Adaptation at the Syntax-Semantics Interface: Evidence from a Vernacular Construction

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Abstract. Expanding on psycholinguistic research on linguistic adaptation, the phenomenon whereby speakers change how they comprehend or produce structures as a result of cumulative exposure to less-frequent or unfamiliar linguistic structures, the present study asks whether speakers can learn the semantic and syntactic properties of the vernacular Negative Auxiliary Inversion (NAI) construction (e.g. *didn't everybody eat*, meaning 'not everybody ate') during the course of an experiment. Participants unfamiliar with the NAI construction were exposed to NAI sentences in either semantically ambiguous or unambiguous contexts. Participants acquired the interpretive properties of NAI and demonstrated native-like syntactic knowledge of restrictions on its subject-type, even after only limited exposure in semantically ambiguous contexts. These results highlight that linguistic adaptation can include the ability to rapidly learn core semantic and syntactic properties of unfamiliar structures, and underscore the utility of incorporating models of hierarchical structure and constituency into theoretical accounts of linguistic adaptation.

Keywords: linguistic adaptation, syntax, semantics, English vernacular, negative auxiliary inversion, scope of negation, quantifier scope

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1. Introduction

The question of whether and how exposure to unfamiliar or infrequent structures modulates speakers' structural representations has been the subject of much psycholinguistic inquiry and debate (see Kaan & Chun 2018, for recent review). Studies addressing this question typically observe whether changes occur in participants' behaviors during the course of an experiment, as a result of cumulative exposure to unfamiliar or infrequent structures. Researchers then draw inferences about grammatical changes that may underlie these observed changes in behavior. Such studies can serve as useful short-term analogs for linguistic processes that occur naturally over longer timespans, such as language acquisition and change (Kaan & Chun 2018: 86), and can therefore inform fundamental questions, including how and why languages change over time, how people acquire languages, and what happens when languages and language varieties come into contact.

Studies have also employed unfamiliar vernacular structures as a way of examining structural changes during an experiment (e.g., Kaschak & Glenberg, 2004; Fraundorf & Jaeger 2016). Observing the processing of unfamiliar vernacular structures is useful since these structures typically have properties that overlap with, but are not identical to, structures already familiar to speakers. The current study advances this line of research by asking whether speakers can learn the specific semantic and syntactic properties of the vernacular Negative Auxiliary Inversion (NAI) structure in English. By moving beyond reading time data to probe people's interpretation of an unfamiliar vernacular structure, the present study advances our understanding of how linguistic adaptation takes place and what structural properties people can (or cannot) adapt to as a result of short-term exposure to an unfamiliar structure.

2. Background

2.1 *Adaptation*

In the psycholinguistic literature, *linguistic adaptation* is the phenomenon by which speakers and listeners change how they comprehend or produce linguistic structures as a result of cumulative exposure to similar structures in the input (see Kaan & Chun 2018, for review). Such changes can occur at all linguistic levels, ranging from adaptation to a particular accent (i.e., at the level of phonology), or word choice, and even to particular syntactic structures. For instance, previous research has shown that people can adapt their interpretation of the quantities denoted by *many* and *some* to match the quantities presented during the course of an experiment (Yildirim, et al. 2016; see e.g., Metzing & Brennan 2003, for related findings at the lexical level). People can also rapidly learn to anticipate either a low- or high-attachment preference for ambiguous relative clause attachment, as in *The uncle of the girl who will ride the motorbike,* based on talker identity, and whether an individual talker produced sentences that always resolved to the high- or low-attachment interpretation (Kamide 2012; see also Chun 2018). People also tend to speed up their reading of less-frequent syntactic structures (e.g., object relative clauses and reduced relative clauses) through repeated exposure, reading them as fast as or even faster than related structures that are more frequent (e.g., Fine et al. 2013; Kaan et al. 2019; Wells et al. 2009; but see Harrington Stack et al. 2018, for counterevidence).

Studies also show similar adaptation behaviors when people are presented with completely unfamiliar structures from an unfamiliar dialect. For instance, Fraundorf and Jaeger (2016) showed that people unfamiliar with the *needs washed* construction (e.g., *the car needs washed*, as used in the Midlands dialect region; see Maher & Wood 2011 for a review) will read such sentences as quickly as people familiar with the structure in as few as four to seven trials (see also Kaschak &

Glenberg 2004). Further, participants then generalized this reading pattern to a different and unattested structure, which Fraundorf and Jaeger referred to as the *be*-drop construction (e.g., *The copier will recycled because it no longer works*), reading *be*-drop sentences as fast as they read *needs washed* sentences. In contrast, participants who were already familiar with the *needs washed* construction exhibited slower reading times upon encountering *be*-drop sentences. Fraundorf and Jaeger attribute this generalization effect to the idea that, since participants previously unfamiliar with *needs washed* had recently been exposed to one unfamiliar structure, they were primed to expect additional unfamiliar structures in their input. The authors further suggest that because participants who were previously familiar with *needs washed* had not treated these sentences as unfamiliar, they had not been primed to adapt to a new structure, hence their slower *be*-drop reading times. An alternative interpretation of this result is that, for those participants already familiar with the *needs washed* construction, their grammatical knowledge of this construction included knowledge of when it does and does not generalize to unattested unfamiliar structures like *be*-drop (see also, Kaan & Chun 2018).

In a related line of research, Luka and colleagues (Luka & Barsalou 2005; Luka & Choi 2012) found that people rated grammatical but relatively infrequent pseudo-cleft sentences (e.g., *What the pharmacist recommended is to read the instructions*) as significantly more acceptable after reading sets of other pseudo-cleft sentences aloud, and that such modulations in acceptability could extend up to 48 hours post-exposure. However, there were no parallel changes in acceptability when participants were simply prompted to repeatedly make acceptability judgments about sentences without reading them aloud, for either similarly infrequent grammatical sentences or for completely ungrammatical sentences. Luka and colleagues argue that such results highlight the key role that "reading for comprehension" plays in how people adapt to less frequent structures.

However, this leaves open the question of whether the lack of adaptation to ungrammatical (and thus unattested) structures was a result of participants having rated those sentences without having attempted to comprehend them in an earlier phase of the study. An alternative interpretation of their results is that adaptation to ungrammatical structures is fundamentally different because such structures are not part of a speaker's grammatical knowledge to begin with (see also Fine et al. 2013), or because the speaker's grammatical knowledge includes rules that prohibit these structures.

Explanations for adaptation effects, such as changes in reading times and acceptability judgments, often implicate implicit learning mechanisms (e.g., Chang et al. 2006; Dell & Chang 2014; Kleinschmidt & Jaeger 2015; but see Reitter et al. 2011, for an alternative explanation). People are aware of the distributional frequencies of different linguistic structures in their input (e.g., Aslin & Newport 2012; Yang 2010). As the frequency with which one encounters a given structure changes—either over the short-term in an experimental context, or over longer periods of time in a more naturalistic environment—people adjust their expectations regarding the likelihood of encountering that same structure in the future. Over time, such adjustments can lead to cumulative changes in the linguistic system, which constitutes a form of learning. One key piece of evidence favoring such accounts is the inverse frequency effect, whereby adaptation over time is strongest for less common or unfamiliar, yet still attested, linguistic structures (e.g., Bernolet & Hartsuiker 2010; Bock 1986; Jaeger & Snider 2013; Kaschak et al. 2011; Peter et al. 2015). In essence, adaptation parallels learning in that such effects are greater for something that is initially less well-known versus something that is already well-known. Further, adaptation generalizes beyond the specific lexicalizations people encounter during initial exposure (see Mahowald et al.

2016, for review), providing additional evidence that cumulative changes over time occur at a more abstract level.

Other researchers posit a role for explicit or episodic memory processes in adaptation, especially when people are faced with reading and comprehending completely unfamiliar or ungrammatical sentences (e.g., Kaschak & Glenberg 2004). Under such an account, when people encounter an unusual structure, this structure leaves a trace in episodic memory. This memory trace then facilitates the comprehension of both the same and other similar structures when they are encountered again in subsequent input. As discussed by Kaan and Chun (2018), the fact that people sometimes exhibit adaptation not only to the specific targeted syntactic structure, but also to similar, but not identical, structures raises the question of what, precisely, constitutes syntactic adaptation. Do people actually adapt to the syntactic structure per se, or rather to some subset of atypical constructions more generally?

To date, a majority of research on syntactic adaptation during comprehension has relied on the analysis of reading times and, to some extent, acceptability judgements. Far less research has considered how people's interpretation of less frequent or potentially unfamiliar syntactic structures may change over time due to increased exposure (but see Chun 2018; Kroczek & Gunter 2017, for exceptions). Further, in addition to questioning what readers actually adapt to, researchers have also asked to what extent adaptation effects, as reported in the experimental literature, are limited in scope to the specific experimental paradigm employed (see Kaan & Chun 2018; Prasad & Linzen 2019, for further discussion). To address these questions, the present study investigates if and how people learn to interpret NAI constructions, a syntactic structure present in numerous vernacular English varieties.

2.2 *Negative Auxiliary Inversion*

2.2.1 *General usage and interpretation*

To understand the syntax of NAI, it is helpful to first observe negative yes-no questions such as the underlined portion of the following context:

(1) A study group is discussing the main points from a lecture. One student is surprised to find that some classmates seem confused. She says: Didn't everybody understand what the professor said? I thought it was super clear.

Example (1) contains a (negative) yes-no interrogative, realized syntactically by placement of the auxiliary in pre-subject position.[3] Typically, such yes-no questions are realized with a final-rising intonation (Bolinger 1978).

In many varieties of American English, strings that appear as yes-no questions as in (1) can also be used as declarative statements, as in the following context:

(2) A study group is discussing the main points from a lecture. Most students agree that things were really clear, but one student disagrees. He says: Didn't everybody understand what the professor said. I was totally confused.

In context (2), the underlined portion is string-identical to the interrogative we saw previously, with the negated auxiliary appearing in pre-subject position. However, in this case the string is

[3] For a review and discussion of negative yes-no questions as in (1), see Dayal (2016: 270–277). We set the meaning properties of these constructions aside, as they are unrelated to NAI interpretation.

pronounced and interpreted as a declarative, with a meaning equivalent to ‘not everybody understood what the professor said’. This is the phenomenon of NAI, first observed by Labov et al. (1968). At its core is the relationship between the subject and the auxiliary, which occur in an order that is non-canonical in both standardized and vernacular Englishes. Two further descriptive characteristics of NAI are that the auxiliary must be negated (e.g., Parrott 2000; White-Sustaíta 2010), and the negation appears as the clitic *n’t* as opposed to the marker *not* (Blanchette 2015; Parrott 2000; Matyiku 2017; Salmon 2018).

Since Labov et al.’s (1968) initial observations of NAI use by vernacular African American and Latinx speakers in New York, NAI has been observed in White Alabama English (Feagin 1979), West Texas English (Foreman 1999, 2001; Matyiku 2017), Vernacular Texas English (Salmon 2018), African American English (Green 2002, 2014; Parrott 2000; Sells et al. 1996; Weldon 1994), and Appalachian English (Wolfram and Christian 1976; Montgomery 2004; Montgomery and Hall 2004; Tortora and Den Dikken 2010). A comprehensive review of the literature on NAI can be found in Matyiku (2011).

Note that the NAI example in (2) above contains the non-negative, universal quantifier subject *everybody*. In anticipation of our methods, we note that this particular NAI pattern served as the focus of our investigation. This is despite the fact that NAI is most commonly found with morphologically negative subjects (e.g., Blanchette & Collins 2018; Matyiku 2017; Sells et al. 1996) (e.g., *Didn’t nobody understand*), as these can also be classified as Negative Concord constructions, in which two or more syntactic negations contribute a single semantic negation (as in the ‘I ate nothing’ reading of *I didn’t eat nothing*). Negative Concord is highly stigmatized in English, and can occur independently of NAI. Because of this stigma, and because of independent syntactic and semantic properties of sentences with two negations, it was necessary to avoid

Negative Concord in our experiment. Our focus on NAI sentences with universal quantifier subjects further allowed us to isolate the semantic property of interest, namely, the obligatory wide scope of negation in NAI.

2.2.2 *Negation and quantifier scope*

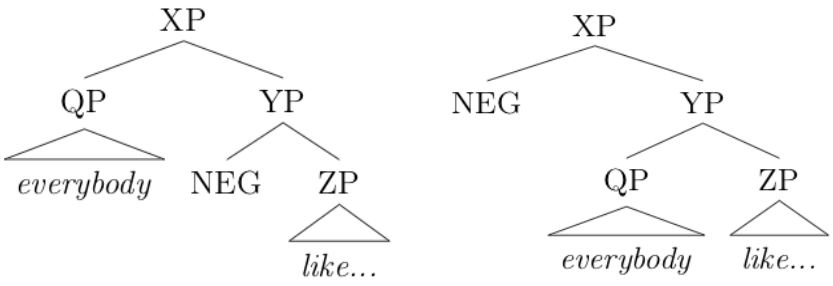
Theoretical analyses of NAI have built on important empirical generalizations about this construction type, one of which pertains to the phenomenon of taking scope. Since May (1977), the phenomenon of scope-taking can be understood as the source of ambiguity in sentences like the following:

(3) Everybody didn't like the movie.

Sentence (3) is compatible with two truth-conditionally distinct interpretations: (i) everybody is such that they did not like the movie (i.e., nobody liked it), and (ii) not everybody liked the movie (but some may have). We henceforth call these the narrow-scope (i) and wide-scope (ii) negation readings.

The availability of both a wide-scope and a narrow-scope negation reading for sentences like (3) can be attributed to the presence of two scope-bearing elements: a negation (*n't*), and a quantificational noun phrase (*everybody*). May (1977) proposes to model the phenomenon of scope-taking as abstract syntactic movement of scope-bearing elements to a higher, structurally peripheral position. It follows that when two scope-bearing elements are present in a sentence, there are two possible abstract structures. The structures for (3) are illustrated here (QP = quantifier phrase, NEG = negation; irrelevant details omitted):

(3a) narrow-scope negation (3b) wide-scope negation



In structure (3a), the universal quantifier *everybody* takes wide scope, yielding the narrow-scope negation reading in which nobody liked the movie. Note that in terms of linear order, the string in (3) maps onto the structure in (3a). This contrasts with structure (3b), in which the negation takes scope over the quantificational subject yielding the wide-scope negation reading, despite its surface appearance following the quantifier. The fact that the wide-scope negation reading represented by (3b) is available for the string in (3) shows that quantifiers need not take scope in the order in which they appear on the surface. Assuming that both the wide- and narrow-scope negation readings of (3) are generally available for English speakers (and setting preferences for one reading over the other aside), both surface and inverse scope relations thus constitute a general part of English speakers' linguistic knowledge.

The proposition in (3) can also be asserted in the form of an NAI construction, as follows:

(4) Didn't everybody like the movie.

Sentence (4) has the same two scope-taking elements as (3), *n't* and *everybody*, so we might expect it to also be truth-conditionally ambiguous. However, as first observed in Foreman (1999:11; see also Matyiku 2017), in NAI only the wide-scope negation reading is possible, and quantificational

subjects must take narrow scope relative to the negation. This means that only (4b) is available as a reading of (4), and (4a) is not:

(4a) 'Nobody liked the movie.' (~~narrow-scope negation)~~

(4b) 'Not everybody liked the movie.' (wide-scope negation)

Numerous theoretical works have sought to model the lack of scope ambiguity in NAI (Blanchette & Collins 2018; Foreman 1999; Green 2014; Matyiku 2017; Sells et al. 1996; among others). Several theories derive the obligatory wide scope of negation by proposing that the negation raises over the subject overtly in the syntax. In theories such as Foreman (1999) and Matyiku (2017), the wide scope negation property of NAI serves as the impetus for overt syntactic raising, while in Green (2014) the construction is associated with a special negative focus feature that triggers raising of the negation (see also White-Sustaíta 2010).

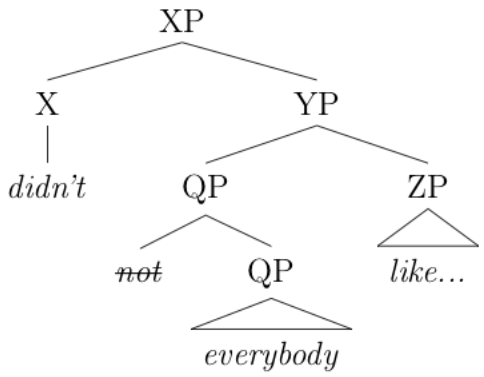
Blanchette and Collins (2018) take a different approach to modeling the lack of scope ambiguity in NAI. They hypothesize that NAI involves the following grammatical constraint:

(5) The NAI Subject Condition (NAISC) (Blanchette & Collins 2018: 9, ex. (19))

In NAI, the subject is negative.

For a sentence like (4), this means that the underlying structure of the quantifier phrase *everybody* is actually a negated quantifier phrase, akin to *not every player*. Instead of raising over the subject as in other theories, the negation instead raises from within the subject, as follows:

(6) Blanchette & Collins (2018)



The negation enters the structure as a specifier of the quantificational noun phrase (see ~~*not*~~), and from there raises and cliticizes to a higher position (as *-n't*). Given that the negation is introduced as part of the quantifier phrase, the structure captures the fact that there is no inverse scope reading in which the quantifier takes wide scope relative to the negation.

Note that prior to raising of the negation, the structure in (6) would yield the following string:

(7) Not everybody liked the movie.

Thus, according to Blanchette and Collins (2018), the NAI construction in (6) is a structural analogue of (7), with the minimal difference of the raised negation. As outlined in the next section,

this proposal also captures restrictions on the type of noun phrase that can occur in NAI subject position.

2.2.3 *Phrase type constraints on NAI subject position*

In addition to the lack of scope ambiguity in NAI, previous theoretical work has also built on an important generalization regarding the type of subject that can occur in NAI, first observed by Foreman (1999: 11–12; see also Matyiku 2017 for an extensive description of the subject restrictions in NAI). Note first that NAI sentences with quantificational and Negative Polarity Item subjects are parallel in meaning and acceptability with sentences in which *not* occurs immediately preceding the subject:

(8) (a) Didn't everybody finish their homework. (Foreman 1999: 11, ex. (29d))

(b) Not everybody finished their homework.

(9) (a) Didn't many people go to the party. (Foreman 1999: 11, ex. (29b))

(b) Not many people went to the party.

(10) (a) Dudn't anybody seem to understand.[4] (Feagin 1979: 235, ex. (73))

(b) Not anybody seemed to understand.

(11) (a) Didn't half the students do their homework. (Foreman 1999: 8, ex. (29f))

(b) Not half the students did their homework.

[4] We maintain Feagin's (1979) original spelling of the auxiliary, which reflects the vowel quality typically employed by the Alabama English speakers she surveyed.

Importantly, the set of subject types that according to previous literature are impossible in NAI are also unacceptable when immediately preceded by *not*:

(12) (a) *Didn't Jamie see the fight. (Matyiku 2017: 16, ex. (1.19))

(b) *Not Jamie saw the fight.

(13) (a) *Didn't the teachers go to the party. (Foreman 1999: 11, ex. (28c))

(b) *Not the teachers went to the party.

(14) (a) *Didn't few people live there then. (Matyiku 2017: 75, ex. (3.5b))

(b) *Not few people lived there then.

(15) (a) *Didn't some person come. (Matyiku 2017: 76, ex. (3.6b))

(b) *Not some person came.

A quantitative acceptability judgment study with speakers familiar with NAI (primarily from Appalachia) in Blanchette and Collins (2018) confirms this pattern, noting that while the acceptability of attested NAI subjects as in (8) through (11) declines as a function of frequency, the unattested subjects in (12) through (15) are all equally unacceptable.[5]

Given these observations, speaker knowledge of NAI thus also appears to include an understanding of the type of phrase that can occur in subject position. Different theories have different ways of deriving this knowledge. For example, Foreman (1999) (following Kiss 1996), attributes the distribution of subjects to a mechanism of obligatory movement of referential subjects as in (12) through a Referential Phrase, which excludes constructions such as (12a). Green

[5] Salmon (2018) observes that for some Texan speakers, NAI sentences with definite subjects as in (13a) are possible under certain pragmatic conditions. We set this issue aside here, as it does not play a role in our experiment design or results interpretation.

(2014) appeals to a more general condition in which NAI subjects must be "strongly quantificational".

For Blanchette and Collins (2018), the distribution of subjects in NAI is derived by the same mechanism that derives the obligatory wide scope negation of NAI, namely, the constraint that NAI subjects must be (underlyingly) negative, as stated in (5) above. Because in this analysis the negation directly modifies the quantifier (see structure (6)), it follows that the same constraints which (dis)allow *not*-phrases in subject position are also in effect in NAI. Under this theory, speaker knowledge of the constraints on NAI subject type is thus equivalent to speaker knowledge of the constraints on *not*-phrase subjects, a more mainstream construction type.

2.3 *Adaptation at the syntax-semantics interface?*

While the previous adaptation studies discussed above examined reading times and acceptability judgments, in the present study we rely on the theoretical models of the semantic and syntactic properties of NAI constructions to probe whether and how native English speakers with no prior experience with NAI constructions adapt to the semantic properties of an unfamiliar construction during an interpretation task, and specifically, to the obligatory wide scope interpretation of negation in NAI constructions with universal quantifier subjects. By manipulating whether participants were exposed to NAI sentences in linguistically ambiguous contexts versus NAI sentences whose meaning is unambiguous based on the surrounding linguistic context during a short training unit, and comparing their performance to a control group who received no additional training exposure and only completed the pre- and post-training interpretation blocks, we investigated the extent to which the amount and type of input impacts participants' adaptation to the syntactic-semantic properties of an unfamiliar vernacular structure. If exposure leads

participants to adapt to the syntactic and semantic properties of NAI, then this will be reflected in an increase in wide-scope negation interpretations from pre-training to post-training, with larger increases in the two groups of participants who complete the training block and thus receive more exposure overall compared to the control group. If receiving unambiguous input that supports only a wide-scope negation reading leads to better adaptation, then in the post-training block, participants receiving unambiguous input during the training unit should select more wide-scope negation responses than participants receiving semantically ambiguous input during training.

Additionally, we asked whether speakers would generalize their learning from the interpretation task to a subsequent naturalness rating task, which included NAI constructions with acceptable and attested *many* subjects and unacceptable and unattested *few* subjects, which they had not been previously exposed to. Given the close and transparent relationship between structure and meaning in NAI, if speakers display evidence of learning its semantic and syntactic properties during the course of an experiment, then this provides support for the existence of structural adaptation to a vernacular structure beyond surface-level properties, at the syntax-semantics interface. If exposure leads to generalization to a new *task*, then participants should give higher ratings to NAI items with universal quantifier (*every*) subjects in wide-scope negation contexts than in narrow-scope negation contexts. If exposure leads to *structural* generalization, then participants should differentiate between NAI sentences with acceptable and attested *many* subjects and those with unacceptable and unattested *few* subjects, giving higher ratings to NAI items with *many* subjects and lower ratings to NAI items with *few* subjects. In both cases, if more exposure or if the nature of the exposure leads to better *structural* generalization, then differences in naturalness ratings across subject types will be greater for the two groups of participants who

completed the training block, and especially for the participants who received unambiguous input during the training block, compared to the control group.

3. Methods

3.1 *Participants*

237 adult native speakers of American English were recruited via Amazon Mechanical Turk and randomly assigned to one of three groups: (1) no additional training group, (2) unambiguous training group, and (3) ambiguous training group. Participants received $10 as compensation for their participation. Fifty-eight participants were excluded based on responses to a post-task questionnaire, either because they reported having spent a significant portion of their lives in a region where NAI is known to be in use (*n*=37; excluded regions included West Texas and states considered part of Southern Appalachia), because they reported hearing the construction regularly despite being from a region where it has not been documented (*n*=12), or because they participated in more than one of our group surveys (*n*=9), such that the final number of participants was 179. Of these included participants, 59 received no additional training on the NAI construction (42 male; 17 female; mean age 36.4, range 22–71), 61 received additional unambiguous input on NAI which biased interpretation toward wide-scope negation (40 male; 21 female; mean age 36.2, range 22–62), and 59 received additional but ambiguous input on NAI (32 male; 27 female; mean age 35.5, range 22–59). Figure 1 illustrates the regions where participants in each group reported to spending the longest portion of their lives.

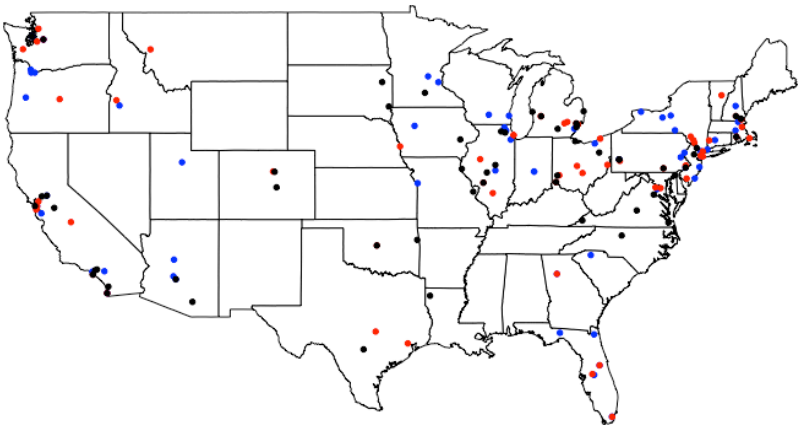


Figure 1. Locations where participants in each group reported to having spent the longest portion of their lives. Participants from the no additional training group are coded in black, participants from the unambiguous training group are coded in blue, and participants from the ambiguous training group are coded in red.

3.2 *Materials*

3.2.1 *The Interpretation Task*

Within the interpretation task, participants were asked to select one of two images that best represented their interpretation of linguistic contexts including an NAI sentence with a universal quantifier subject (e.g. *everybody*, *every kid*). This task included 16 NAI sentences with an *every* subject placed in ambiguous contexts that could support either a wide-scope negation or a narrow-scope negation interpretation (e.g., *I was planning a class activity about Hogwarts yesterday. I was really surprised when my coworker told me it was a bad idea because didn't*

every kid read Harry Potter in class last year). Eight ambiguous NAI sentences with *every* subjects appeared in the pre-training block and eight appeared in the post-training block. The ambiguous contexts for these sentences were accompanied by a set of two images, one depicting a wide-scope negation interpretation, and the other depicting a narrow-scope negation interpretation. Visuals conveyed separate readings through the placement of red Xs over different objects in the composite image. To illustrate, Figure 2 contains the NAI construction *didn't every kid read Harry Potter in class last* year presented in context followed by two graphics of students in class, one with some but not all of the students Xed out, which is compatible with the wide-scope negation reading, and one where all of the students are Xed out, compatible with the narrow-scope negation reading. The NAI items in the interpretation task were all presented in this way, with the location of the wide-scope negation versus narrow scope-negation interpretation balanced across items such that both interpretations occurred as option A and option B the same number of times. In addition, all NAI constructions were presented in embedded contexts (Green 2014) to prevent participants from interpreting them as yes-no questions.

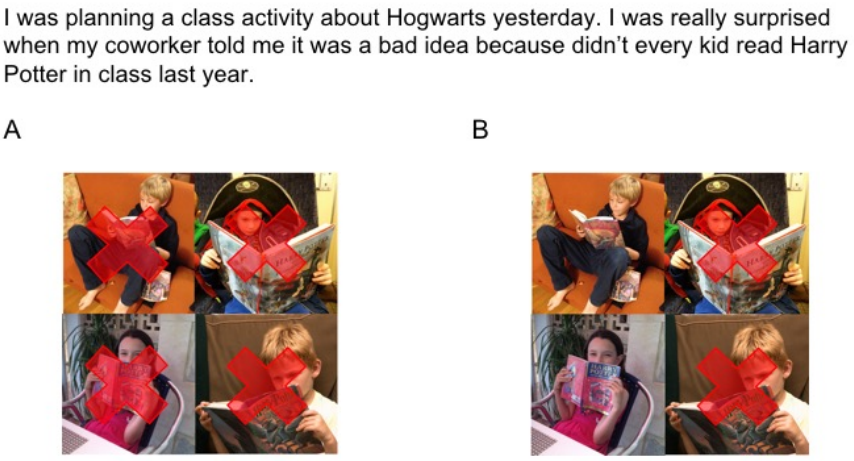


Figure 2. Sample stimulus item from the interpretation task.

B is the correct (target) wide scope negation interpretation for NAI

In between the pre- and post-training blocks, the unambiguous training and ambiguous training groups both received a "training" block with ten additional NAI sentences with *every* subjects. For the unambiguous training group, the items were presented in unambiguous contexts that biased the reader towards a wide-scope negation interpretation, as in (16). The ambiguous training group received the same NAI constructions but in contexts that were ambiguous between a wide- and a narrow-scope negation interpretation, as in (17), paralleling the ambiguous contexts from the pre- and post-training blocks. For the ambiguous training group, the training block thus amounted to additional exposure, while for the unambiguous training group this block involved implicit training toward interpreting the negation in NAI as taking wide scope. As in the pre- and post-training blocks, all items in the training block were accompanied by images illustrating the narrow and wide-scope negation interpretations.

(16) Wide-scope negation

I asked people to RSVP to my party by this Friday. I'm getting really frustrated because, even though I have a couple responses, didn't everybody call me to RSVP.

(17) Narrow-scope negation

I asked people to RSVP to my party by this Friday. I'm getting really frustrated because didn't everybody call me to RSVP.

Thirty-two filler stimuli of three separate types were created to accompany the target stimuli. Sixteen items appeared in the pre-training block, 16 appeared in the post-training block, and 10 appeared in the training block. The filler items included sentences with ambiguous relative clause attachment (e.g., *My husband told me that the coach of the football player who was standing on the sidelines got really upset about the call by the referee*), vernacular forms (e.g., *Number 815 is running so fast that he might could win the race*, with double modal *might could*), or non-systematic spelling errors (e.g., *The wresler in the middle won the gold medal*). The fillers were presented in context and with images, in a style consistent with the presentation of the critical items.

Twenty-two speakers from Appalachia and 24 speakers from regions where NAI has not been identified in the literature and who reported themselves as non-NAI users completed the interpretation task in a norming study prior to the present experiment (see AUTHORS, accepted, for details). These norming data showed that speakers from Appalachia selected wide-scope negation responses more frequently (M = .67, SD = .25) than speakers from outside the region

(*M* = .59; *SD* = .32), with the non-Appalachian speakers also exhibiting greater inter- and intra-speaker variability in their responses compared to the Appalachian speakers. Based on the Appalachian participants' norming study responses, three critical items were modified prior to running the present study.

3.2.2 *The Naturalness Rating Task*

Naturalness rating stimuli were created by placing NAI constructions with *every*, *many*, and *few* quantifier subject types in written contexts of one to three sentences. Participants were prompted to rate the naturalness of the NAI sentence as presented in context on a scale from 1 to 7 (1 = completely unnatural; 7 = completely natural). The task included eight sentences with *many* NAI subjects, as in example (18), and eight sentences with *few* NAI subjects, as in (19). Sixteen *every* NAI subject-type contexts were also included, eight of which biased participants towards a wide scope negation reading, as in (20), and eight of which biased participants towards a narrow scope negation reading, as in (21).

(18) *Many*

> The kennel was full of dogs who needed new homes. One family showed up last Friday afternoon to buy a puppy but for the most part didn't many parents want a dog for their kids.

(19) *Few*

I was arguing with Jen because she said she had blocked the most shots of any goalkeeper in the league. I had to break the news to her that didn't few goalies block shots like she did.

(20) Wide-scope negation

Last night my coworkers and I decided to go out for karaoke. All the girls had a great time, and even though my friends Tom and Chris did a duet, I noticed that didn't every guy sign a song.

(21) Narrow-scope negation

Last night my co-workers and I decided to go out for karaoke. All the girls had a great time, but I thought the guys didn't want to be there because I noticed that didn't every guy sing a song.

There were two versions of the 16 *every* subject-type items, such that each NAI sentence with a universal quantifier subject appeared in both a wide-scope and a narrow-scope negation context. Different versions of the same context were distributed to separate lists in a Latin Square design, such that each participant only saw one version of any given item.

Thirty-two filler items were also included with the naturalness rating stimuli. Eight filler items featured word order errors (e.g. *My wife and I went on a trip to the Grand Canyon last weekend. It was amazing, but I forgot to bring a camera us with*), eight filler items featured

different vernacular forms (e.g., *Grace was talking to her friend about whether to volunteer at the animal shelter. She knew she'd be busy on Monday, but she said she might could go Tuesday*), eight filler items featured an ambiguous relative clause attachment (e.g., *The judge at the recent murder trial was trying really hard to maintain a fair and impartial atmosphere in the courtroom. At one point during the trial the judge was annoyed that the attorney of the defendant who mumbled was questioned about personal matters*), while an additional eight filler items contained no special features.

3.3 *Procedure*

Participants were recruited through Amazon Mechanical Turk and independently completed the survey on personal devices. All participants were prompted to complete the pre-training and post-training modules, which had NAI sentences with universal quantifier (*every*) subjects in ambiguous contexts that elicited either a wide-scope negation or a narrow-scope negation reading. As described above, participants in the ambiguous and unambiguous training groups also completed a training module in between pre- and post-training, either with *every* subjects in ambiguous contexts (the ambiguous training group) or in unambiguous contexts (the unambiguous training group). Participants completed the modules in one continuous task and were not made aware of these module changes. After the interpretation task, all participants completed the naturalness rating task in which they rated contexts featuring a variety of NAI subject-types (see above). Target and filler items were presented together in randomized order within each task and task block.

Finally, participants completed a language background questionnaire, in which they self-reported personal and demographic information. The unambiguous training group and ambiguous training group surveys took approximately 60 minutes to complete, while the no training group survey took approximately 45 minutes to complete.

3.4 *Statistical Analyses*

3.4.1 *The Interpretation Task*

Analysis of the interpretation task results was conducted using a mixed-effect logistic regression model with the package lme4 version 1.1.21 (Bates et al. 2015) and *a priori* contrasts for hypothesis testing (Schad et al. 2020) in R version 3.6.1 (R Core Team, 2019). Testing block (pre-training vs. post-training) was included as a fixed effect, coded using repeated contrasts. Training group (no training vs. ambiguous input vs. unambiguous input) was coded using Helmert contrasts. This allowed us to compare the two "training" groups (i.e., the groups that received additional input; ambiguous and unambiguous) with each other, and then combine these groups to compare them with the no training group participants, who did not receive additional input via a training block. The random effects structure was determined according to a parsimonious approach (Bates et al. 2015; Matuschek et al. 2017), beginning with a maximal model including all random slopes and intercepts justified by the design, and removing components accounting for little or no variance whose removal did not lead to a loss in goodness of fit relative to the maximal model. All correlations greater than .95 were removed from the random effects structure, leaving in the decorrelated random slopes (Baayen et al. 2008).

3.5.2 *The Naturalness Rating Task*

For the naturalness rating task, because the data were collected on a 7-point Likert scale, which is an ordinal as opposed to a continuous measure, the ratings were analysed using ordinal regression (Lidell & Kruschke 2018). A cumulative link model was fit using the *clmm()* function of the ordinal package (version 2019.4-25; Christensen 2019). Repeated contrasts were used to code the context (i.e. subject type) factor. Since this factor has four levels, three comparisons were possible, but we tested only the two that our experiment was designed to inform: *many* vs. *few* and wide-scope vs. narrow-scope negation. Training Group was coded using the same Helmert contrast coding as in the interpretation task analysis. Since the random slopes and intercepts for subjects and items account for individual variation in the use of the Likert scale, as well as variation in responses to particular items not based on the experimental manipulation, the analyses were run over raw (as opposed to z-score transformed) rating scores.

4. Results

4.1 *The Interpretation Task Results*

Figure 3 shows results for the interpretation task, and Table 1 contains the results of the mixed logit model.

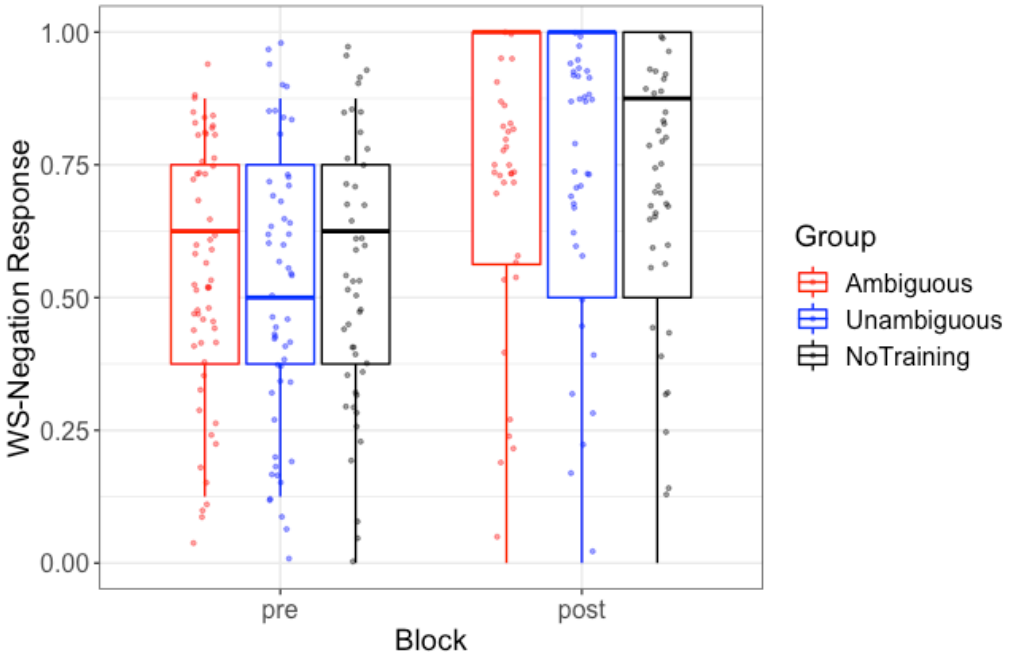


Figure 3. Proportion of wide-scope negation responses by group for pre- and post-training blocks. Box plots show overall quartiles and median. Box plots show overall quartiles and median, and jittered points represent individual participants' average responses for each condition.

Predictor	Parameter estimates			
Fixed effects	Est.	Std. error	z-value	Pr (>|z|)
(Intercept)	2.05	0.30	6.80	< .001
Block	–3.53	0.53	–6.56	< .001
Training Group				
Input: Ambiguous vs. Unambiguous	0.16	0.31	0.50	.615

Training: No Training vs. Training	–0.11	0.18	–0.58	.563
Block x Training Group				
Block x Group (Input: Amb. vs. Unamb.)	–0.19	0.55	–0.35	.726
Block x Group (Training: No Training vs. Training)	0.21	0.31	0.66	.509
Random effects structure: (1|Item) + (1 + Block||Subject)				

Table 1. Summary of the mixed logit model for the interpretation task

As seen in Table 1, there was a reliable effect of block because all three groups were more accurate overall in post-training (ambiguous: M = 75%, SD = .19; unambiguous: M = 75%, SD = .21; no training: M = 73%, SD = .16) than in pre-training (ambiguous: M = 55%, SD = .19; unambiguous: M = 56%, SD = .21; no training: M = 57%, SD = .16). However, there was no reliable block by group interaction because the accuracy gains made by the ambiguous and unambiguous groups were similar, and the overall gains for the two training groups were also similar to those made by the no training group.

4.2 *The Naturalness Rating Task Results*

Figure 4 illustrates the results for the naturalness rating task. The results of the ordinal regression model are included in Table 2.

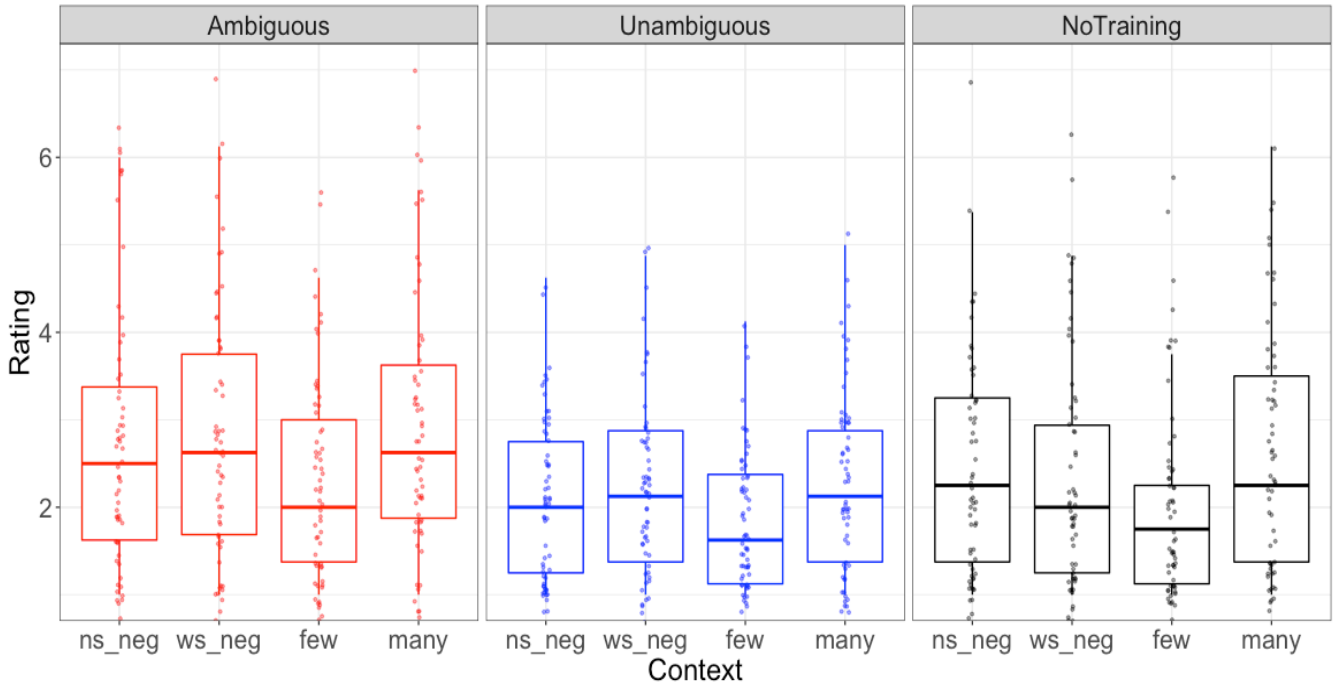


Figure 4. Naturalness ratings by group for narrow-scope negation (ns-neg), wide-scope negation (ws-neg), 'many', and 'few' subject types. Box plots show overall quartiles and median, and jittered points represent individual participants' average responses for each condition.

Predictor	Parameter estimates			
Fixed Effects for Context	Est.	Std. error	z-value	Pr (>|z|)
Many vs. *Few*	.54	.11	5.07	<.001
Wide-scope vs. Narrow-scope negation	.02	.05	0.46	.646
Fixed Effects for Group				
Input: Ambiguous vs. Unambiguous	.36	.15	2.36	.018
Training: No Training vs. Training	–.03	.09	–.45	.651

Context x Ambiguous vs. Unambiguous Training				
Wide-scope vs. Narrow-scope negation x Group	.00	.05	.05	.959
Context x Training vs. No Training				
Many vs. *Few* x Group	.03	.05	.69	.493
Wide-scope vs. Narrow-scope negation x Group	–.08	.03	–2.56	.011
Random effects structure: (1|Item) + (1 + Context|Subject)				

Table 2. Summary of the ordinal mixed effects regression model for naturalness ratings

Within the context type fixed effects, there was a reliable effect of *many* vs. *few*, because participants gave higher ratings overall for acceptable and attested *many* items (ambiguous M = 2.60, SD = .46; unambiguous M = 2.56, SD = .40; no training M = 2.64, SD = .46) than for unacceptable and unattested *few* items (ambiguous M = 2.01, SD = .62; unambiguous M = 2.13, SD = .57; no training M = 2.09, SD = .55). However, there was no reliable effect of context for the *every* sentences, because overall speakers did not rate *every* sentences in wide-scope negation contexts (ambiguous M = 2.51, SD = .52; unambiguous M = 2.48, SD = .36, no training M = 2.38, SD = .38) differently from those in narrow-scope negation contexts (ambiguous M = 2.40; SD = .42; unambiguous M = 2.37, SD = .35; no training M = 2.42, SD = .31) .

Despite the lack of main effect for *every* sentences, a reliable interaction between training group (training vs. no training) and the *every* subject context (wide-scope vs. narrow-scope negation) reflects the fact that the groups who received additional input via a training block gave slightly higher ratings to wide-scope negation items than to narrow-scope negation items, while the no training group gave slightly higher ratings to narrow-scope negation items. However, observing figure 4 we see that these differences were numerically very small, thus this

interaction should be interpreted with caution. There was no reliable interaction between the group effect of input type (ambiguous vs. unambiguous) and *every* subject contexts, and no reliable interaction between the group effect of additional input and ratings of *few* vs. *many* subject sentences.

5. Discussion

The present study was designed to explore whether adaptation can be observed at the interface between syntax and semantics. The results of the interpretation task revealed a reliable increase for all three groups from pre- to post-training in the selection of wide-scope negation responses for NAI sentences with universal quantifier subjects. In the naturalness rating task, participants from all three groups clearly preferred sentences with *many* subjects over those with *few* subjects, but there was only limited evidence that learning effects during the interpretation task with *every* subjects carried over to their rating of wide-scope vs. narrow-scope negation with *every* subjects in the naturalness rating task. We discuss these results here, in light of both adaptation theories and existing theoretical models of NAI.

5.2 *Implications for Adaptation Theories*

The results of the interpretation task—in which participants from all three input groups coalesced on the wide-scope negation interpretation of the NAI construction from pre-training to post-training blocks—demonstrate that speakers can adapt to the specific meaning properties of an unfamiliar construction, or at least one that is attested and grammatical in a variety that is not their own. As this adaptation was equivalent across all three groups, this suggests that mere

exposure during the pre-training block was sufficient to trigger adaptation to the wide-scope negation interpretation, and that neither additional input, nor input presented in a semantically unambiguous context, was necessary for adaptation to occur. The present findings expand the scope of research on how exposure can rapidly modulate speakers' interpretations of familiar, yet ambiguous, constructions (e.g., Chun 2018; Kamide 2012; Kroczek & Gunter 2017; Yildirim et al. 2016), by showing that speakers can coalesce on a particular interpretation, even when exposed to a construction—and its corresponding unambiguous meaning—that is completely unfamiliar. As such, the present results also complement studies investigating adaptation to an unfamiliar structure via reading times (e.g., Fraundorf & Jaeger 2016; Kaschak & Glenberg 2004), revealing that adaptation—as measured via an interpretation task—can also occur rapidly, after exposure to only eight ambiguous sentences.

Another open question in research on linguistic adaptation is the extent to which adaptation reflects genuine changes in *structural* representations, or merely changes in sensitivity to atypical surface forms (e.g., Kaschak & Glenberg 2004; see also Kaan & Chun 2018). The results from the interpretation task suggest something beyond mere sensitivity changes took place. In order to achieve the observed change from chance-level performance in the pre-training block to reliably choosing the wide-scope negation interpretation in the post-training block, participants would have had to adjust the mapping between NAI constructions and their meaning. This adjustment would have required some degree of adaptation beyond simply becoming more familiar with the surface form of this construction and, in turn, using this increased familiarity to speed up processing of the targeted—and possibly other similar—constructions.

Despite the robust adaptation that occurred for all groups during the interpretation task, the increase in wide-scope negation responses on the interpretation task did not translate into meaningful differences in naturalness ratings for wide-scope versus narrow-scope negation readings with *every* subject sentences in the naturalness rating task. Although the two groups who received additional input during the training portion of the interpretation task exhibited a slight preference for wide-scope negation over narrow-scope negation contexts in their ratings, whereas the group that received no additional input beyond the pre-training and post-training blocks exhibited a slight trend in the opposite direction, these differences were not robust. In line with other lab-based research on structural priming and adaptation (e.g., Kaschak et al. 2014; see also discussion in Kaan & Chun 2018), where exposure often consists of a short period of concentrated exposure to relatively homogeneous sentences, this highlights that adaptation under more controlled circumstances may not generalize across distinct experimental tasks. The absence of more generalized adaptation may be heightened by differences in the type of knowledge that different tasks tap into, especially in cases like the naturalness rating task here, where the task required participants to make distinctions based on acceptability—and the acceptability of the targeted NAI constructions in a larger context—rather than interpreting the unfamiliar structure itself.

At the same time, the participants in all three groups made a reliable distinction in their ratings of sentences with attested *many* subjects versus sentences with unattested *few* subjects in the naturalness rating task. Further, this distinction was similar across all three training groups, again independent of the amount and type of input participants received during the interpretation task. To account for the combined results from the interpretation task and naturalness rating task, and, critically, for the fact that exposure to additional unambiguous input did not lead to

increased learning over exposure to additional ambiguous input or no additional input beyond the pre-training block, we hypothesize that when interpreting an unfamiliar structure during the interpretation task, participants quickly learned to analogize NAI constructions with a parallel structure that was already part of their grammar, namely sentences with *not every* subjects (e.g., *not everybody liked the movie*). As outlined in greater detail below, this led participants to adopt the wide-scope negation interpretation of NAI constructions during the interpretation task, which would be analogous to the wide-scope negation interpretation of *not every* subjects (i.e., some but not all) that was already part of their grammar. Similarly, they would reliably distinguish between *many* and *few* subject sentences in the naturalness rating task based on analogy with attested and acceptable *not many* subjects (e.g., *not many people lived there then*) versus unattested and unacceptable *not few* subjects (e.g., **not few people lived there then*). Under such an account, analogy with a similar and already familiar structure could lead to rapid adaptation, even in the absence of additional (unambiguous) input.

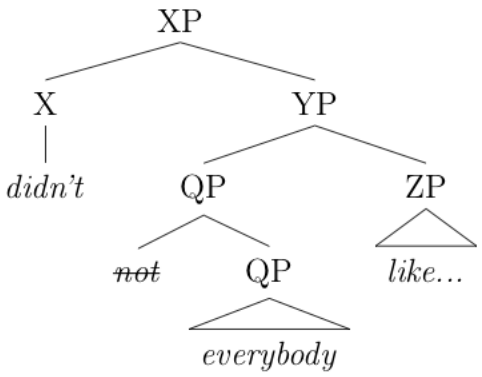
5.3 *Implications for Syntactic Theories of NAI*

As described in section 2.2, a subset of syntactic theories of NAI appeal to semantically or pragmatically motivated syntactic raising of the negation over the subject. Under these theories, the negation raises for semantic reasons, in order to mark its wide scope (Foreman 1999; Matyiku 2017), or for pragmatic reasons, to mark the focal status of the construction (Green 2014; White-Sustaíta 2010). Under a theory that postulates semantically motivated movement, we might expect unambiguous input that forces the wide-scope negation to trigger adaptation toward this reading, but as we saw in the interpretation task, simple exposure was sufficient. With regard to the hypothesis that the construction is pragmatically marked, since

focal status was not manipulated in the experiment, we cannot address this question directly. However, because adaptation toward the wide-scope negation reading occurred without any pragmatic focusing of the critical items, for our participants at least, focus was not the crucial component in deriving the wide-scope negation reading.

Blanchette & Collins (2018) provide a model in which NAI constructions are parallel to constructions in which *not* immediately precedes a quantificational subject. Under this theory, NAI constructions prohibit narrow scope negation and *few* subjects for the same reason: The negation directly modifies the subject underlyingly, as in structure (6), repeated here as (22):

(22)



Extending this analysis to the results of the interpretation task, it is possible that participants were analogizing to an already familiar construction: sentences with *not every* subjects (e.g., Foreman 1999). The fundamental connection between NAI and *not every*—or *not*+QP—sentences under Blanchette & Collins is that the subject has the same underlying structure, with the negation directly modifying the QP and forming a negative noun phrase constituent. Assuming that sentences with *not every* subjects have the structure in (22) but without raising of

the negation, participants could have extended their semantic knowledge of these more mainstream constructions, and specifically the obligatory wide scope of negation, to the unfamiliar syntactic structure they encountered during the experiment. Under this interpretation, it is possible that participants learned to derive structures akin to (22) during the course of the interpretation task. This analysis extends to explain the fact that participants reliably distinguished between *many* and *few* subjects, even in the absence of additional training input. If participants understand that *not* and *many* can form a constituent underlyingly, and that *not* and *few* cannot, then the hypothesis that their behaviours toward NAI represent an analogy to this more mainstream construction predicts their ratings of NAI sentences with *many* and *few*.

An alternative explanation of participants' lower *few* ratings is that, since *few* introduces an implicit negation and occurs immediately following an explicit negation, they simply disliked the sequencing of two negations in a row, possibly due to a violation of the Gricean maxim of quantity, where a single affirmative would suffice. In ruling out NAI and *not* phrase constructions with *few*, Blanchette & Collins (2018) appeal to a syntactic condition that prohibits a negation from directly modifying another negation (the so-called *NEG NEG constraint; see Collins 2018). Such an appeal to syntax seems necessary since *few* subjects can apparently precede negation, as in *few people didn't eat*, and it is possible for negation to precede and outscope *few* subjects, as in *it is not the case that few people ate*. The available evidence therefore supports a syntactic explanation in which the negation directly modifies the quantifier, as in (22), for participants' distinction between *many* and *few* subjects in NAI, though future work could benefit from exploring the effect of implicit double negation in NAI with *few* subjects more directly.

While the syntactic account in Blanchette & Collins (2018) appears to extend to the results of both tasks, one question still remains: If participants were analogizing to sentences with *not*+QP subjects in both tasks, then why did they not distinguish overall between wide-scope and narrow-scope negation contexts for sentences with *every* subjects in the naturalness rating task? One possible explanation for this lies in the nature of the tasks. The interpretation task elicited judgments of meaning from participants, forcing them to choose between the wide-scope and the narrow-scope interpretation for NAI sentences with the same universal quantifier subject type. The naturalness rating task, on the other hand, asked participants to focus on the relative naturalness or acceptability of NAI sentences, in which the subject type was varied systematically. Participants may have focused primarily on the syntactic properties of the NAI sentences in the naturalness rating task rather than the presentation of these sentences in their larger context. This could lead them to make a clear distinction between acceptable *many* subject sentences and unacceptable *few* subject sentences, since this acceptability distinction was embedded in the syntactic properties of the target sentences themselves, and was not dependent on the context. However, to successfully make an acceptability distinction between wide-scope and narrow-scope negation *every* sentences required participants to interpret the *every* subject sentences as sounding more or less natural in their larger context. The fact that participants did not do this robustly suggests that in the naturalness rating task, participants were more focused on the syntactic properties of the target sentence than they were on computing its meaning in the larger context. This explanation is supported by the fact that, as figure 4 shows, participants rated both the wide-scope vs. narrow-scope negation sentences with *every* subjects higher overall than those with unnatural *few* subjects, while sentences with attested and natural *many* and *every* subjects received similar ratings. Participants' ratings therefore appear to have been driven

primarily by the syntactic properties of the subject as preceded by the negation, as opposed to the semantic interpretation of the sentence as elicited by the context.

6. Conclusion

Using the vernacular NAI construction, the present study explored whether linguistic adaptation can be observed at the syntax-semantics interface. Indeed, the participants were able to acquire the interpretive properties of the NAI construction after only a brief period of exposure, and this extended to their naturalness ratings of acceptable and attested sentences with *many* subjects versus their ratings of unacceptable and unattested sentences with *few* subjects. As such, the present study showed ways in which linguistic adaptation research can extend beyond questions pertaining to reading times to investigate whether speakers can learn novel interpretive properties. In so doing, this study provides evidence that structural change can occur during adaptation. Regarding the structural changes underlying speakers' shift toward the wide-scope negation reading of NAI, our explanation relied crucially on the syntactic properties of hierarchical structure and constituency. This suggests that future studies of adaptation, and syntactic adaptation in particular, could benefit from extending beyond linear order to consider more explicitly how the notions of hierarchical structure, constituency, as well as other syntactic properties, can help explain how speakers adapt their mental representations as a result of exposure to unfamiliar or infrequent structures.

Also central to our explanation of the observed results is the notion of adaptation as analogy. Specifically, we proposed that the adaptation observed during the interpretation task and the native-like knowledge speakers demonstrated during the naturalness rating task were the result of their having analogized this unfamiliar structure to a structure already present in their

grammar. Analogy has played a central role in historical linguistics in explaining language change over longer periods of time (e.g., Lahiri 2003), but to our knowledge, it has not previously been considered in the context of linguistic adaptation. By appealing to analogy, alongside syntactic theory, the present study highlights ways in which drawing on established concepts in other fields of linguistic inquiry can lead to a more fine-grained understanding of the processes underlying linguistic adaptation. Similarly, the present study adds to our understanding of how, through studying linguistic adaptation, we can gain insights into fundamental and cross-cutting questions in linguistics more broadly.

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