the details of the statistical analysis.

## 5 Experiment 3: VP ellipsis

Experiment 3 provides additional evidence that n-words behave like negative sentences with respect to the occurrence of sentential negation in agreeing responses involving VP ellipsis. This experiment complements experiment 2 in two ways. First, we use a diagnostic other than polarity particles to distinguish between NI and NQ approaches, namely VP ellipsis with and without sentential negation. Second, the n-words occur in direct object, not subject position. Based on distributional patterns instantiated by other languages (e.g., Spanish and Italian), it is possible that direct object n-words trigger different patterns of agreeing responses than subject n-words and we would like to test that.

The direct object position of the initiatives contains an n-word, a referential NP (proper name or definite description) or an existential (*some*). Based on the findings from experiment 2, we expect VP ellipsis in agreeing responses to preferentially have a negated auxiliary in the case of negative quantifiers and to overwhelmingly have an affirmative auxiliary in the case of referential direct objects – this is the main contrast we are interested in. Existential direct objects are included to control for / factor out the possibility that the preference exhibited by negative quantifiers should be primarily attributed to their quantificational nature in general instead of their particular negative meaning.

**Method.** Just as for experiments 1 and 2, we used online questionnaires to test whether people prefer to use positive VP ellipsis (no sentential negation, only *do*-support) or negative VP ellipsis (sentential negation plus *do*-support) in agreeing responses to a previously made assertion. Three examples of experimental items are provided below:

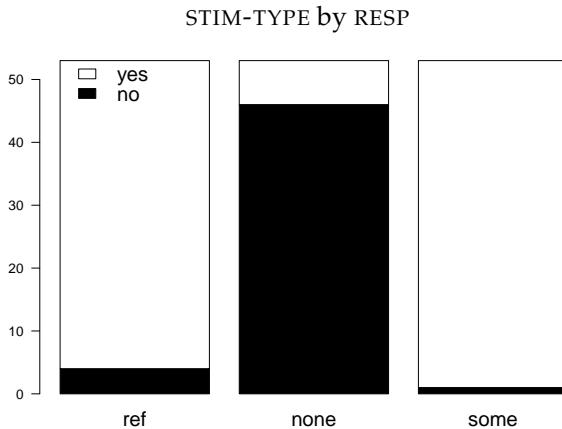
- (27) The published review overestimates the true  
effect of the interventions. [stimulus]
- a.  I agree, it does. [response option 1]  
b.  I agree, it doesn't. [response option 2]

- (28) The first two candidates answered none of the questions convincingly. [stimulus]
- a.  I agree, they did. [response option 1]  
b.  I agree, they didn't. [response option 2]
- (29) The lawyers ignored some of the most important pieces of evidence. [stimulus]
- a.  I agree, they did. [response option 1]  
b.  I agree, they didn't. [response option 2]

The dependent variable RESP encodes the form of VP ellipsis in responses, i.e., it is a factor with 2 levels: just *do*-support, coded **yes** for uniformity with the previous two experiments, and *do*-support plus sentential negation, coded **no** for uniformity; ‘success’ level: *yes*. We have one independent variable STIM-TYPE (factor with 3 levels: **ref**, **none**, **some**; reference level: **ref**), which encodes the three types of stimuli we considered: (*i*) sentences with referential direct objects (**ref**, exemplified in (27)); (*ii*) sentences with n-word direct objects (**none**, exemplified in (28)); and finally (*iii*) sentences with existential direct objects (**some**, exemplified in (29)). If the stimulus is positive (STIM-TYPE = **ref** or STIM-TYPE = **some**), we expect that agreement is generally signaled with positive VP ellipsis (coded as *yes*). If the stimulus is negative (STIM-TYPE = **none**), we expect that agreement can be signaled with both positive VP ellipsis (coded *yes*) and negative VP ellipsis (coded **no**), with a preference for negative VP ellipsis.

For each of the 3 conditions, 3 stimulus sentences were generated for a total of 18. The sentences were randomly selected from the Brown Corpus and the Corpus of Contemporary American English and simplified in various ways (shortened etc.). A total of 53 subjects in an undergraduate class completed the online experiment for extra-credit. For each subject, we randomly selected 1 sentence for each of the 6 combinations. Total number of observations:  $N = 53 \times 3 = 159$ . For each subject, we randomized both the order of the stimuli and the order of the two possible responses for each stimulus. Experiments 1 and 2 plus 7 items in which the responses disagreed with the stimulus were used as fillers.

**Results.** A barplots for STIM-TYPE by RESP is provided below. The main observation is that sentences with n-words license both positive and negative VP ellipsis in agreeing responses with a very strong preference for negative responses, unlike sentences with referential or existential direct objects, which basically license only positive VP ellipsis.



Thus, this experiment confirms the findings of experiment 2 by means of a different diagnostic (VP ellipsis as opposed to polarity particles) and seems to indicate that n-words in direct object position exhibit the same kind of semantic behavior as when they occur in subject position. Appendix A.3 provides the details of the statistical analysis.

## 6 Conclusion

The goal of this paper was to contrast two major approaches to n-words: the NI approach, which treats n-words as indefinites in the scope of a (possibly covert) sentential negation operator, and the NQ approach, which treats n-words on a par with ordinary quantifiers. We considered two cases where these two approaches make different predictions, and tested these predictions experimentally.

The first set of experiments was concerned with polarity particles. We found that in agreeing responses to negative sentences both *yes* and *no* are licensed, while in agreeing responses to positive sentences only *yes* is possible. Sentences with n-words were shown to license both *yes* and *no* in such responses, i.e., with respect to particle distribution in responses sentences containing n-words in English behave like sentences with sentential negation. This is directly predicted by NI analyses, but not, at least not without further stipulations, by NQ analyses.<sup>9</sup> Note also that the results of Experiment 1 confirm the theoretical approach to polarity particles we adopted here in as much as that approach predicts that both particles will occur in such responses, with a preference for the negative particle. There are two features of our theoretical account

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<sup>9</sup>As noted before, the account of [de Swart and Sag \(2002\)](#) falls, for our purposes, within the NI approach, as it assumes that the same polyadic negative operator occurs both in ordinary negative sentences and in sentences involving n-words in English, the only difference between them being the addicity of the operator.

of particle distribution that are crucial for distinguishing between the NI and the NQ analyses of n-words: (i) the distinction between positive and negative initiatives with respect to the distribution of polarity particles in responses, and (ii) the prediction that both particles are possible in agreeing responses to negative antecedents but not in agreeing responses to positive ones.

The last experiment was concerned with responses involving VP ellipsis to initiatives with and without n-words. We saw that initiatives with n-words triggered agreeing responses with a negated auxiliary verb, in sharp contrast with positive initiatives without n-words. Again, this is in line with NI analyses, but not with NQ analyses.

Thus, the experimental results obtained here favor the NI approach over the NQ approach. They also raise a number of issues for future work. Perhaps most strikingly, in experiment 2 we found a clear contrast between different types of subject NPs. For instance, in agreeing responses to sentences like *Peter didn't step forward* (with a referential subject NP) we found a strong preference for *no* over *yes*, while in agreeing responses to sentences like *Exactly five students didn't step forward* (with a non-monotonic quantificational subject NP) we found a strong preference for *yes* over *no*. This contrast is not relevant for the purposes of the present paper, but does of course stand in need of explanation.

A second striking finding was that, even though in response to sentences like *Mary visited none of her friends* there was a strong preference for *I agree, she didn't* over *I agree, she did*, the second type of response was not completely ruled out. It should be tested whether this is also the case for ordinary negative sentences like *Mary didn't visit any of her friends*. If so, this would be in line with the experimental results obtained here. If not, however, (and this is actually what we suspect) there would be a contrast between ordinary negative sentences and sentences involving n-words, which is unexpected on the NI approach. One would then have to explain both the data where the NI approach makes the right predictions and the data where it does not.

## A Statistical modeling

### A.1 Experiment 1

Given that the dependent variable RESP is binary, we use logistic regression models to analyze the data. The first model we consider is the full model as far as the fixed effects STIM-POL, NP-TYPE and PART-POS are concerned: main effects plus all two-way and three-way interactions; in addition, we consider intercept-only random effects for both subjects and items.

No term involving PART-POS (main effect or interaction) is significant. Dropping PART-POS (all 8 terms: the main effect, 4 two-way interactions, 3 three-way interactions) does not significantly increase the deviance ( $p = 0.41$ ). Furthermore, the item random effects account for practically no variance, so we drop them. Therefore, we focus exclusively on the STIM-POL and NP-TYPE fixed effects and the subject random effects.

We investigate whether we need to add random effects for slopes in addition to the intercept random effects. Adding random effects for STIM-POL in addition to intercept random effects is highly significant ( $p = 7.81 \times 10^{-8}$ ). Adding random effects for NP-TYPE in addition to the random effects for STIM-POL and the intercept is not significant ( $p = 0.86$ ). Similarly, adding random effects for NP-TYPE to the model with intercept-only random effects is not significant, but adding random effects for STIM-POL in addition to random effects for NP-TYPE and the intercept is highly significant. Therefore, we will focus exclusively on the model with STIM-POL and NP-TYPE fixed effects (including interactions) and random effects for the intercept and the STIM-POL slope.

We check that we need all the fixed effects. Adding NP-TYPE to the model with STIM-POL as the only fixed effect and random effects for both the intercept and the STIM-POL slope is highly significant ( $p = 6.81 \times 10^{-16}$ ). Similarly, adding the interaction between STIM-POL and NP-TYPE to the model with STIM-POL and NP-TYPE as additive fixed effects and with random effects for both the intercept and the STIM-POL slope is highly significant ( $p = 3.15 \times 10^{-6}$ ).

Thus, our final mixed-effects logistic regression model is as follows. Fixed effects: STIM-POL, NP-TYPE and their interaction. Random effects: subject random effects for the intercept and the STIM-POL slope. The maximum likelihood estimates (MLEs) for this model are provided below:

RANDOM EFFECTS		std.dev.	corr.	
	INTERCEPT	3.89		
	STIM-POL- <b>neg</b>	4.2	-0.95	
FIXED EFFECTS		estimate	std.error	p-value
	INTERCEPT	8.58	1.62	$1.21 \times 10^{-7}$
	STIM-POL- <b>neg</b>	-10.21	1.66	$7.44 \times 10^{-10}$
	NP-TYPE- <b>atmost</b>	-2.55	1.39	0.067
	NP-TYPE- <b>exactly</b>	-1.47	1.44	0.31
	NP-TYPE- <b>some</b>	-2.25	1.4	0.11
	STIM-POL- <b>neg</b> : NP-TYPE- <b>atmost</b>	5.43	1.44	$1.61 \times 10^{-4}$
	STIM-POL- <b>neg</b> : NP-TYPE- <b>exactly</b>	4.47	1.49	$2.74 \times 10^{-3}$
	STIM-POL- <b>neg</b> : NP-TYPE- <b>some</b>	3.74	1.44	$9.45 \times 10^{-3}$

We observe the following. The intercept (i.e., a positive polarity sen-

tence with a referential subject) indicates a highly significant preference for the particle ‘yes’. Changing the polarity of the sentence while keeping the subject referential contributes a strong preference for the particle ‘no’, as expected; however, the particle ‘yes’ is not ruled out, it is just overall dispreferred. For positive polarity sentences, changing the NP type of the subject does not contribute any significant preference for ‘yes’ (or ‘no’) compared to the preferences exhibited by positive sentences with referential subjects. For negative polarity sentences however, all non-referential NP types contribute strong preferences for the ‘yes’ particle (compared to referential NPs). This interaction between negative polarity and non-referential NP type was already visible in the mosaic plot above – and it is rather unexpected (discovering new fine-grained generalizations of this kind is one of the most important contributions that experimental methods and statistical modeling can make to formal semantics).

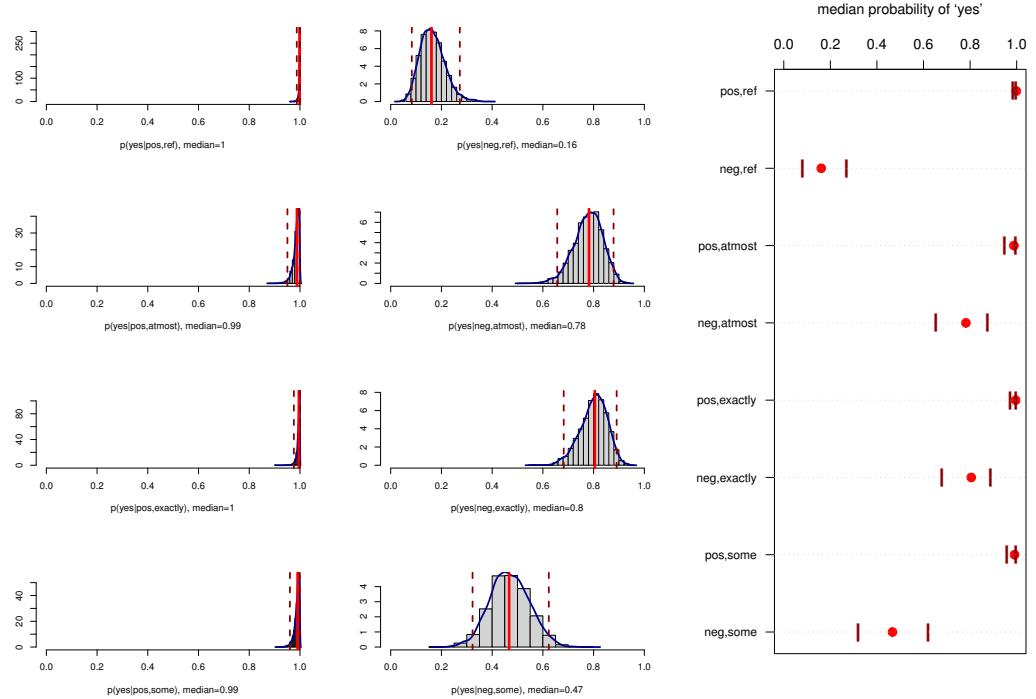
We will quantify all these ‘yes’ / ‘no’ preferences more precisely based on the Bayesian estimates of their posterior distributions. Priors for fixed effects: the priors for the intercept and the non-reference levels STIM-POL, NP-TYPE and their interaction are all independent normals  $N(0, 10^2)$ . Priors for random effects: we assume a bivariate normal distribution for the intercept and STIM-POL-NEG random effects with correlation  $\rho$  between the two random effects  $N \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2 & \rho\sigma\tau \\ \rho\sigma\tau & \tau^2 \end{bmatrix} \right)$ .

The priors for the intercept standard deviation  $\sigma$  and the STIM-POL-NEG standard deviation  $\tau$  are independent uniforms  $Unif(0, 10)$  and the prior for  $\rho$  is  $Unif(-1, 1)$ . MCMC estimation: 3 chains, 300000 iterations per chain, 50000 burnin, 125 thinning. As the table below shows, the means and standard deviations of the posterior distributions for the random and fixed effects are close to the MLEs (with some shrinkage):

RANDOM EFFECTS		mean	std.dev.
	$\sigma$	2.22	0.75
FIXED EFFECTS	$\tau$	2.84	0.74
	$\rho$	-0.82	0.11
FIXED EFFECTS	INTERCEPT	6.72	1.39
	STIM-POL- <b>neg</b>	-8.39	1.43
	NP-TYPE- <b>atmost</b>	-2.18	1.13
	NP-TYPE- <b>exactly</b>	-1.14	1.22
	NP-TYPE- <b>some</b>	-1.91	1.15
	STIM-POL- <b>neg</b> : NP-TYPE- <b>atmost</b>	5.13	1.21
	STIM-POL- <b>neg</b> : NP-TYPE- <b>exactly</b>	4.22	1.29
	STIM-POL- <b>neg</b> : NP-TYPE- <b>some</b>	3.45	1.21

We plot below the posterior distributions of the preference for, i.e., prob-

ability of, a ‘yes’ response together with the median probability and 95% credible interval for each of the two stimulus polarities and the four NP types. The second plot juxtaposes the median probabilities and their 95% credible intervals for easier comparison.



## A.2 Experiment 2

The first model we consider is the full model as far as the fixed effects STIM-TYPE and GRAM-FUN are concerned (main effects plus all two-way interactions) and intercept-only random effects for both subjects and items.

We investigate whether we need to add random effects for slopes in addition to the intercept random effects. Adding subjects and items random effects for STIM-TYPE slopes in addition to intercept random effects is not significant ( $p = 0.38$ ). Adding subjects and items random effects for the GRAM-FUN slope in addition to intercept random effects is not significant ( $p = 0.98$ ). Therefore, we will focus exclusively on the model with STIM-TYPE and GRAM-FUN fixed effects (including interactions) and intercept-only random effects for subjects and items.

We check that we need all the fixed effects. The interaction between STIM-TYPE and GRAM-FUN does not significantly reduce deviance ( $p = 0.08$ ). Moreover, adding GRAM-FUN to the model that has STIM-TYPE as the only fixed effect is not significant ( $p = 0.47$ ) and adding GRAM-FUN to the null (intercept) model is not significant either ( $p = 0.93$ ).

In contrast, adding STIM-TYPE to the null (intercept) model is highly significant ( $p = 3.15 \times 10^{-8}$ ) and adding STIM-TYPE to the model that has GRAM-FUN as the only fixed effect is also highly significant ( $p = 2.43 \times 10^{-8}$ ). Thus, we will consider models with STIM-TYPE as the only fixed effect from now on.

Random effects for items account for practically no variance, so we drop them.

Our final mixed-effects logistic regression model is as follows. Fixed effects: STIM-TYPE. Random effects: subject random effects for the intercept. The MLEs for this model are:

RANDOM EFFECTS		std.dev.		
	INTERCEPT	0.63		
FIXED EFFECTS		estimate	std.error	p-value
	INTERCEPT	-0.04	0.21	0.85
	STIM-TYPE- <b>none</b>	-0.64	0.29	0.025
	STIM-TYPE- <b>some</b>	3.22	0.52	$8.76 \times 10^{-10}$

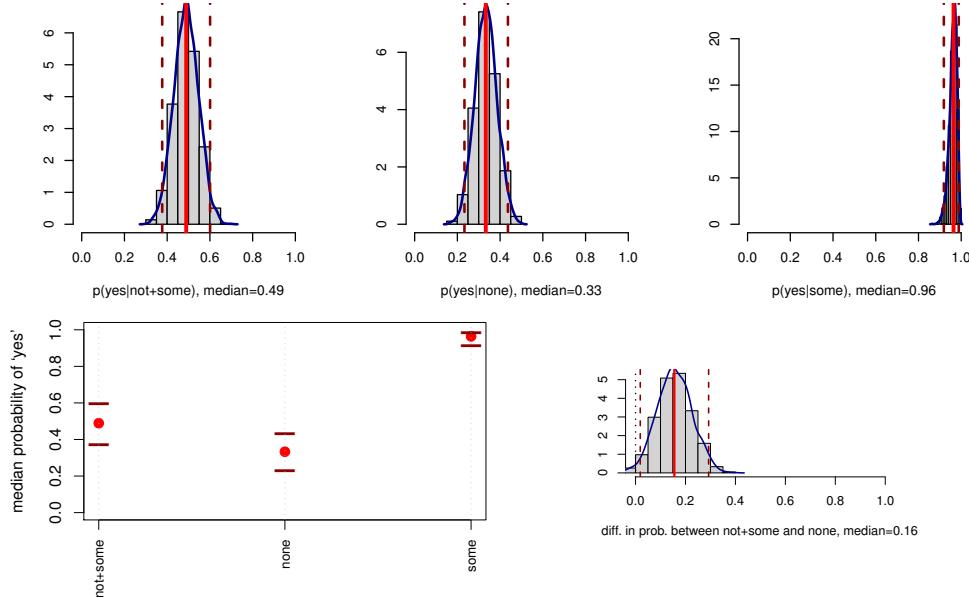
We observe the following. Negative quantifiers have a higher preference for ‘no’ than negation + existentials that is statistically significant. However, the intercept is not statistically significant: negation + existential sentences have no clear preference for ‘yes’ vs. ‘no’. Finally, existential sentences have a significantly higher preference for ‘yes’ than negation + existential sentences.

We will quantify all these ‘yes’ / ‘no’ preferences more precisely based on the Bayesian estimates of their posterior distributions. Priors for fixed effects: the priors for the intercept and the non-reference levels of STIM-TYPE are all independent normals  $N(0, 100^2)$ . Priors for random effects: we assume a normal distribution  $N(0, \sigma^2)$  for the intercept random effects; the prior for the standard deviation  $\sigma$  is uniform  $Unif(0, 100)$ . MCMC estimation: 3 chains, 225000 iterations per chain, 25000 burnin, 200 thinning. As the table below shows, the means and standard deviations of the posterior distributions for the random and fixed effects are very close to the MLEs:

RANDOM EFFECTS		mean	std.dev.
	$\sigma$	0.71	0.3
FIXED EFFECTS		mean	std.dev.
	INTERCEPT	-0.04	0.23
	STIM-TYPE- <b>none</b>	-0.66	0.3
	STIM-TYPE- <b>some</b>	3.37	0.55

We plot below the posterior distributions of the preference for, i.e., probability of, a ‘yes’ response together with the median probability and 95% credible interval for the three stimulus types. The second plot jux-

poses the median probabilities and their 95% credible intervals for easier comparison. The third plot shows the difference in probability of ‘yes’ between negation + existentials and negative quantifiers; since the 95% interval (0.019, 0.293) does not overlap 0, we are fairly confident that negative quantifiers have a higher preference for ‘no’.



### A.3 Experiment 3

The first model we consider has STIM-TYPE as the only fixed effect and intercept-only random effects for both subjects and items. Therefore, we will focus exclusively on the model with STIM-TYPE and GRAM-FUN fixed effects (including interactions) and intercept-only random effects for subjects and items. The random effects for subjects and items account for practically no variance, so we omit them. The final model is an ordinary logistic regression with only one categorial predictor, namely STIM-TYPE. The MLEs for this model are:

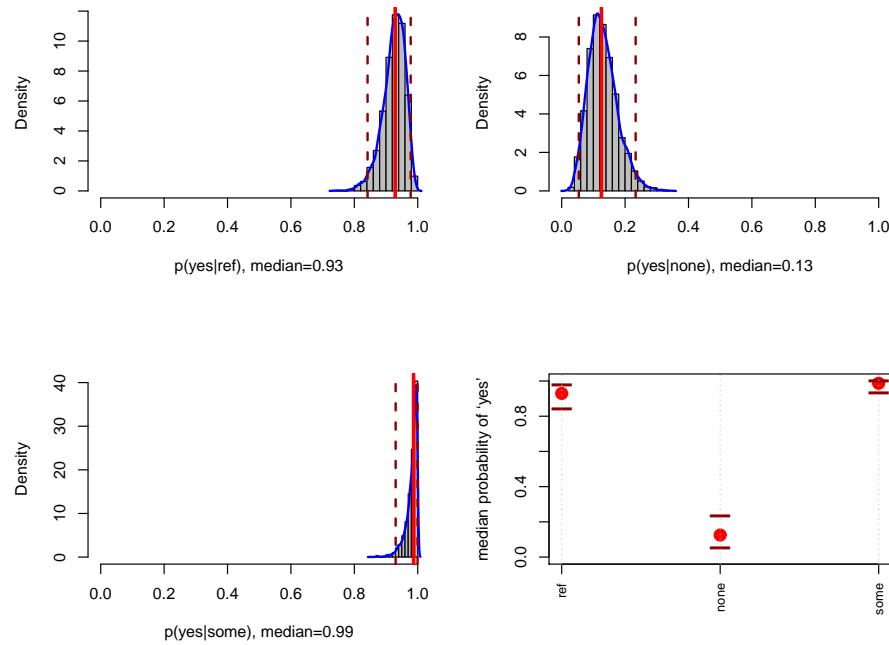
FIXED EFFECTS		estimate	std.error	p-value
	INTERCEPT	2.51	0.52	$1.4 \times 10^{-6}$
	STIM-TYPE-none	-4.39	0.66	$2.9 \times 10^{-11}$
	STIM-TYPE-some	1.45	1.14	0.2

We observe that initiatives with n-words in direct object position have a much higher preference for negative VP ellipsis than initiatives with referentials in direct object position. Moreover, existentials have pretty much the same overwhelming preference for affirmative VP ellipsis as referentials.

We can take a closer look at these preferences based on the Bayesian estimates of their posterior distributions. Priors for fixed effects, i.e., the intercept and the non-reference levels of STIM-TYPE, are all independent normals  $N(0, 100^2)$ . MCMC estimation: 3 chains, 50000 iterations per chain, 10000 burnin, 40 thinning. As the table below shows, the means and standard deviations of the posterior distributions for the fixed effects are very close to the MLEs:

FIXED EFFECTS		mean	std.dev.
	INTERCEPT	2.62	0.55
	STIM-TYPE- <b>none</b>	-4.58	0.68
	STIM-TYPE- <b>some</b>	1.88	1.37

We plot below the posterior distributions of the preference for, i.e., probability of, an affirmative VP-ellipsis response (coded as **yes**, just as we before) together with the median probability and 95% credible interval for the three stimulus types. The final plot juxtaposes the median probabilities and their 95% credible intervals for easier comparison.



We see that the probability of a negative VP-ellipsis response to initiatives with referential or existential direct objects is practically null. In contrast, the probability of a negative VP-ellipsis response to initiatives with n-word direct objects is very high (median  $0.87 = 1 - 0.13$ ) – but an affirmative VP-ellipsis response to initiatives with n-word direct objects is also possible, although very unlikely.

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