1. Introduction

This paper tests children’s knowledge of quantifiers (i.e. no man, two women). In psychology quantifiers are used as a way of testing logical competence. Piaget did testing in this domain and found that children did not understand sentences containing quantifiers until the age 7 or 8, the age of concrete operational reasoning. In recent linguistic studies it has been found that children often misinterpret sentences containing quantifiers - Example: when shown a picture of 3 mice in a cup with one extra cup and asked “Is every mouse in a cup” they will often answer no and point to the empty cup showing that they interpret the sentence to mean something along the lines of “Is every mouse in every cup” This is called “quantifier spreading,” “symmetrical reading” or “conversion” While Piaget took these misinterpretations to be problems at the conceptual level, linguists generally take this to be a problem at the linguistic level

This article will present two experiments with adult and child speakers of English and Kannada (Dravidian) and their interpretation of numeral quantifiers (i.e. two horses) and negation.

2. Linguistic Background

Two assumptions:
First  Sentences have a hierarchical structure, meaning they are nested constituents and not just chronological strings of words
Second  Languages exhibit displacement, meaning there are some elements that are not interpreted entirely in the positions in which they appear

2.1 Hierarchy

The clown juggled three balls can be represented in the following diagram

```
  S
 / \                          / \                          / \
 NP VP                          NP VP                          NP VP
 / \                            / \                            / \
 D N V                           D N V                           D N
  \                            / \                            / \                            / \
  \                          the clown juggled three balls
```

This sentence is not just a string of words but has a structure

Rules and constraints make reference to this structure
Example:  (a) Hillary, thinks she, won the election.
           (b) She, thinks that Hillary, won the election.
           (c) After Bill embarrassed her, Hillary, won the election
The generalization from these example sentences is that the coreferent refers to whatever the smallest nontrivial constituent containing the pronoun is in that sentence.
This is formalized by Chomsky in “c-command”

\[
x \text{ c-commands } y \text{ iff}
\begin{align*}
  & \text{a. the first branching node dominating } x \text{ also dominates } y \\
  & \text{b. } x \text{ does not dominate } y \\
  & \text{c. } x \neq y
\end{align*}
\]

\[
x \text{ binds } y \text{ iff}
\begin{align*}
  & \text{a. } x \text{ c-commands } y \\
  & \text{b. } x \text{ and } y \text{ are coreferential}
\end{align*}
\]

Therefore we get the following:
A referring expression cannot be bound.

2.2 Displacement

In English the direct object must appear adjacent to the verb:

Ex. a. Rudy at the pizza
    b. *Rudy ate quickly the pizza

This rule is relaxed however when the direct object is questions;

What did Rudy eat ____?

Here the “what” is interpreted as the object of the verb.

2.3 Hierarchy, displacement and scope ambiguity

Example: Everyone didn’t smile.
This has two interpretations:
No-one smiled.
It is not the case that everyone smiled, some people smiled and some didn’t.

\(\varnothing\) One note is that surface syntactic structure and semantic structure are not necessarily isomorphic (or with the same structure)
\(\varnothing\) In order to account for this either the syntactic or semantic rules must be complicated.

3. Psycholinguistic background

In a study done by Musolino et al. (2000) he tested children’s comprehension in complex mapping using the Truth Value Judgment Task (TVJT) methodology. They found that adults easily interpreted and accepted the non-isomorphic interpretation (defined below) while children did not accept this interpretation in the example given below in which 3 horses try and jump over the fence but only 2 are able to.

\textit{Every horse didn’t jump over the fence.}

Two interpretations:
1. None of the horses jumped over the fence.
This is the isomorphic interpretation. The subject “every” takes scope over the negation (abbreviated every > not)

**Isomorphic:** scope relation between universally quantified NP and negation coincide with their surface position

2. Not all the horses jumped over the fence.
This is the non-isomorphic interpretation. The negation takes scope over the subject

**Non-isomorphic:** negation takes over the scope of the whole sentence

In this sentence certain elements are interpreted in positions that are different from the one’s they occupy on surface syntax.

As a control a sentence such as the following was used in a situation in which a Smurf bought only one out of three oranges hence:

*The Smurf didn’t buy every orange.*

In this example inserting a “not all” for “every” produces an isomorphic interpretation, which children had no trouble in deeming correct. Musolino termed this:

**The Observation of Isomorphism:**
Unlike adults, young children systematically interpret negation and quantified NPs on the basis of their position in overt syntax.

**This observation raises several questions:**
First This doesn’t explain children’s resistance to non-isomorphic interpretations.

As the authors suggest that maybe this is a result of linear interpretation.

They also suggest it could be a result of children holding to c-command constraints between the elements in the sentence.

They call this their *structural* question.

Second They raise the question of is children’s isomorphism preference due to lexical properties of the different quantifiers.

*Ex. The detective didn’t find some guys.*

This sentence requires a non-isomorphic interpretation, however if “some guys” is replaced by “any guys” the sentence can no longer be interpreted isomorphically. The difference therefore must be in the quantifier itself.

They don’t give a special name for this question but I call it the *lexical* question.

Third The authors wonder if isomorphism can be observed in languages other than English, given the language has the same kind of scope ambiguities as English QNPs and negation. They call this their *cross-linguistic* question.

Fourth In this question the authors raise the point that in previous studies (Musolino 2000), children did not accept non-isomorphic statements that were true because the isomorphic statement was false, the authors of this study however did not provide any examples in which the isomorphic statements were true. Because of the way the entailment works out for iso and non-isomorphic interpretations it would be impossible to construct a scene in which the isomorphic is true and the non-isomorphic false.

They call this the *entailment* problem.
4 and 5 Experiments in English and Kannada
The experiments for both languages were carried out in the same way, the main differences being in the results. I will describe them both at the same time.

One problem that authors were able to overcome in their study is the entailment problem with sentences such as *The detective didn’t find two guys*.

2 goals of this study are:
- Confirm ambiguity of sentences by the judgments of adults
- Refine understanding of children’s non-adult-like interpretations

Procedure:
- In the experiments for both languages 24 children and 24 adults were tested.
- There were two experimenters; one that would act out a short scene and one that would play a puppet that watched the scenes with the children.
- Once the scene was finished they would make a statement about what happened in the story.
- The subjects then had to say whether or not what the puppet was saying was right.

Note: In the experiments narrow scope reading corresponds to an isomorphic interpretation (as in the above example not > two) and wide scope reading corresponds to a non-isomorphic interpretation (two > not).

They also abbreviate the following pertaining to the reading of the numeral: W= wide scope; N=narrow scope; t=true; f=false

Example: *Donald didn’t find two guys.*

WtNf Condition
- In this example Donald and 4 of his friends are playing hide and seek. Donald finds 2 of his friends while 2 remain hidden.

*Fig 1. ‘Donald didn’t find two guys’, WtNf Condition.*
WfNt Condition

- In this setup Donald is playing hide and seek with two of his friends. He finds one of them but not the other.

Each subject received 4 test stories, like the one described above and 3 control stories. In the control stories the sentences were not ambiguous. The purpose of this was to control for the child’s knowledge of the meaning of the separate linguistic elements.

Results:

**English:**

*Yes responses:*

<table>
<thead>
<tr>
<th></th>
<th>WtNf</th>
<th>WfNt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>93%</td>
<td>97%</td>
</tr>
<tr>
<td>Children</td>
<td>81%</td>
<td>33%</td>
</tr>
</tbody>
</table>

![Graph showing proportion of YES responses for children and adults in each condition.]

Fig. 3. Proportion of YES responses to test trials for children and adults in each of the two conditions.

WtNf: two objects/characters were found by the main character and two were not.

WfNt: one object/character was found by the main character and one was not.

*Yes responses for control:*

<table>
<thead>
<tr>
<th></th>
<th>WtNf</th>
<th>WfNt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Children</td>
<td>97%</td>
<td>94%</td>
</tr>
</tbody>
</table>
Discussion:
- The results show that the predictions the authors made were correct
- They also bring up the point that the subjects seem to prefer to take the puppets statement as truthful; in reality the statements could be interpreted either way
- The perfect performance on the control stories shows that they don’t have difficulty with either negation or quantified NPs

2 principals to explain the difference in adult and child responses:
- linear order: the preferred scope reading corresponds to linear order
- hierarchical relations: accounts for scope preferences based on the c-command relationship between the quantified phrases

The results suggest that children’s interpretations are constrained by the position of these elements in the sentence but it is unclear whether linear order or hierarchical relations play a bigger role in determining children’s interpretation, both roles are compatible with the results.

Kannada:

In terms of the experiment the major difference between Kannada and English is that in Kannada linear order and c-command relations are not confounded. In English negation comes before and c-commands object position but in Kannada negation c-commands the object but does not come before it.

As in English children are limited to 2 interpretations of the ambiguous sentence.

2 Predictions:

<table>
<thead>
<tr>
<th>C-command/hierarchical</th>
<th>Kannada</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precedence/linear</td>
<td>Narrow</td>
<td>Narrow</td>
</tr>
</tbody>
</table>

Results:

Yes responses:

<table>
<thead>
<tr>
<th></th>
<th>WtNf</th>
<th>WfNt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>87.5%</td>
<td>85.4%</td>
</tr>
<tr>
<td>Children</td>
<td>75%</td>
<td>22.9%</td>
</tr>
</tbody>
</table>

Fig. 7: Proportion of YES responses to test trials for children and adults in each of the two conditions.
Yes responses for control:

<table>
<thead>
<tr>
<th></th>
<th>WtNf</th>
<th>WfNt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>94%</td>
<td>94%</td>
</tr>
<tr>
<td>Children</td>
<td>97%</td>
<td>100%</td>
</tr>
</tbody>
</table>

As in the English experiment the justifications given by the children were the same.

**Discussion:**
- The results for Kannada basically mirrored the English results.
- Children have a reliable preference for narrow scope interpretation
- Isomorphism is a result of hierarchical structure
- Children do not use precedence relations when computing the scope but rather use the syntactic structure of the sentence.

6. General Discussion

What is the cause of the difference in adults and children in non-isomorphic interpretations:

1. Children lack the implicit knowledge necessary to make non-isomorphic interpretations.
   Another linguist, Krämer, makes the claim that children don’t know that indefinite NPs can have free variable interpretation (i.e. wide scope interpretation)
2. While they may be able to generate both interpretations children may lack the computational resources necessary to interpret such sentences
   - They may experience something like the garden-path effect and not be able to recover.

The authors raise the point of whether isomorphism effects are due to performance or other factors.

How do children get to being able to access the adult (non-isomorphic) interpretation?
- If the problem is in competence then simply being in a situation in which the non-isomorphic interpretation is correct will allow children to become aware and hence acquire this interpretation
- If the problem is computational resources, then as the child gets older and their computational resources improve they should be able to process the non-isomorphic interpretation

The authors point out a possible connection between scalar terms and pragmatic vs logical interpretations. In each case they are only able to access the logical interpretation

There are some difficulties in this:
Scalar implicature relies on entailment in a statement like All students can write well vs. Some students can write well. Here all entails some but not vice versa making all the more informative statement

The authors state that the similarity between scalar implicature and scope ambiguity is superficial.