The interaction of grammatical and visual information in preschoolers' understanding of doubly quantified sentences

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Research question

How do preschoolers interpret doubly quantified sentences?

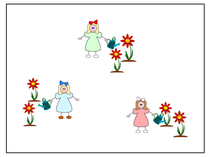
The problem

Sentences containing two quantified expressions are ambiguous, e.g., (1) can mean (1a) and (1b):

(1) ***Three girls are watering two flowers***.

a.' There are 3 girls, each flowering 2 flowers' b.' There are 2 flowers, each watered by 3 girls'

(***3 girls* has wide scope = direct scope**) (***2 flowers* has wide scope = inverse scope**)



In Hungarian, unlike in English and most other well-known languages, quantifier scope is encoded syntactically; scope order corresponds to surface order (only direct scope).
I.e., doubly quantified sentences are disambiguated (É. Kiss 1991, 2010, Szabolcsi 2007):

(2)a. ***Három lány is két virágot locsol***.
three girl each two flower-ACC waters
' Three girls (each) are watering two flowers.' (3 girls, 6 flowers; ***three girls* wide scope**)

(2)b. ***Két virágot is három lány locsol***.
two flower-ACC each three girl waters
' Two flowers (each), three girls are watering.' (2 flowers, 6 girls; ***two flowers* wide scope**)

Two previous sentence-picture matching experiments (É. Kiss, Gerőcs 2012, É. Kiss, Gerőcs, Zétényi 2012) found that 6-year old Hungarian preschoolers can access the multiplicative reading of doubly quantified sentences; they can associate sentences like (2a) and (2b) with a picture showing 3 girls and 6 flowers, or 2 flowers and 6 girls.
In a control group of Hungarian adults, the scope order of quantifiers was isomorph with their linear order for 90% of subjects. Lidz & Musolino (2002) predicts the same for English kids. However, **Hungarian children's preferred scope order cannot be derived from the linear order of quantifiers, or from any other linguistic cue such as subject/object function, or agent/patient role.** E.g., sentence (3) was judged as a true statement about picture (2) by 63% of children, though it represents a scope order that is the inverse of linear order, and the object/patient has scope over the subject/agent.

(3) ***Három maci is két autóval játszik***.
three teddy-bear each two car-with plays
' Three teddy bears (each) are playing with two cars.'

Picture 2

In another experiment, children had to decide about the sentences in (4a) and (4b) whether they are statements about picture (3a) or (3b).

(**4)a.*Két markoló is három gödröt ás***.
two excavator each three hole-ACC digs
' Two excavators each are digging three holes.'

b. ***Három gödröt is két markoló ás***
three hole-ACC each two excavator digs
' Three holes each, two excavators are digging.'

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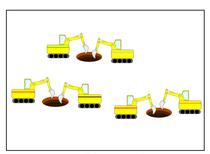
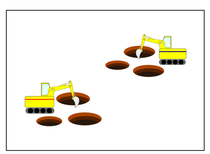


Picture 3a



Picture 3b

The majority of children chose picture (3b) in both cases. 85% of them chose picture (3b) when hearing (4a), and 78% of them chose it when hearing (4b), which indicates that their scope interpretation was independent of the linear order of quantifiers. Other test cases showed that their choice did not depend on the subject/agent vs. objec/patient role of quantifiers, either. At the same time, children's choice of scope order was not random, but followed a strategy. The data suggested that it was determined by visual cues provided by the picture stimuli. Here we present a follow-up study intended to clarify the interaction of linguistic and visual information in children's scope interpretation.

The hypothesis:

Children choose the scope interpretation whose visual representation is easier to chunk into identical subevents.

Background:
It has been observed that children exhibit non-adult-like behavior in the interpretation of the universal quantifier *every*. They tend to judge the sentence *'Every boy is riding an elephant'* as false in a situation where there are three boys each riding an elephant and an extra elephant without a boy. It has been claimed that in child grammar the universal quantifier does not quantify over individuals but over events. Children construct sub-events from the participants of the original event (boys and elephants), and they reject this sentence beacuse it is not the case that every sub-event involves a boy riding an elephant (Philip 1995, Kang 2001, Roeper et al. 2004, Brooks & Sekerina 2006).
Along this line of reasoning, we assumed that children decompose the original event into sub-events in the case of doubly quantified sentences, as well. For them, each member of the wide scope set constitutes a sub-event in which it is associated with an instance of the narrow scope set. E.g., in the case of (1) under reading (1a), shown in Picture 1a, a sub-event consists of 1 girl + 2 flowers, whereas under reading (1b), shown in Picture 1b, a sub-event consists of 1 flower + 3 girls. We hypothesized that children associate with the sentence the visual representation that is easier is to chunk into sub-events, i.e., where the sub-events are more clearly separated by spaces.

Experiment:
38 Hungarian children (aged 5;6 – 6;6) participated in a sentence-picture matching task. Subjects listened to quantified sentences of type (2a) and (2b) uttered by a puppet. The test sentences, listed below, were separated by fillers. Each sentence was presented together with a pair of pictures, one showing its direct scope reading, the other showing its inverse scope reading. One member of each picture pair was chunked into identical sub-events separated by spaces. In the other picture, the participants were mingled randomly. The child had to point at the picture that she thought the puppet was talking about.
Observe the test sentences and the picture pairs associated with them.
D represents their direct scope reading, I represents their inverse scope reading.
The numbers show the percentage of children who matched the sentence with the picture.

(1) **Három tornyot is két fiú épít.**
three tower-ACC each two boy builds
' Three towers are being built by two boys.'
D: 3 towers, 6 boys **mingled: 16%** **I**: 2 (1boy+3towers) **chunks: 84%**

(2) **Két markoló is három gödröt ás**.
two excavator each three hole-ACC digs
' Two excavators are digging three holes.'
D: 2 excavators 6 holes **mingled: 66%** **I**: 3 (1 hole+2 excavators) **chunks: 34%**

(3) **Két szánkót is három mackó húz**.
two sled-ACC each three teddy-bear pull
' Two sleds are being pulled by three teddy bears.'
D: 2 (1 sled+3 bears) **chunks: 61%** **I**: 3 bears, 6 sleds **mingled: 39%**

(4) **Három lány is két virágot locsol**.
three girl each two flower waters
' Three girls are watering two flowers.'
D: 3 (1 girl+2 flowers) **chunks: 68%** **I**: 2 flowers, 6 girls **mingled: 32%**

(5) **Két fiú is három tornyot épít**.
two boy each three tower builds
' Two boys are building three towers.'
D: 2 boys, 6 towers **mingled: 76%** **I**: 2 (1 boy+3 towers) **chunks: 24%**

(6) **Három gödröt is két markoló ás**.
three hole-ACC each two excavator digs
' Three holes are being dug by two excavators.'
D: 3 holes, 6 excavators **mingled: 24%** **I**: 3 (1 hole+2excavators) **chunks: 76%**

(7) **Három mackó is két szánkót húz**.
three teddy-bear each two sled pulls
' Three teddy bears are pulling three sleds.'
D: 3 (1 bear+2 sleds) **chunks: 63%** **I**: 2 bears, 6 sleds **mingled: 37%**

(8) **Két virágot is három lány locsol**.
two flower-ACC each three girl waters
' Two flowers are being watered by three girls.'
D: 2 (1 flower+3 girls) **chunks: 55%** **I**: 3 girls, 6 flowers **mingled: 45%**

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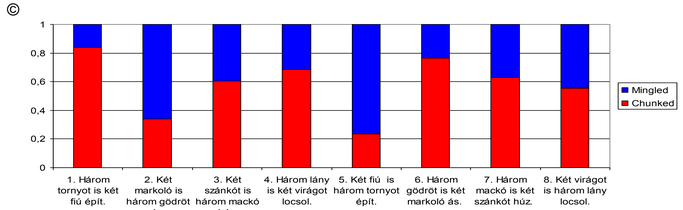
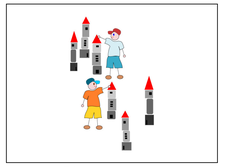


Results:
The visual grouping of objects affected children's choice of scope interpretation: they matched with the doubly quantified sentence the picture that was more clearly chunked into distinct sub-events in 58% of all answers.
Bias towards **visual representations chunked** into **subevents (58%)** is comparable to the bias towards representations with **subject/agent wide scope (65%)**, and to the bias towards **direct scope representations (54%).**

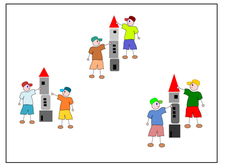
The effects of linguistic and visual clues combine.
Bias towards a **chunked direct scope visual representation is 62 %.** Bias towards a **chunked direct scope representation with subject wide scope is 66%**.

In examples (2) and (5), where the majority of the children preferred the non-chunked visual interpretation, the quantifier to which they assigned wide scope is linguistically more prominent than the other quantifier in every respect: it is subject (versus object), it is agent (versus patient), and it is initial; furthermore, the preferred mingled picture (Picture 4a) is also fairly easy to chunk into identical subevents. Observe the pictures associated with ex. (5):

(5) *Két fiú is három tornyot épít.*
'Two boys (each) are building three towers.'



Picture 4a



Picture 4b

Discussion:
Our results confirmed that
- Hungarian preschoolers' interpretation of relative scope is not isomorph with the linear order of quantifiers (contrary to adult linguistic input, and to the isomorphism hypothesis of Lidz and Musolino (2002)).
- It cannot be derived directly from the subject vs. object role, or the agent vs. patient role of the quantifiers, either.
- Children prefer interpretations which are visually easier to chunk into distinct identical subevents.
- However, the visual cue can be counterbalanced by converging grammatical prominence relations.
- Hence children's preferred scope interpretation is determined by linguistic and visual cues.

More generally,
whereas Hungarian adults only use grammatical cues in the processing of doubly quantified sentences, children rely on both grammatical and visual resources.

A further perspective:
The finding that children's interpretation of doubly quantified sentences and of *every* involves quantification over sub-events converges in an interesting way with the generalization that Amazonian and Australian languages with deficient number systems only use adverbial quantifiers quantifying over events; they lack determiner quantifiers quantifying over individuals. Further study of the issue might bear on the question whether or not the ontogeny of language reflects philogeny (Bickerton (1981) vs. Slobin (2004)).

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