INTONATIONAL EFFECTS ON ENGLISH SCOPALLY-AMBIGUOUS SENTENCES

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Abstract

This paper examines the effect of intonation contour on two types of scopally-ambiguous constructions in English: configurations with a universal quantifier in subject position and sentential negation (e.g., *Every horse didn't jump*) and configurations with quantifiers in both subject and object positions (e.g., *A girl saw every boy*). This was investigated via an auditory acceptability judgment task, in which native English speakers rated the acceptability of auditorily presented sentences in contexts matching surface-scope vs. inverse-scope readings. The results provide evidence that fall-rise intonation facilitates the inverse-scope readings of English quantifier-negation configurations (supporting findings from prior literature), but not those of double-quantifier configurations.

Keywords: English; Intonation; Quantifier Scope

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1. Introduction

Intonation has been identified as having several functions in English, such as distinguishing sentence types, emphasizing certain words/phrases, and revealing a speaker's attitude (Lee, 1955). In this paper, we are concerned with how intonation does, or does not, affect scope interpretation. Our focus here is on two types of scopally- ambiguous sentences.

The first type is sentences with sentential negation and a universal quantifier such as *all* or *every* in subject position. An example is given in (1). On the surface-scope reading, the subject quantifier scopes over negation; the resulting reading is paraphrased in (1a). On the inverse-scope reading, negation scopes over the universal quantifier, resulting in the reading paraphrased in (1b). The two readings are disambiguated in a situation in which some of the men went and some did not; in such a scenario, (1) is false on the surface-scope reading but true on the inverse-scope reading.

(1)   All the men didn't go.   [quantifier-negation configuration]
       a.   surface-scope (all>not): For every man, that man did not go.
       b.   inverse-scope (not>all): It is not the case that every man went (possibly, some men went and some did not).

The second sentence type we consider in this paper is sentences with an existential quantifier in subject position and a universal quantifier in object position. An example is provided in (2); the surface-scope reading is paraphrased in (2a) and the inverse-scope one, in (2b). The two readings are disambiguated in a context in which every book was read by a different student; in such a context, (2) is false on the surface-scope reading but true on the inverse-scope reading.

(2)   A student read every book. [double-quantifier configuration]
       a.   surface-scope (a>every): There exists a specific student who read all the books.
       b.   inverse-scope (every>a): For every book, there is a (potentially different) student who read it.

It is well-established that the configurations in (1) and (2) are ambiguous between the two scope readings in English (see May, 1977; Fox, 2000 for theoretical proposals on how to derive the two scope readings; see, e.g., Musolino, Crain, Thornton, 2000; Musolino & Lidz, 2006; Scontras, Polinsky, Tsai, Mai, 2017; Wu & Ionin, 2019, in press, for experimental findings supporting availability of both readings). While surface-scope readings are generally found to be preferred / more accessible for native English speakers (Anderson, 2004; Scontras et al., 2017; Wu & Ionin 2019, in press), inverse-scope readings are still found to be available. An interesting question is whether the two readings correspond to different prosodic contours. The quantifier-negation configuration

in (1) in English has been much discussed with regard to the role of prosody (Jackendoff, 1972; Liberman & Sag, 1974; Ladd, 1980; Ward & Hirschberg, 1985). As for the double-quantifier configuration in (2), while the role of prosody in this configuration has not received much attention in English, it has been discussed for other languages, notably German (Frey, 1993; Büring, 1997a; Krifka, 1998) and Russian (Ionin & Luchkina, 2018).

In this paper, we consider the role of prosody in both configurations, using experimental methodology in order to test particular semantic theories concerning the relationship between the prosodic contour and the availability of inverse scope. Our first objective is to determine whether the relationship between prosody and scope in English is constrained to the quantifier-negation configuration in (1), or whether it is a more general phenomenon that spans across different syntactic configurations, as has been proposed for German (e.g., Krifka, 1998). Our second objective is to examine the nature of the relationship between prosody and scope: specifically, whether a particular prosodic contour makes inverse scope obligatory (Jackendoff, 1972), or whether it only facilitates inverse scope.

2. Prior literature on scope and prosody

In this section, we first consider the role of prosody in the quantifier-negation configuration in (1), and then move onto the role of prosody in double-quantifier configurations such as (2).

2.1 *The role of prosody in the universal-quantifier - negation configuration*

Literature on English scope has considered the role of prosody in the availability of inverse scope in the configuration in (1), repeated below.

(1)   All the men didn't go.
      a.   surface-scope (all>not): For every man, that man did not go.
      b.   inverse-scope (not>all): It is not the case that every man went (possibly, some men went and some did not).

2.1.1 *Theories of intonation and scope*
One of the earliest and most important works to discuss the relation between scope and intonation is Jackendoff (1972). Jackendoff proposed that the two readings (1a-b) are disambiguated prosodically, corresponding to Accent A and Accent B in Bolinger (1958), respectively. While Bolinger (1958) did not discuss quantifier-negation configurations such as (1) per se, his proposed Accents A and B in (3) were the basis of Jackendoff's claims.[1] (See also Syrett, Simon, & Nisula, 2014a, 2014b for more extensive discussion of Jackendoff's and later proposals).

(3)   a.   Accent A

"A relative leveling off of the accentable syllable followed by a relatively abrupt drop, either within the accentable syllable (which is prolonged for the purpose) or in the immediately following syllable..." (Bolinger, 1958, p. 142).

b.   Accent B

"The characteristic of this accent is upmotion. It is neither skipped down to nor skipped down from. It may be approached from below and skipped up to, with the following motion continuing level, or rising (the usual thing), or falling slightly (an abrupt drop would create an A)..." (Bolinger, 1958, p. 142).

In short, the dropping of pitch is the characteristic of Accent A, and the rising of pitch is the characteristic of Accent B.

Jackendoff (1972) discusses how an accented syllable, termed focus ("F") by Jackendoff, can interact with negation in a negated sentence such as (4), and how Bolinger's Accents A and B can induce different interpretations for (4) (Jackendoff, 1972, p. 354).
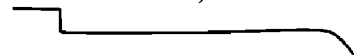
(4)   Fred didn't see John.

Jackendoff applies Accents A and B (the falling/rising of pitch) at the end of the sentence. The accented syllable/focus serves the purpose of introducing a new piece of information. However, Jackendoff's analysis centers on whether the negation is a part of the focus (the "assertion") as well; in other words, whether the negation is introduced as a part of the new information. To distinguish them from Bolinger's Accents A and B, Jackendoff's adaptations of the two Accents are henceforth referred to as the falling intonation and the fall-rise intonation, respectively.[2] The two different scopal relations for (4) are derived based on the scenario and intonation described in (5) and (6) (Jackendoff, 1972, p. 354).

Under falling intonation (5), *Fred* is accented and is thus the focus of the sentence. The stressed syllable is followed by an abrupt drop to a lower pitch immediately, and there is a further falling pitch in the last syllable at the end of the sentence. In this case, the negation is not associated with the focus in the assertion but is a part of the presupposition. In this interpretation, it is presupposed that someone did *not* see John (there exists an x and x did not see John), and the assertion is that Fred is the person who did not see John.

(5)   (Which one of them didn't see John?)
       FRED didn't see John.

Presupposition: λx [x didn't see John] is well-formed
Assertion: Fred $\in \lambda x$ [x didn't see John]

On the other hand, under fall-rise intonation (6), again, *Fred* is accented and is thus the focus of the sentence. The stressed syllable is also followed by an abrupt drop to a lower pitch immediately, but there is a rising pitch in the last syllable at the end of the sentence. In this case, the negation is associated with the focus in the assertion. In this interpretation, it is presupposed that someone saw John. However, since Bill is the person who saw John, the assertion of this sentence is that Fred is *not* the person who saw John.

(6)   FRED didn't see John. (BILL did)

Presupposition: λx [x saw John] is well-formed

Assertion: Fred $\notin \lambda x$ [x saw John]

Jackendoff also applied falling intonation and fall-rise intonation to English scopally-ambiguous configurations such as (1), proposing that the prosodic contour disambiguated between the surface-scope and the inverse-scope reading (see (7) and (8), respectively, pp. 356-357). Under falling intonation in (7), the negation is not associated with the focused element *all* in the assertion but it is a part of the presupposition. Here the variable Q represents a *quantified* part of men (e.g., *none, some, all*) that belong to the set of men who did not go. In this case, it is presupposed that there is a quantified amount of men who did not go, and the assertion is that *all* is the quantified amount of men who did not go, which means all the men did not go (the surface-scope reading).

(7)   ALL the men didn't go.

Presupposition: λQ [Q of the men didn't go] is well-formed

Assertion: all $\in \lambda Q$ [Q of the men didn't go]

Under fall-rise intonation (8), the negation is associated with the focused element *all* in the assertion. In this case, it is presupposed that there is a quantified amount of men who went, and the assertion is that *all* is *not* the quantified amount of men who went, which means not all the men went (the inverse-scope reading).

(8)   ALL the men didn't go.

Presupposition: λQ [Q of the men went] is well-formed

Assertion: all $\notin \lambda Q$ [Q of the men went]

In sum, under Jackendoff's analysis, intonation determines the scopal interpretation of English quantifier-negation configurations. The falling intonation induces the surface-scope readings, while the fall-rise intonation induces the inverse-scope readings. In this analysis, intonation directly disambiguates sentences such as (1).

However, others (Liberman & Sag, 1974; Ladd, 1980; Ward & Hirschberg, 1985) argued that listeners arrive at different interpretations via pragmatic calculation induced by intonation. For instance, Liberman & Sag (1974) suggested that the intonation contour exemplified in (9) (termed the "contradiction contour" by Liberman & Sag, p. 420) can be used to contradict another speaker who believes that elephantiasis is incurable.

(9)   Elephantiasis isn't incurable.

Applying the contradiction contour to (1) can help generate the inverse-scope reading. As Liberman & Sag (1974) explained:

> If a sentence containing a negative is used as a contradiction, it is natural to adopt an interpretative strategy which takes the negative itself to be the vehicle of that contradiction, i.e. to assume that what is being contradicted can be discovered by simply removing the negative particle from the sentence in question. This will guarantee that the negation will take wide scope with respect to any other operators in the sentence. (pp. 422-423)

This reasoning applies successfully to both (1) and (9). With (1) uttered under the contradiction contour, listeners can infer that "it is not the case that all the men left", which is the inverse-scope reading. As for (9), the inferred interpretation is "it is not the case that elephantiasis is incurable", which indicates that elephantiasis is curable.[3]

The explanation from Ladd (1980) is that the use of fall-rise intonation labels a set-member relation between the context and the focus, as in (10) (Ladd, 1980, p. 153). In (10), *cat* denotes a member of the previously mentioned set of *animals*. It is thus asserted that Speaker B fed the cat, and implied that s/he did not feed the other animals.

(10)   A: Did you feed the animals?
        B: I fed the \cat/.

Ladd (1980) also explained how fall-rise intonation can affect quantifier scope interpretations in his reasoning of set relation. When (1) is uttered under fall-rise intonation, the focused/accented quantifier *all* is labeled as the subset (as *cat* in (10)). However, because there is no quantifier that *all* is a subset of, *all* thus interacts with the negation to derive the reading of *not all*, which leads to the inverse-scope reading.

Finally, Ward & Hirschberg (1985) proposed that fall-rise intonation is used to express speakers' uncertainty about the appropriateness of utterances in a given context. Ward & Hirschberg followed Ladd's reasoning that the presence of fall-rise intonation induces some kind of relation between the focused element

and the context (which Ward & Hirschberg termed a *scale*). However, sometimes the speaker uses the fall-rise intonation because s/he is uncertain if the focused element forms an appropriate relation regarding the context, or simply because s/he wonders if it is an appropriate response at all (see (11), Ward & Hirschberg, 1985, p. 765).

(11)   A: So you speak Sephardic?
       B: Huh?
       A: Do you speak Ladino?
       B: I speak \Spa/nish.

Here, Speaker B uses fall-rise intonation to express uncertainty regarding whether Spanish is an appropriate or good enough response to Speaker A.

Regarding scopally-ambiguous configurations such as (1), however, Ward & Hirschberg (1985) believed that context plays a bigger role than fall-rise intonation. For instance, in (12) (Ward & Hirschberg, 1985, p. 770), a disambiguated context itself can induce the inverse-scope reading, even without fall-rise intonation on the configuration, which suggests that fall-rise intonation is not a necessary condition for inverse-scope readings.

(12)   George said that everyone had left for the game by five, but I know that all the men didn't go that early.

In sum, the proposal of Jackendoff (1972) is that falling and fall-rise intonations generate two different scopal readings with English scopally-ambiguous configurations. Though other proposals (Liberman & Sag, 1974; Ladd, 1980; Ward & Hirschberg, 1985) agree that fall-rise intonation helps induce inverse-scope readings, for them, they do not agree with Jackendoff that intonation is in a one-to-one mapping with scopal relations. Rather, on these later proposals, inverse-scope readings are derived from the pragmatic calculation induced by the intonation. Moreover, Ward & Hirschberg (1985) pointed out that context plays a bigger role than intonation. Therefore, we may observe that (1) is acceptable both in contexts matching the surface-scope reading (no man went) and those matching the inverse-scope reading (some of the men went, some didn't), regardless of intonation (falling vs. rise-fall), though fall-rise intonation may facilitate the inverse-scope readings.

2.1.2 Experiments on English scope and intonation

The only comprehensive examination of intonation and quantifier-negation configurations we could identify was by Syrett et al. (2014a, 2014b). Syrett et al. (2014b) conducted a production task to analyze what prosodic cues English native speakers use to disambiguate scopally-ambiguous sentences such as (1).[4] Participants (native English speakers) were asked to read paragraphs of disambiguated contexts, with the target sentence embedded. With each

paragraph, participants were asked to read it silently first. After they answered a comprehension question regarding the paragraph to make sure they understood it, they were asked to read the whole paragraph out loud and were recorded.

The overall results showed that there were no reliable prosodic cues English native speakers used to disambiguate the sentences. Regarding the pitch level and the duration of the quantifier *all*, no significant difference was found between the two scopal readings. No significant difference was found with the pitch level at the sentence final syllable between the two scopal readings either; though there was a significant effect of the duration of the sentence final syllable, Syrett et al. (2014b) claimed that it was hard to identify definite cues for disambugation. Still, some native speakers were found to apply falling intonation to the *all>negation* reading and fall-rise intonation to the *negation>all* reading; those production recordings were then used in the perception tasks in Syrett et al. (2014a).

Two within-subject perception tasks are reported in Syrett et al. (2014a). In the first perception task, after listening to English sentences such as (13) read under falling or fall-rise intonation, English native speakers were asked to choose an appropriate continuation, in this case, choosing between (13a) and (13b). Each participant listened to the same sentence in both the falling and the fall-rise intonation conditions.

(13)   All the moms didn't allow eyeliner.
    a.   They were all in agreement.
    b.   Only the moms of the older girls let their daughters wear it.

When the sentences were read under falling intonation, the participants chose A, which matches the *all>neg* reading, 63.9% of the time; while under fall-rise intonation, the participants chose B, which matches the *neg>all* reading, 66.2% of the time.

In the second perception task, English native speakers had to choose between fall-rise intonation and falling intonation for English scopally-ambiguous sentences after reading a context matching either the *all>neg* or the *neg>all* reading. Participants first read a written context, then were presented with two recordings of the target sentence, one under falling intonation and the other under fall-rise intonation, and were asked to select the one they believed to better match the context. For each sentence, each participant saw two contexts, one matching the *all>neg* reading, as in (14), and the other one matching the *neg>all* reading, as in (15).

(14)   Some of the girls in the neighborhood decided to throw a party, where they would help each other apply makeup in preparation for the upcoming dance. The girls anticipated that some of their moms wouldn't let them wear eyeliner. It turns out that the moms were all on the same page. All the moms didn't allow eyeliner. This didn't come as a real surprise.

(15) Several moms were helping their daughters get ready for the upcoming school dance. This is a progressive school, and moms are usually lenient about certain things, so even the younger girls thought their moms would approve of eyeliner. But at the dance only the older girls were wearing it. All the moms didn't allow eyeliner. Only the moms of the older girls let their daughters wear it.

After the context that matched the *all>neg* reading (14), participants chose the variant with falling intonation 76.9% of the time; after the context matching the *neg>all* reading (15), participants chose the variant with fall-rise intonation only 53.1% of the time.

In sum, the results of the first perception task suggest that while the preferences go in the predicted direction, falling intonation does not exclusively lead to the surface-scope interpretation, nor does fall-rise intonation exclusively lead to the inverse-scope interpretation. The results of the second perception task suggest that inverse scope does not require fall-rise intonation, and indeed is equally compatible with the fall-rise and falling intonation contours. Together, the results of Syrett et al. (2014a, 2014b) contradict Jackendoff's proposal that falling vs. fall-rise intonation disambiguates scopal readings.

2.2 The role of prosody in the quantifier - quantifier configuration

We next consider the configuration in (2), repeated below.

(2)   A student read every book.
      a.   surface-scope (a>every): There exists a specific student who read all the books.
      b.   inverse-scope (every>a): For every book, there is a (potentially different) student who read it.

We are aware of only one study that examined the effects of prosody on this syntactic configuration in English. Ionin & Luchkina (2019) tested the effect of making the indefinite determiner prosodically prominent in this configuration, in order to directly compare the behavior of scope in English to that in Russian (see section 2.2.2). Across three different versions of the same experiment, Ionin and Luchkina compared the three sentence types in (16), with *a, one* and stressed *ONE*; participants judged the sentences true or false in the context of pictures. For the examples in (16), the target picture showed three girls each stroking a different kitten; in the context of this picture, the sentences are true on the inverse-scope but false on the surface-scope reading.

(16)   a.   A girl stroked every kitten.
       b.   One girl stroked every kitten.
       c.   ONE girl stroked every kitten.

Ionin & Luchkina (2019) found inverse scope to be much more readily available to this sentence type when the indefinite determiner was *a* (16a) than when it was *one*, but found no difference between stressed and unstressed variants of *one*. This indicates that, in English, prosodic prominence on the subject determiner does not affect the availability of inverse scope. However, the study did not vary the prosodic contour of the entire sentence.

2.2.1 Intonation and scope in German

While the role of prosody in the configuration in (2) has not been much discussed in the case of English, the corresponding construction in German has received much attention (e.g., Frey, 1993; Krifka, 1998). Unlike English, German is generally argued to have frozen scope (i.e., to allow only surface scope) of the equivalent of (2) under neutral prosody (see (17a), Krifka, 1998, p. 80);[5] in contrast, scrambling of the object to the sentence-initial position results in the availability of inverse scope. In an experimental study with native German speakers, Bott & Schlotterbeck (2012) found that in an offline task, both inverse scope and surface scope readings of doubly quantified sentences were allowed with both SVO and OVS word orders (contra Frey, 1993), though surface scope was preferred; in an online task, SVO sentences, unlike OVS, allowed only surface scope. This study used written stimuli and hence did not control for prosody.

(17) a. Mindestens ein   Student hat jeden   Roman gelesen.
          at least   one-NOM   student has every-ACC   novel   read
          "At least one student has read every novel." (at least one>every)
      b. Mindestens /EIN   Student hat \JEDen   Roman gelesen.
          at least   one-NOM   student has every-ACC   novel   read
          "At least one student has read every novel."
          (at least one>every; every>at least one)

For the canonical SOV/SVO word order, inverse scope is said to be facilitated by the rise-fall contour on the two quantifiers, as shown in (17b) (from Krifka, 1998, p.80). In the case of German, the rise-fall contour has been proposed to be tied to inverse scope in the quantifier-negation configuration in (1) as well as the double-quantifier configuration in (2) (e.g., Jacobs, 1982, 1983, 1984; Büring, 1997b).[6] According to Krifka (1998), the relationship between inverse scope and the rise-fall contour has been primarily studied for the configuration in (1), but it is in fact just as robust in the configuration in (2).

It is beyond the scope of this paper to consider all the different theoretical explanations that have been proposed for the role of the rise-fall contour in German (see Krifka, 1998 for an overview). Both Büring (1997b) and Krifka (1998) analyze the rise-fall contour as involving a topic-focus configuration, with the first quantifier being a (contrastive) topic, and the second quantifier - the focus. Krifka extends this analysis to double quantifier structures such as (17b) as well.

Krifka suggests that the role of the rise-fall contour in German (where it affects both configurations in (1) and (2)) is different from the role of the fall-rise contour in English, where it has been tied only to the configuration in (1). One of the goals of this paper is to experimentally examine whether English prosody in fact matters only for (1), and not for (2).

2.2.2 Intonation and scope in Russian

In a series of experiments with adult native Russian speakers, Ionin & Luchkina (2017, 2018) examined how prosody affects the availability of inverse scope in the Russian equivalent of sentences such as (16b-c) (since Russian has no articles, no equivalent of (16a) could be tested). Participants had to judge the Russian equivalents of (16b-c) read with either neutral prosody or prosodic prominence on the subject, indicating contrastive focus. Additionally, Ionin and Luchkina tested OVS variants, with a scrambled indefinite object and a universal postverbal subject.

Ionin and Luchkina found that in canonical SVO order, inverse scope was strongly dispreferred relative to surface scope, and that the same held for scrambled OVS order. When the preverbal element was given prosodic prominence, indicating contrastive focus, inverse scope was greatly facilitated for OVS order, but not for SVO order. Ionin and Luchkina analyzed the effect as focus-driven reconstruction of the object in OVS order.

In an additional variant of the experiment, reported in an unpublished conference presentation (Ionin & Luchkina, 2015), the target sentences were presented with a rise-fall contour, in order to examine whether this contour facilitates inverse scope in Russian, as it does in German (see section 2.2.1). However, the result was null: the availability of inverse scope, for both SVO and OVS word orders, was no different with a rise-fall contour as with neutral intonation.

2.2.3 Summary

To sum up, there is evidence that the prosodic rise-fall contour facilitates inverse scope in the configuration in (2) in German but does not do so in Russian (where the only prosodic effect is achieved via prominence on a scrambled object). We are not aware of any prior literature on the effect of the prosodic contour on inverse scope in (2) in the case of English. Given that the fall-rise contour has been found to have an effect on inverse scope in the quantifier-negation configuration (1), we examine whether it also has an effect on (2).

3. Research Questions

The above discussion brings up two important points. First, there is the question of whether inverse scope is related to a particular intonational contour (fall-rise) in English only for quantifier-negation configurations (a universal quantifier in subject position and sentential negation), or for double-quantifier configurations (specifically, an existential quantifier in subject position and a universal quantifier

in object position) as well. The literature on English scope addresses the role of prosody only for the former, whereas the literature on German, in particular Krifka (1998), argues that the same prosodic contour is related to inverse scope in both configurations. The first goal of this paper is to determine whether the role of the fall-rise contour in English is restricted to the quantifier-negation configuration or whether it makes a difference in the double-quantifier configuration as well. If the former is the case, this would provide support to theories such as Jackendoff (1972), Liberman & Sag (1974), Ladd (1980), and Ward & Hirschberg (1985), which specifically tie the role of the fall-rise contour to the behavior of negation. If the latter is the case (if the fall-rise contour affects double-quantifier sentences as well), this would suggest that an account in terms of topic and focus, based on Krifka (1998), is a better explanation.

The second goal of this paper is to examine whether the fall-rise intonation makes inverse scope obligatory, per Jackendoff (1972), or whether it only facilitates inverse scope, but is still compatible with surface scope as well, per most later accounts (Ward & Hirschberg, 1985). This latter question was investigated by Syrett et al. (2014a) (see section 2.1.2), who found that there was no one-to-one relationship between the prosodic contour and the scope reading; while the fall-rise contour was preferred for inverse scope, and the falling contour - for surface scope, both contours were selected for both scope configurations. We aim to replicate the findings of Syrett et al. (2014a) using a different methodology: while they asked which reading was preferred for each contour, we have participants judge the acceptability of each contour with each reading. Thus, unlike Syrett et al. (2014a), we do not require participants to choose; given that surface scope is generally preferred to inverse scope, we expect that the target sentences will be rated quite high in the surface-scope context regardless of the intonation contour. What we are interested in is whether the contour makes a difference to the acceptability of the inverse-scope reading.

To sum up, our two research questions are thus as follows:

(18) a. Is fall-rise intonation related to availability of inverse scope in English only in quantifier-negation, or in double-quantifier configurations as well?
  b. Does fall-rise intonation require inverse scope, or only facilitate it?

4. Methodology

4.1 Task

The task was an auditory acceptability judgment task, in which participants rated auditorily presented sentences such as the ones in (19) on a scale from 1 (unacceptable) to 4 (acceptable) against two kinds of written contexts: surface-scope (SS) matching contexts ((20a) for quantifier-negation sentences such as (19a-c), and (21a) for double-quantifier sentences such as (19d)); and inverse-scope (IS) matching contexts ((20b) and (21b), respectively).

(19) a. All the girls didn't leave.   [all-neg]
     b. Every girl didn't leave.   [every-neg]
     c. Each girl didn't leave.   [each-neg]
     d. A girl trained every seal.   [a-every]

(20) a. **"SS-matching" context for sentences (19a-c):**
Anna, Lily and Jessica went to a party. Because it was Friday night, they decided to stay longer at the party and have more drinks. *both surface-scope and inverse-scope readings of (19a-c) true.*

     b. **"IS-matching" context for sentences (19a-c):**
Jenny, Diane, Emma and Becky were studying in the library. Jenny and Diane had to leave because they had other appointments, while Emma and Becky continued staying in the library. *surface-scope reading of (19a-c) false, inverse-scope reading true.*

(21) a. **"SS-matching" context for sentence (19d):**
Chloe worked in an aquarium. Yesterday, she trained the three seals named Felix, Cody and Nova in the aquarium to balance balls on their noses. *both surface-scope and inverse-scope readings of (19d) true.*

     b. **"IS-matching" context for sentences (19d):**
Angelina, Michelle and Isabel were asked to train three seals named Roy, Paco and Orion. Therefore, Angelina trained Roy; Michelle trained Paco; and Isabel trained Orion.
surface-scope reading of (19d) false, inverse-scope reading true.

In the SS-matching contexts ((20a) and (21a)), both the surface-scope and the inverse-scope readings of the corresponding sentences in (19) are true, because of entailment: if none of the girls left (surface-scope), then it followed that is it not the case that all of the girls left (inverse-scope); and in the same manner, if one specific girl trained every seal (surface-scope), it followed that every seal was trained by a girl (inverse-scope), it just happened to be the same girl. Thus, the sentences in (19) are expected to be rated as fully acceptable with the SS-matching contexts. In contrast, in the IS-matching contexts ((20b) and (21b)), only the inverse-scope readings are true: with (20a), it is true that not all of the girls left (inverse-scope) but it is false that none of the girls left (surface scope), given that two of the four girls did leave. Similarly, with (21b), it is true that every seal was trained by a girl (inverse scope), but false that a specific girl trained all the seals (surface scope), since the girls were different. Thus, acceptance of the sentences in (19) in the IS-matching scenarios would be indicative of availability of the inverse-scope readings.

The sentences used in this task were read by a female English native speaker, and two versions of the task were created: version 1 contained all sentences read with falling intonation, while version 2 contained all sentences read with fall-rise intonation (see Figure 1 for the sample contours). The between-subjects

design ensures that participants do not explicitly compare the two contours, and decide to assign them different interpretations. The prosodic differences appear sentence-finally, with version 1 sentences having falling pitch in the sentence-final syllable/word, and version 2 sentences having rising pitch in the sentence-final syllable/word.

Within each test version, there were 40 target items (10 tokens of each sentence type in (19), five presented in the SS-matching and five in the IS-matching scenario) and 40 fillers. All the items were divided into 10 blocks, with four targets and four fillers per block. Pseudo-randomization of the target items was applied to ensure that the SS-matching and the IS-matching versions of the exact same sentence were five blocks apart (e.g., (19a) appeared with context (20a) in Block 1 and with context (20b) in Block 6). Also, for the four target items in each block, 2 appeared with SS-matching contexts, while the other two appeared with IS-matching contexts. The fillers were unrelated structures, such as sentences testing scalar implicature with numeral NPs (e.g., *Two triangles were colored* with a context indicating that three triangles were colored). The filler sentences were presented without specific intonational cues.
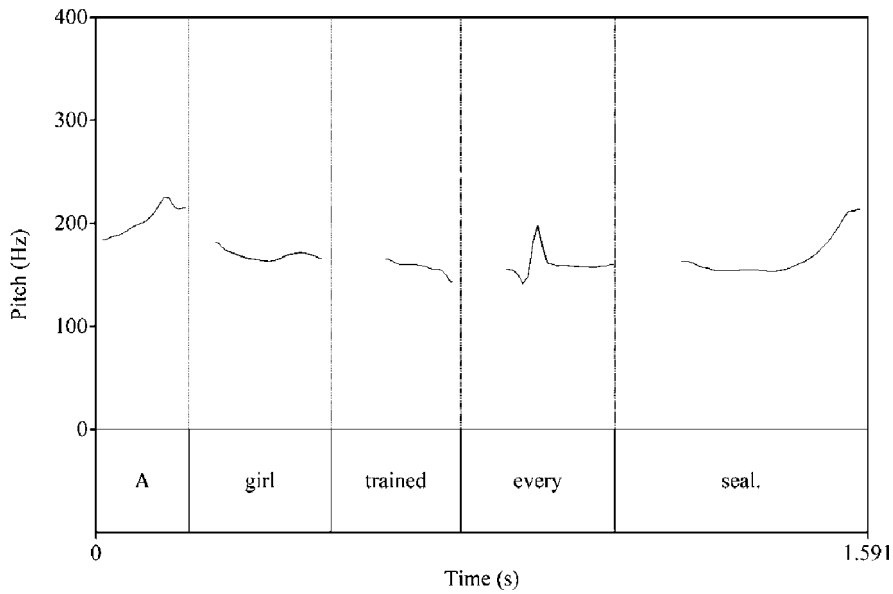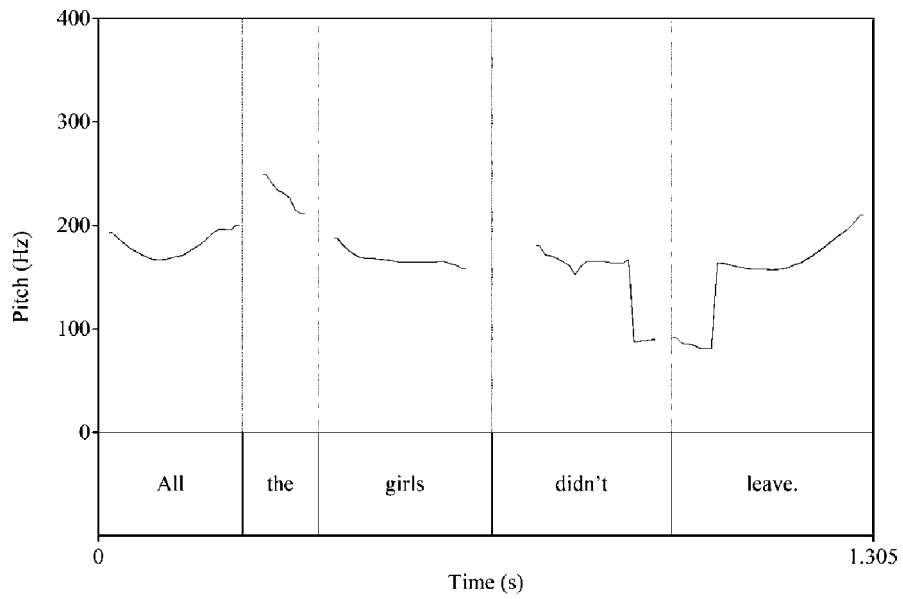
Figure 1: Sample Contours

a.   www.cursosextra.com Falling intonation samples
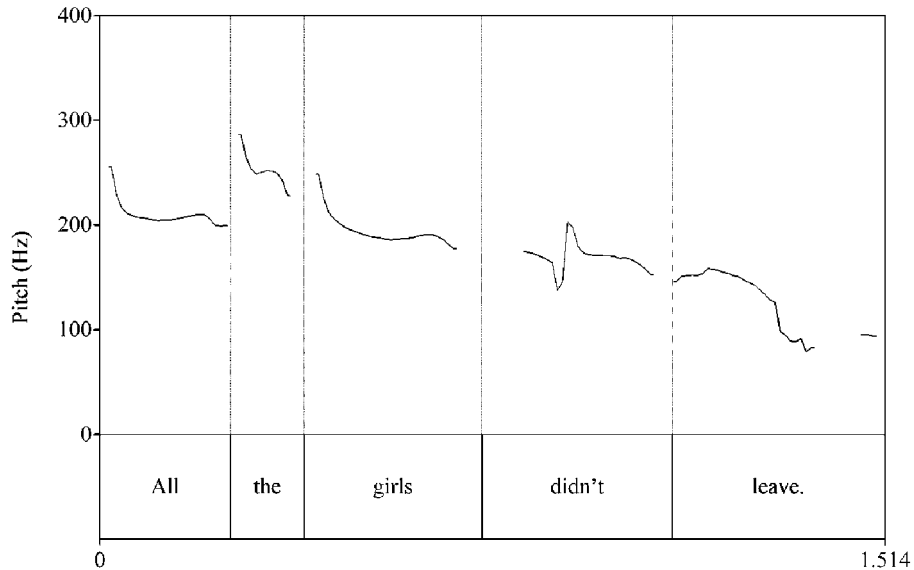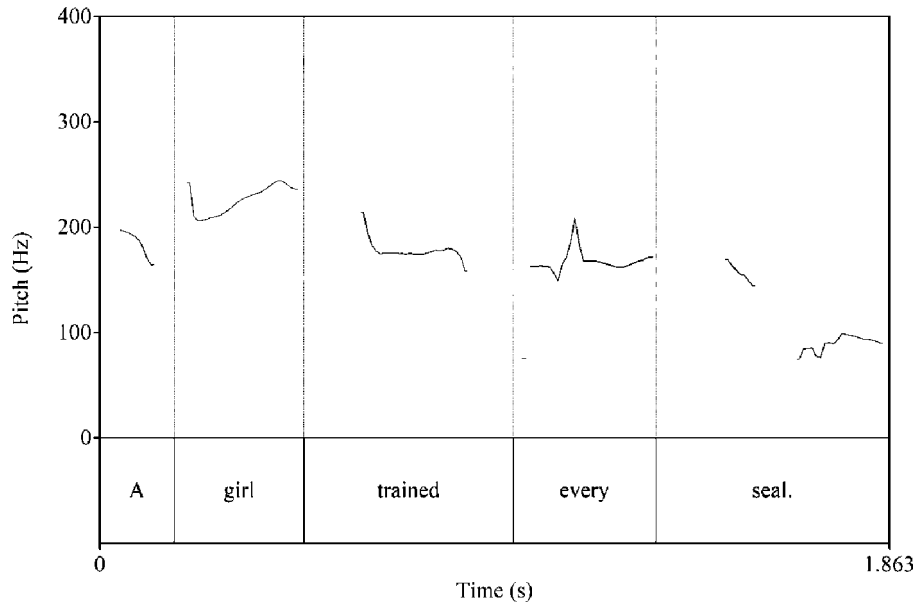
b.   Fall-rise intonation samples

4.2 Predictions

We first consider the predictions for the negation-quantifier structures in (19a-c). No differences between these three sentence types are expected on any proposal; we test the three sentence types in order to ensure that any claims about interactions between negation and universal quantifiers generalize across different universal quantifiers.

Under the proposal of Jackendoff (1972), according to which intonation disambiguates English scopally-ambiguous sentences, the falling contour requires surface scope and the fall-rise contour requires inverse scope. Thus, under the falling contour, the sentences should be accepted in the SS-matching scenario (where the sentences are true on surface scope) and rejected in the IS-matching scenario (where the sentences are false on surface scope). The predictions under the fall-rise contour are somewhat more complex. For Jackendoff, this contour requires inverse scope; since both the IS-matching and the SS-matching scenarios are compatible with the inverse scope reading, the prediction is that acceptability ratings in the two scenarios should be equally high under the fall-rise contour.

On later accounts (such as Ward & Hirschberg, 1985), and given the findings of Syrett et al. (2014a), the predictions are much weaker. Both contours should be accepted in both scenarios; however, since the fall-rise contour is more compatible with inverse scope than the falling contour, we should see higher acceptability ratings with the fall-rise contour compared to the falling contour in the IS-matching scenario. In the SS-matching scenario, both contours should be fully acceptable, since this scenario matches both surface-scope and inverse-scope readings.

As for the double-quantifier configurations, it is an open question whether the prosodic contour would have any effect, given the lack of prior literature on this topic. If the prosodic contour is not relevant to this configuration, then we expect to see a preference for surface-scope, manifested in higher acceptability in the SS-matching than the IS-matching scenario, regardless of the contour.

4.3 Participants

The participants were 32 English native speakers, 11 males and 21 females, age range 18-23. The participants were recruited in a U.S. university in the Midwest. Half of the participants received version 1 (falling intonation), and the other half received version 2 (fall-rise intonation).

4.4 Procedure

After giving informed consent, all participants completed the auditory acceptability judgment task in a small quiet room using headphones. After they finished the judgment task, they were asked to fill out a background questionnaire regarding their basic information such as age and gender.

5. Results

5.1 Descriptive Results

Figures 2 through 5 show the mean ratings for quantifier-negation (Q-Neg) configurations (*all-neg, every-neg, each-neg*) under falling intonation (Figure 2), quantifier-negation configurations under fall-rise intonation (Figure 3), double-quantifier (Q-Q) configurations (*a-every*) under falling intonation (Figure 4), and double-quantifier configurations under fall-rise intonation (Figure 5). All four figures show much higher acceptability ratings in the SS-matching than the IS-matching scenarios, for both intonation contours.
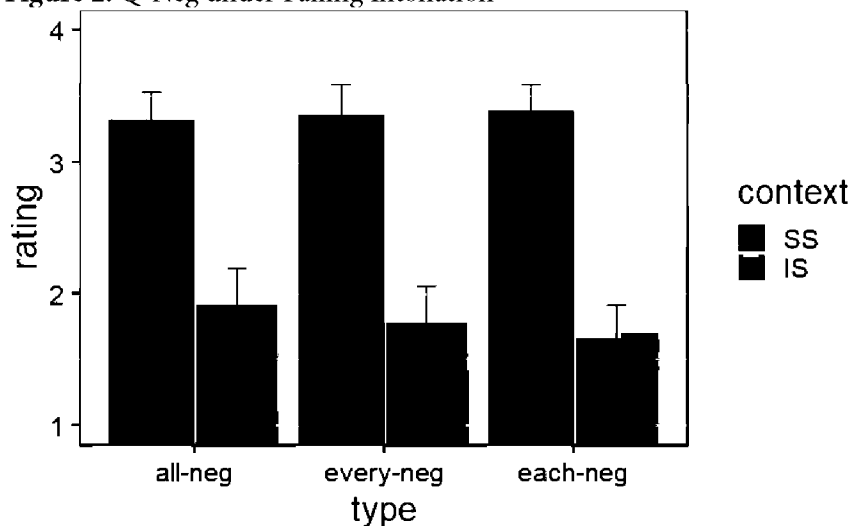
Figure 2: Q-Neg under Falling Intonation
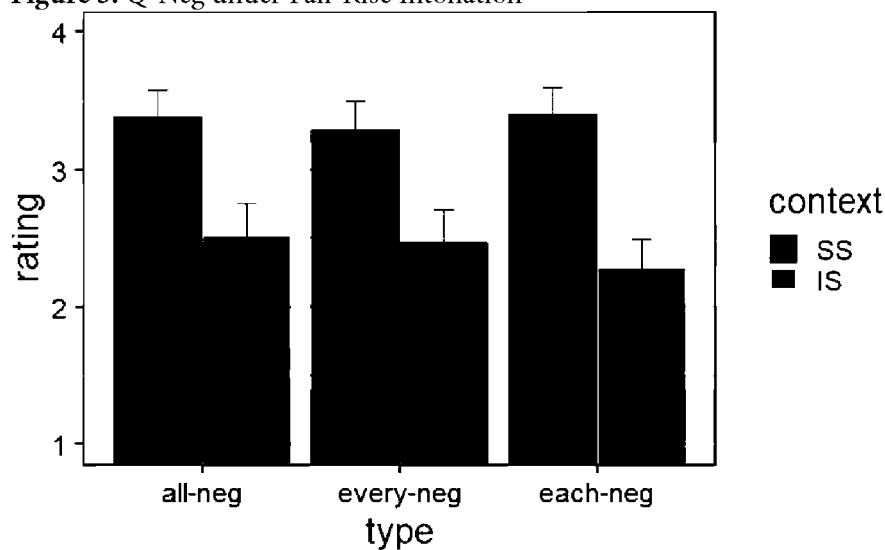

Figure 3: Q-Neg under Fall-Rise Intonation

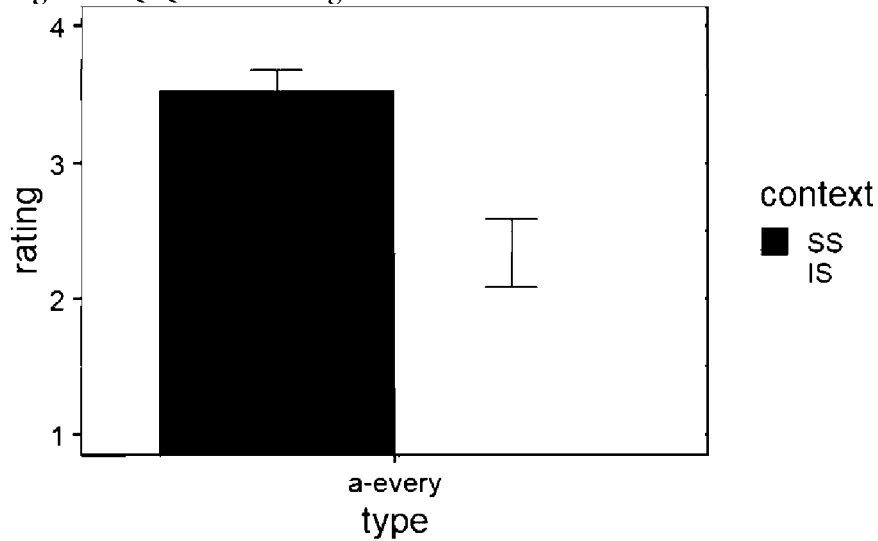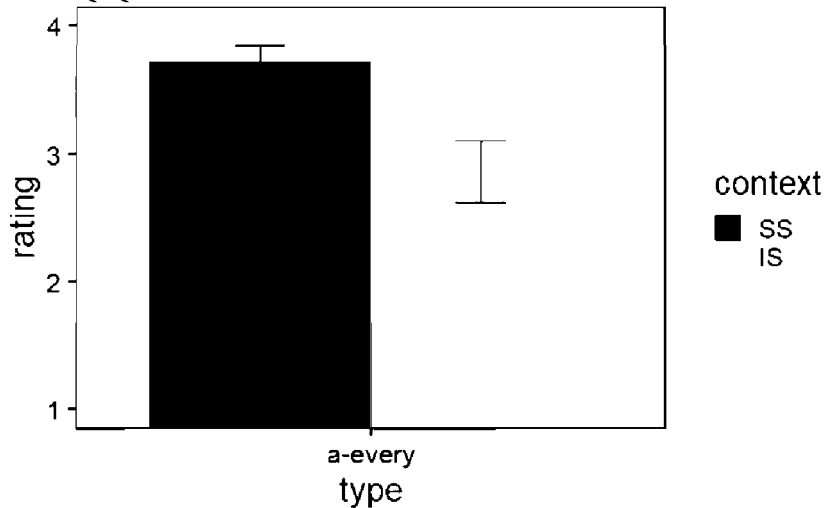**Figure 4:** Q-Q under Falling Intonation

Figure 5: Q-Q under Fall-Rise Intonation

5.2 Statistical Analysis

The data from the target items were analyzed using the Cumulative Link Mixed Model in R (Christensen, 2018), which analyzes data similarly to Linear Mixed-Effects Models. The only difference is that the dependent variable is ordinal, such as ratings on a scale. Two models were run: Model 1 analyzed the data with the quantifier-negation items, in both falling and fall-rise intonation; and Model 2 analyzed the data with the double-quantifier items, in both falling and fall-rise intonation. The fixed effects in Model 1 were type (*all-neg*, *every-neg* and *each-neg*; 3 levels), context (SS-matching and IS-matching; 2 levels) and intonation (falling and fall-rise; 2 levels). Since type had 3 levels, *all-neg* was set as the reference level, and contrast coding was used to compare it to the other 2 levels. The fixed effects in Model 2 were context (SS-matching and IS-matching; 2 levels) and intonation (falling and fall-rise; 2 levels). In each model, the random effects were participants (N=32) and items (N=30 for Model 1; N=10 for Model 2).

Table 1: Model 1 output: quantifier-negation conditions

	estimate	std. error	z value	p value
type: *all-neg* vs. *every-neg*	0.1887	0.3375	0.559	0.5761
type: *all-neg* vs. *each-neg*	0.2093	0.3289	0.636	0.5245
context: SS vs. IS	-2.6666	0.3255	-8.193	<.0001*
intonation: falling vs. fall-rise	0.1276	0.4542	0.281	0.7788
type: *all-neg* vs. *every-neg* X context	-0.5748	0.4570	-1.258	0.2085
type: *all-neg* vs. *every-neg* X intonation	-0.3853	0.4669	-0.825	0.4093
type: *all-neg* vs. *each-neg* X context	-0.8674	0.4547	-1.908	0.0564†
type: *all-neg* vs. *each-neg* X intonation	-0.1448	0.4627	-0.313	0.7543
context X intonation	0.8560	0.4433	1.931	0.0535†
type: *all-neg* vs. *every-neg* X context X intonation	0.7392	0.6278	1.178	0.2390
type: *all-neg* vs. *each-neg* X context X intonation	0.4115	0.6266	0.657	0.5114

*p<.05; † .05<p<.10

In the Model 1 output, shown in Table 1, there was a significant effect of context, due to significantly higher acceptability ratings in the SS-matching than the IS-matching context, as expected given the overall surface-scope preference found for English in prior studies. There was also a marginal interaction between type, when *all-neg* was compared to *each-neg*, and context; visual examination suggests that this is due to *each-neg* sentences receiving lower ratings in the IS-matching contexts than *all-neg* sentences, while the two were rated similarly in the SS-matching context. This was constant across both prosodic contours.

Finally, there was a marginally significant interaction between context and intonation, which is due to higher ratings in the IS-matching contexts with the fall-rise contour than with the falling contour, but no corresponding difference in the SS-matching context. This is precisely what is predicted if the fall-rise contour facilitates inverse scope. In order to explore this interaction further, we ran pairwise comparisons on the Model 1 output, averaging across all three sentence types; the pairwise comparisons were implemented using the *emmeans* function package in R (Lenth, 2018). The pairwise comparisons, reported in Table 2, show that sentences presented in the SS-matching contexts were rated significantly higher than those in the IS-matching contexts, regardless of the intonation. Crucially, sentences in the IS-matching contexts were rated significantly higher under fall-rise intonation than under falling intonation, with no corresponding difference in the SS-matching contexts.

Table 2. Model 1 pairwise comparisons

pair	estimate	p value
SS, falling > IS, falling	3.1252	<.0001*
SS, fall-rise > IS, fall-rise	1.9045	<.0001*
SS, falling = SS, fall-rise	0.0469	0.9993
IS, falling < IS, fall-rise	-1.1739	<.05*

*$p<.05$

The Model 2 output, on the *a-every* conditions, is given in Table 3. There was a significant effect of context, with higher acceptability ratings in the SS-matching than the IS-matching condition, which is expected given the surface-scope preferences of English. There was a significant main effect of intonation, due to higher ratings with fall-rise than with falling intonation. Crucially, there was no interaction between context and intonation, unlike with quantifier-negation sentences. Since the effect of intonation was constant across both context types, it could indicate that the fall-rise intonation is somewhat more natural than the falling intonation for *a-every* sentences. Importantly, fall-rise intonation does not facilitate inverse scope relative to surface scope with this sentence type.

Table 3: Model 2 output: double-quantifier conditions

	estimate	std. error	z value	p value
Context	2.5117	0.3718	6.756	<.0001*
Intonation	1.0982	0.4807	2.284	<.05*
context X intonation	-0.2732	0.4844	-0.564	0.5728

*$p<.05$

6. Discussion

We now revisit our two research questions in (18), repeated below:

(18) a.   Is fall-rise intonation related to availability of inverse scope in English only in quantifier-negation, or in double-quantifier configurations as well?
       b.   Does fall-rise intonation require inverse scope, or only facilitate it?

With regard to the first question, our findings indicate that fall-rise intonation facilitates inverse scope only for quantifier-negation sentences, and not for double-quantifier sentences. In the case of the former, we found a marginally significant interaction between context and prosody, with significantly higher ratings under fall-rise than under falling intonation only in the IS-matching context. There was no such interaction for double-quantifier sentences, where prosody affected both contexts equally.

With regard to the second question, we find evidence that fall-rise intonation does not require inverse scope for quantifier-negation sentences, but only facilitates it. Regardless of prosody, significantly higher ratings were obtained in the SS-matching than the IS-matching contexts, which indicates that surface

scope is always available in English, and it is always preferred relative to inverse scope. The fall-rise intonation does not result in inverse scope being the only possible reading (see Figure 3, which shows higher ratings in the SS-matching contexts than the IS-matching contexts, indicating a preference for surface scope even under fall-rise intonation). Rather, fall-rise intonation makes inverse scope more readily accessible relative to falling intonation.

The preference for surface scope, found for all sentence types and under both prosodic contours, is fully compatible with prior experimental findings for English; following psycholinguistic literature (e.g., Tunstall, 1998; Anderson, 2004), we assume that surface scope readings are easier to process than inverse scope readings due to their lower complexity. The fact that we find an effect of prosodic contour only for quantifier-negation sentences and not for double-quantifier sentences is consistent with prior literature on English (see section 2.1), which attributes the role of the fall-rise contour to the specific semantic/ pragmatic properties of the quantifier-negation configuration. Our finding that inverse scope in this configuration is only facilitated, not made required, by fall-rise intonation, goes against the proposal of Jackendoff (1972) and in favor of later proposals on which context plays a greater role than prosody. Our results are convergent with those of Syrett et al. (2014a), despite differences in methodology (forced-choice for Syrett et al., 2014a vs. acceptability ratings for us). We furthermore showed that the role of the fall-rise contour that Syrett et al. (2014a) found for *all-neg* sentences generalizes to *every-neg* and *each-neg* sentences as well.

7. Conclusion and suggestions for further research

As discussed above, our findings confirm and extend the findings of prior literature by establishing that the fall-rise contour facilitates inverse scope readings in English for negative sentences containing a universal quantifier in subject position. Our results are compatible with pragmatic accounts on which inverse scope places a facilitative rather than a deterministic role.

It would be interesting and fruitful to extend this study cross-linguistically, in particular to German, a language in which the interpretations of both quantifier-negation and double-quantifier sentences have been argued to be influenced by prosody (Krifka, 1998). It would also be interesting to explore further why the English double-quantifier sentences in our study received higher ratings with fall-rise than with falling intonation, regardless of context. Finally, it would also be interesting to examine whether different quantifiers within the double-quantifier configuration affect inverse scope availability (e.g., *a/one/some* as the subject quantifier and *all/every/each* as the object quantifier).

Finally, these findings have potential implications for second language acquisition. In prior studies with L1-Mandarin L2-English learners (Wu & Ionin, 2019, in press), we have found that these learners do not accept inverse scope in English at all, consistent with transfer from Mandarin, a frozen-scope

language. Wu (in progress) is currently implementing an intervention study that investigates whether this learner population can acquire inverse scope in English through input flooding and/or explicit instruction. An interesting question to consider in future research is whether teaching learners about prosodic cues to inverse scope vs. surface scope would facilitate acquisition of scope in English.

Notes

1. There is also an Accent C but it is not discussed here due to it being irrelevant to the research purpose.

2. Jackendoff himself did not use the terms "falling intonation" and "fall-rise intonation" in his work, but since work after Jackendoff used these terms, we also do so in this article.

3. However, later Ladd argued that this contradiction contour is different from Jackendoff's fall-rise intonation. Phonologically, the contradiction contour in (9) does not include an accented syllable at the beginning, or at any other part of the contour; the initial rise is a characteristic of the contour itself.

4. These studies also included other English scopally-ambiguous sentences such as *Liam doesn't know many alumni* and *Neil doesn't enjoy most musicals*. However, only quantifier-negation sentences such as *All the magnolias won't bloom* are discussed here because they are relevant to the present study.

5. In German, the canonical word order is SOV; in a sentence containing an auxiliary, as in (17), the auxiliary *hat* ("has") occurs in second position, and the non-finite lexical verb *gelesen* ("read") occurs sentence-finally; if a sentence contains only a finite lexical verb (no auxiliaries), that verb occurs in second position, resulting in SVO order. The scope facts are the same for SOV and SVO word orders.

6. The literature on German discusses a rise-fall contour, while the literature on English discusses a fall-rise contour. Büring treats the two as equivalent, presenting an analysis in terms of topic-focus that covers sentences such as (2) in English as well as in German.

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