Quantifier Scope and Intonation in German
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1. Introduction

When a speaker says a sentence like (1), which contains a universal quantifier Alle and negation nicht, these two logical expressions interact scopally. As a result, two interpretations are available that can be paraphrased as follows: (i) All politicians are such that they are not corrupt (all $\gg$ not; the wide scope interpretation of universal quantifier with respect to negation), and (ii) It is not the case that all politicians are corrupt (not $\gg$ all; the narrow scope interpretation of universal quantifier, with respect to negation).

(1) Alle Politiker sind nicht korrupt
    all politicians are not corrupt
    ‘All politicians are not corrupt.’

Jacobs (1984), adapting work by Jackendoff (1972) on English, observes that (1) in German can be partially disambiguated by intonation. While both interpretations are available with the neutral intonation contour, only the not $\gg$ all interpretation is available with a marked intonation the so-called Hat Contour.1

In this paper, we examine whether young children could make use of the particular prosody to derive the intended interpretation in German.

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1This intonation contour pattern has also been called Rise-Fall contour, Contrastive Topic Intonation, or the Bridge accent. In English, Jackendoff uses the term B-accent.

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2. Two intonation patterns

Consider in some more detail the two intonation patterns in German that we compare in this paper: the ** Neutral intonation contour ** and the ** Hat intonation contour **. Let us use the spectrograms of the audio stimuli we have used in our experiment to describe the two patterns.

In the neutral intonation, there is no rise in pitch when the first quantifier (alle) is produced. There are two accents that one can see, main accent falling on the word T-shirts, and the second accent on the negation nicht. This intonation pattern is said to allow both scope interpretations, all not and also not all.

\[(2) \text{ Alle T-shirts sind nicht getrocknet.} \]
all T-shirts are not dry
‘No T-shirts are dry’ OR
‘It is not the case that all the T-shirts are dry.’

With the hat intonation contour, on the other hand, there is a rise in pitch at the first quantificational expression followed by a fall at the second quantificational expression, as you can see in (3). The rise in pitch can be observed on alle and it stays at the same level until it finally goes down at the negation nicht. When this intonation contour is used with a sentence involving a universal quantifier in the subject position and negation, only the inverse scope interpretation is said to be available; i.e. all not is blocked, and only not all is possible. In the example in (3), for example, the only interpretation available states that the assertion that all T-shirts are dry is not correct.

\[(3) \text{ Alle T-shirts sind nicht getrocknet.} \]
all T-shirts are not dry
‘It is not the case that all T-shirts are dry’

In this section, we present a simplified version of one successful analysis of the scopal effect of the hat contour on sentences involving universal quantifier and negation (henceforth, all … not sentence) due to Büring (1997). In focus semantics (Rooth 1985, 1992), expressions bearing focus like all and negation above are analyzed as triggering alternatives. The alternatives for all include many, some, among others, and the alternative for negation is a sentence without the negation. A sentence like Alle T-shirts sind nicht getrocknet ‘All t-shirts are not dry’, therefore, has several alternative sentences: ‘Many t-shirts are not dry’, ‘Some t-shirts are not dry’, ‘All T-shirts are dry’, ‘Some T-shirts are dry’, and others. According to Büring, the hat-contour leads to an implicature of uncertainty, and there must be at least one focus alternative to the asserted proposition that is left unresolved. In the case of sentences involving alle and negation, if we assume that the asserted meaning is that of surface scope (All T-shirts are such that they are not dry=none of the T-shirts are dry), the truth-value of all the alternative sentences will be known/settled, however, as shown in (4).

(4)  
   a. all $\gg$ not: True  
   b. many $\gg$ not: True  
   c. some $\gg$ not: True  
   d. All $\gg$ ---: False

But when the asserted meaning is that of inverse scope, on the other hand, there would be many propositions that are not resolved, as shown in (5). Suppose that you know that all t-shirts are dry is not true. But the assertion it is not true that all t-shirts are dry does not implicate the truth of many t-shirts are dry or its negation, or some t-shirts are dry or its negation.
According to Büring’s theory, the lack of uncertainty rules out the all Þ not scope interpretation between universal quantifier and negation, when uttered with the hat contour. Consequently, only the not Þ all interpretation remains possible with the hat contour.

Slightly different semantic explanations of the effect of hat intonation have been proposed in the work of Büring (2003), Sauerland (2005), Wagner (2008) and others. But these alternative explanation share at least the reference to alternatives and residual uncertainty. Independent of the theoretical debate, therefore, the acquisition of the effect of hat intonation on quantifier scope of all … not sentences, specifically, but also sentences with two quantificational expressions, in general, can serve as an indicator of children’s acquisition of alternative sets and other elements of the theoretical analyses.

4. Expectations for Child Language Acquisition

There are different reasons to expect all … not sentences with the hat contour to be difficult for young children. The known difficulties children struggle with that have been found in other work but should affect the scope-intonation interaction are listed in (6).

(6) a. Children’s reported difficulty with utilizing prosodic information (Crain et al. 1994 and others)
   b. Children’s reported difficulty with accessing non-linear scope (Musolino 1998 and others)
   c. Children’s reported difficulty with access to scalar and focus alternatives (Chierchia et al. 2001, Barner et al. 2011 and others)

Consider each of the three difficulties in more detail: Crain et al. (1994) find that children do not use focus intonation to associate with the focus particle only. Furthermore, previous literature is split on whether children could make use of prosodic cues for ambiguity resolution. Choi and Mazuka (2003) report that 5-to 6-year-old Korean children cannot use prosodic information for phrasal segmentation disambiguation; Snedeker and Yuan (2008) and Ito et al. (2012) show that children could do so, albeit taking longer time. Whereas Sekerina and Trueswell (2012) show that Russian children seem not to be sensitive to the contrastive pitch accent from an eye-tracking experiment, Szendrői et al. (2018) show that 3-6-year-old children are sensitive to focus marking prosody on subject and object. Zhou et al. (2012) also show that Mandarin speaking children can use prosodic cue to distinguish different speech acts (question and declarative). Our study, therefore,
contributes to the growing research on children’s ability to incorporate prosodic information into semantic interpretation.

Musolino (1998) was one of the first attempts to understand how children understand sentences that involve a quantifier and a negation. Unlike our study, his and several subsequent studies concerned primarily negation and existential quantifiers. Musolino (see also Musolino et al. 2000, Lidz and Musolino 2002) described his findings in terms of isomorphism between the linear word order and quantifier scope. Later work by Gualmini et al. (2008) has argued for an alternative explanation of Musolino’s data in terms of the question-answer requirement. Musolino (2011) argues that nevertheless isomorphism has general importance in language acquisition. If the factors underlying the isomorphism observation play a role for sentences with universal and negation as well, non-adult behavior by children would be predicted.

In the semantic proposal explaining scope-inversion by the hat contour by Büring (1997) access to alternative interpretations play a crucial role. Children, however, have been reported to have difficulties with accessing alternatives. Chierchia et al. (2001), Barner et al. (2011) and others have proposed that young children’s ability to derive scalar implicatures is affected by their access to scalar alternatives. Barner et al. (2011) propose furthermore that children also exhibit difficulties accessing focus-alternatives of quantifiers associated with the focus particle only. This should lead us to expect that children would also be unable to access focus and topic alternatives with contrastive topic intonation, which in turn might predict that the residual uncertainty condition of Büring (1997) should never be satisfied. This should lead us to expect that children’s interpretation should be affected by the hat contour in a way that is unrelated to the adults’ interpretation. While the prediction for children is unspecific, it makes it unlikely that children should exhibit adult behavior.

In sum, the previous findings predict that children should reach different interpretations of sentences involving universal quantifier in subject position and negation from adults. As we report, in the following section this is not case.

5. Experiment

In this section, we report results from a picture selection experiment we carried out on the interaction between intonation and quantifier scope interpretation in children to test the predictions outlined in the previous section. Recall that prior results on children’s ability to integrate prosody into interpretation, on access of non-linear quantifier scope, and on their ability to access alternatives lead us to expect non-adult behavior in children. In a prior study, Sugawara et al. (2018) reports though that English speaking children exhibit performance similar to adult in a test of the interaction of quantifier scope interpretation and intonation. For German thought the intonational marking involved is phonologically distinct from English and furthermore it allows us to add a two quantifier control to the study.
5.1. Method and material

The experiment was designed after Sugawara et al. (2018). The experiment was conducted individually, using a presentation program (Keynote) on a tablet (iPad, Apple). Audio stimuli were pre-recorded by a trained native speaker, and were played from the speaker of the tablet.

Each item consisted of two slides. We exemplify the procedure for the target sentence (7) (repeated from (2)):

(7) Alle T-shirts sind nicht getrocknet.
‘All T-shirts are not dry.’ or ‘It’s not the case that all T-shirts are dry.’

The procedure was designed to portray a conversation between a protagonist in the slide and the experimenter. On the first slide, participants see a picture of a protagonist with some objects, and hear the context from the perspective of hers. An example of the first slide is shown in (8).

(8) Protagonist: Ich habe viel zum Waschen heute. Ich bin gerade damit fertig geworden die Shirts zu waschen, aber sie sind immer noch nass. (I have a lot of laundry today. I just finished washing the shirts but they’re still wet.)

The experimenter then says, for example, Ich frage mich, was mit den T-Shirts passieren wird ‘I wonder what has happened to the T-shirts’. This is, then, followed by the experimenter asking the protagonist if all T-shirts dried.

The second slide was partitioned into four parts, each part showing pictures as follows:

(9) a. surface scope picture (all $\gg$ not)
b. inverse scope picture (not $\gg$ all)
c. without negation (e.g. all t-shirts are dry)
d. Irrelevant situation (e.g. all jeans are dry)
The experimenter asks the protagonist a question (Sind alle T-Shirts getrock-net? ‘Did all the T-shirts dry?’), to which the protagonist answers, using the After hearing the target sentence, the participant is asked to choose one of the pictures that matched the test sentence.

There were two intonation contours (hat vs. neutral). We created two lists, each one using only one type of intonation contour. There were two warm-up items to get the participants familiarized with the task of choosing one picture from four candidates. There were eight test items with all and negation, six control items with two quantifiers, and six fillers, resulting in 22 items. The order of the items were pseudo-randomized so that items from the same condition would not appear consecutively.

The responses were recorded on a response sheet, indicating which picture the participant chose for each item.

5.2. Participants

We tested 42 monolingual German speaking children (3;6–6;11, \( M=5;1 \)), and 20 adult speakers as the control group. Among the 42 children, 22 children (4;0-6;6, \( M=5;2 \)) were tested with with the neutral contour, and 20 children (3;6-6;11, \( M=5;0 \)) were tested with the hat contour. There was no significant difference in age between two groups (t-test: \( p = .5831 \)). 11 adults were tested with the neutral contour, and 9 adults were tested with the hat contour.

6. Results

Let us first see the results from adults. Recall that, when spoken with the neutral contour, all … not sentences are ambiguous, whereas with the hat contour, they are expected to be compatible only with the inverse scope interpretation.
There were 8 all … not items per participant, which resulted in 88 test items tested with the neutral intonation and 72 test items with the hat contour. With the neutral intonation contour, the adult participants chose the surface scope picture 45 times and the inverse scope picture 43 times. With the hat intonation contour, on the other hand, the participants chose the surface scope picture 9 times, whereas they chose the inverse scope picture 63 times. Fisher’s exact shows that the difference in the ratios of choosing the surface scope picture and inverse scope picture between the two intonation contours was significant ($p < 0.01$).

The results are in line with the predicted pattern: as the test sentences with the neutral intonation contour is ambiguous, participants’ choice between surface and inverse scope pictures should be around chance.

Let us now turn to the results from children. There were 176 test items with the neutral intonation contour and 160 test items with the hat intonation contour. With the neutral contour, child participants chose surface scope pictures 119 times and inverse scope pictures 43 times (and a third picture, 14 times). With the hat intonation contour, on the other hand, child participants chose surface scope pictures 55 times and inverse scope pictures 86 times (and a third picture, 19 times.) When we compared the ratio of choosing the surface scope picture and that of the inverse scope pictures between the two intonation contours, the difference in ratios is statistically significant (fisher’s exact test: $p < 0.01$).

7. Interim Summary

We found that overall, both adults and children strongly preferred the inverse scope pictures for the all … not sentences when they were produced with the hat intonation contour. This does not mean that there were no differences between the two groups, however. Both the ratios of choosing surface scope pictures vs. inverse scope pictures with the neutral contours for children and adults (Fisher’s Exact test: $p < 0.01$) and that with the hat contours (Fisher’s Exact test: $p < 0.01$) were statistically significant. Compared to adults’ response pattern, overall, children were more likely to choose the surface scope pictures with the neutral intonation contour.

Let us discuss the individual data. The all … not sentences are ambiguous with the neutral intonation contour. This might lead us to expect that we may find this reflected on each individual. If this is the case, we expect that adults would choose each type of picture about chance. If we define “chance level” from three pictures (Recall: one is with irrelevant objects), choosing certain type of picture more than chance would be choosing 6 to 8 items of 8 items (based on Binomial test with the $p$ set to $1/3$). That is, only when a participant is choosing one type of picture 6 to 8 items, we could conclude that they are choosing the specific type of picture at more than chance level.
Table 1: Adult individual results for all-not scope

<table>
<thead>
<tr>
<th>Participant</th>
<th>( \forall \gg \neg ), ( \neg \gg \forall )</th>
</tr>
</thead>
<tbody>
<tr>
<td>neutral.47.20</td>
<td>8, 0</td>
</tr>
<tr>
<td>neutral.48.22</td>
<td>8, 0</td>
</tr>
<tr>
<td>neutral.51.58</td>
<td>8, 0</td>
</tr>
<tr>
<td>neutral.61.29</td>
<td>8, 0</td>
</tr>
<tr>
<td>neutral.52.23</td>
<td>6, 2</td>
</tr>
<tr>
<td>neutral.45.55</td>
<td>3, 5</td>
</tr>
<tr>
<td>neutral.55.40</td>
<td>3, 5</td>
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<tr>
<td>neutral.49.22</td>
<td>0, 8</td>
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<tr>
<td>neutral.57.27</td>
<td>0, 8</td>
</tr>
<tr>
<td>neutral.59.25</td>
<td>0, 8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant</th>
<th>( \forall \gg \neg ), ( \neg \gg \forall )</th>
</tr>
</thead>
<tbody>
<tr>
<td>hat.44.49</td>
<td>0, 8</td>
</tr>
<tr>
<td>hat.46.54</td>
<td>0, 8</td>
</tr>
<tr>
<td>hat.50.22</td>
<td>0, 8</td>
</tr>
<tr>
<td>hat.54.19</td>
<td>2, 6</td>
</tr>
<tr>
<td>hat.56.29</td>
<td>1, 7</td>
</tr>
<tr>
<td>hat.58.22</td>
<td>0, 8</td>
</tr>
<tr>
<td>hat.60.28</td>
<td>5, 3</td>
</tr>
<tr>
<td>hat.62.36</td>
<td>0, 8</td>
</tr>
<tr>
<td>hat.63.23</td>
<td>1, 7</td>
</tr>
</tbody>
</table>

Table 1 show the individual results of the adult participants. What we found is that each participant seems to have mostly fixed on one of the types of interpretation, either consistently choosing the surface scope pictures or the inverse scope pictures. There were two participants that chose the picture at chance, but the rest of the participants chose either the surface scope picture above chance (5 participants) or the inverse scope picture above chance (4 participants). When the all–not sentence is produced with a hat intonation contour, on the other hand, only the inverse scope interpretation should be available. We found that this is mostly true. Except for one participant, the participants that were tested with the hat intonation contour chose the inverse scope picture above chance.

Consider next the individual results of the child participants in table 2. Recall that children as a group did not differ from adults as a group, and the likelihood of choosing the surface scope picture was not significantly different from that of choosing the inverse scope picture. Below, we show only the times each participant chose either the surface scope or the inverse scope pictures. Some children did not choose one of the target pictures, and this is why the sum of the times the two types of pictures were chosen do not add up to 8 for some children.
Table 2: Children’s individual results for all-not scope

<table>
<thead>
<tr>
<th>Neutral contour</th>
<th>Hat contour</th>
</tr>
</thead>
<tbody>
<tr>
<td>participant</td>
<td>∀ ≫¬ ¬ ≫∀</td>
</tr>
<tr>
<td>neutral.7.5</td>
<td>8</td>
</tr>
<tr>
<td>neutral.15.6</td>
<td>8</td>
</tr>
<tr>
<td>neutral.41.5</td>
<td>8</td>
</tr>
<tr>
<td>neutral.17.4</td>
<td>7</td>
</tr>
<tr>
<td>neutral.27.4</td>
<td>7</td>
</tr>
<tr>
<td>neutral.31.4</td>
<td>7</td>
</tr>
<tr>
<td>neutral.35.5</td>
<td>7</td>
</tr>
<tr>
<td>neutral.37.5</td>
<td>7</td>
</tr>
<tr>
<td>neutral.43.6</td>
<td>7</td>
</tr>
<tr>
<td>neutral.1.4</td>
<td>6</td>
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<tr>
<td>neutral.5.5</td>
<td>6</td>
</tr>
<tr>
<td>neutral.25.5</td>
<td>6</td>
</tr>
<tr>
<td>neutral.29.4</td>
<td>6</td>
</tr>
<tr>
<td>neutral.19.4</td>
<td>6</td>
</tr>
<tr>
<td>neutral.21.5</td>
<td>6</td>
</tr>
<tr>
<td>neutral.13.5</td>
<td>5</td>
</tr>
<tr>
<td>neutral.33.4</td>
<td>5</td>
</tr>
<tr>
<td>neutral.39.5</td>
<td>3</td>
</tr>
<tr>
<td>neutral.11.5</td>
<td>2</td>
</tr>
<tr>
<td>neutral.3.5</td>
<td>1</td>
</tr>
<tr>
<td>neutral.23.5</td>
<td>1</td>
</tr>
<tr>
<td>neutral.9.4</td>
<td>0</td>
</tr>
</tbody>
</table>

Among the 22 child participants that were tested with the neutral intonation contour, 15 of them chose the surface scope pictures more than at chance. Among the 20 child participants tested with the hat intonation contour, on the other hand, only 4 chose the surface scope pictures above chance level.

The inverse scope pictures were chosen above chance by 3 of the 22 child participants that were tested with the neutral intonation contour, and 9 of the 20 child participants that were tested with the hat intonation contour.

Number of children who chose the surface scope pictures above chance, at chance, and those who chose the inverse scope pictures above chance, for each type of intonation contours are shown below. The results show that (i) with the neutral contour, children prefer to assign the surface scope for the all … not sentences; (ii) the pattern is reversed for the hat contour.
Returning to the reasons that we listed above to believe that all ... neg sentences with the hat intonation contour may be difficult for children, we show that children do access the inverse scope interpretation with or without the hat intonation contour, although they do prefer the surface scope interpretation, as previously observed by Musolino (1998). But they more easily access the inverse scope interpretation with the hat intonation contour. Do our results show decisively that children use the same mechanism as adults to access the inverse scope interpretation? Could it be that, for example, children assume that the hat intonation reverses the scope relations?

To find out whether this is the cause of the preference for the inverse scope with the hat intonation contour, let us next examine our control items with two quantifiers.

8. Two quantifier sentences

When a matrix sentence contains an existential quantifier as the subject and a universal quantifier as the object, the sentence is reported to be ambiguous in German (Frey 1993). Hat intonation is possible for (10), however, it does not affect the ambiguity of the sentence according to the available descriptions of how scope and hat intonation in German interact. The account of Büring (1997) and other theoretical proposals to explain the interaction between hat contour and quantifier scope provide a theoretical understanding of why such a difference between the universal-negation scope and the existential-universal scope sentences is expected: Above we explained how Büring’s theory derives the obligatory scope inversion in universal-negation sentences from the fact that if the universal-negation scope is true, the truth values of all alternatives are also predicted to be true – i.e. no residual uncertainty remains. In an existential-universal sentences, neither scope removes residual uncertainty in this way: the one \( \gg \) all scope of (10) still leaves open whether two boys picked some flowers, and the all \( \gg \) one scope of (10) still leaves open whether half of the boys picked two flowers.

(10) Ein Junge hat alle Blumen gepflückt.
One boy has all flowers picked

2Krifka (1998) reports that hat intonation affects the scope interpretation of two quantifiers in an embedded clause in German, but not in a matrix clause.
The sentence in (11) is therefore compatible with the pictures in the top left corner and the one in the bottom left corner of figure 2.

![Figure 2: Pictures associated with sentence (10)](image)

The prosody is not predicted to constrain scope in matrix sentences.

1. **one boy** \(\gg\) **all flowers**: open issue ‘Did many boys pick many flowers?’
2. **all flowers** \(\gg\) **one boy**: open issue ‘Did many boys pick many flowers?’

If the sentences are ambiguous for adults but children associate the hat intonation contour with the inverse scope interpretation, we should observe differences in the way two groups react to these sentences with the hat contour.

There were 6 items with two quantifiers for each list. As a result, there were 66 tokens of items with the neutral intonation contour and 54 tokens with the hat intonation contour among adult participants, and 132 tokens with the neutral intonation contour and 120 tokens with the hat intonation contour among child participants.

Adult participants exclusively chose the surface scope pictures with both the hat and the neutral intonation contours. One participant from the neutral intonation list chose one of the irrelevant pictures with one item, although the same participant chose the surface scope pictures for the other 5 items. All other participants chose only the surface scope pictures. With 6 items, above chance level would be choosing the same condition 5 to 6 times, hence, we can conclude that all participants chose the surface scope pictures, irrespective of the intonation contour, even though sentences may be ambiguous.

How about children? Among the 132 items that were tested with the neutral intonation, child participants chose the surface scope pictures 77 times, the inverse scope pictures 33 times, and one of the irrelevant pictures 22 times. With the hat intonation contour, children chose the surface scope pictures 81 times, the inverse
scope pictures 18 times, and one of the irrelevant pictures 21 times. The comparison between the surface and the inverse scope pictures shows that children are more likely to choose the surface scope pictures with the hat intonation, although the difference in ratios is not significant (Fisher’s Exact test: p=0.5375).

Considering the individual data, we observe that 9 child participants that were tested with the neutral intonation contour chose the surface scope pictures above chance and 3 chose the inverse scope pictures above chance. 10 children were at chance. With the hat intonation contour, 11 children chose the surface scope pictures above chance, and 2 chose the inverse scope pictures above chance. 7 children chose the pictures at chance, chose one of the irrelevant pictures, or did not choose any of the pictures.

The data from control items, therefore, do not support the hypothesis that children understand the hat intonation contour to be the marker for the inverse scope interpretation.

9. Conclusion

In this paper, we examined children’s ability to incorporate prosodic information during interpreting scope relations between two quantificational expressions. We observed that children, like adults, do choose the inverse scope interpretation with the hat intonation contour, although there seems to be variability with respect to how sensitive they are.

References


