

# **Children's scope interpretation of doubly quantified sentences and the problem of isomorphism**

## **1. Introduction**

English children display a strong preference for 'isomorphism', i.e., for direct/surface scope interpretation, in sentences involving quantification and negation – as was observed by Musolino (1998) and has been confirmed many times since then. Our experiments on doubly quantified sentences to be summarized in this paper have brought different results: Hungarian preschoolers' interpretation of doubly quantified sentences is less isomorphic than the adult input they receive. We survey the explanations offered to account for children's isomorphism attested in sentences containing quantification and negation, and examine if they can be reconciled with the lack of prevalent isomorphism in doubly quantified sentences. We will argue that the explanation that can be extended to doubly quantified sentences is the theory that analyzes children's isomorphism as a consequence of their reluctance to „turn back” in ambiguous „garden-path” situations and to revise their initial interpretations (Musolino & Lidz 2003, 2006). According to this view, the isomorphic reading is the default reading of ambiguous sentences, to which children are committed until the context or the situation forces them to revise it. We will claim that the default reading of doubly quantified sentences for Hungarian preschoolers is the collective reading (also in the presence of the distributive particle *is* ('*each*'). A distributive reading always represents the revision of the collective reading computed online – as is shown by its increased reaction time, and since the second attempt at sentence interpretation is dissociated from the linear flow of speech, the linear order of the two quantifiers does not determine scope order any more.

The paper is structured as follows: Section 2 introduces the facts on which the observation of isomorphism is based, and its major explanations. Section 3 presents the results of our experiments on doubly quantified sentences carried out with Hungarian preschoolers. Section 4 surveys the results of two experiments testing children's interpretation of doubly quantified sentences in English and Chinese. Section 5 examines how the theories summarized in section 2 fare with our findings. Section 6 is a conclusion.

## **2. Background**

*2.1. The observation of isomorphism, and its analysis as a grammatical epiphenomenon*

Musolino (1998) observed that children understand sentences like (1) differently from adults. Whereas adults can access both interpretation (1a) and interpretation (1b), preferring the latter, for the majority of children, only interpretation (1a) is available.

- (1) Every horse didn't jump over the fence.
- a. 'Every horse is such that it didn't jump over the fence.'
  - b. 'It is not the case that every horse jumped over the fence.'

Musolino called the observed tendency to identify the relative scope of operators with their relative surface position the Observation of Isomorphism. Isomorphism also seemed to hold for quantifiers in object position, e.g.:

- (2) Donald didn't find two guys.
- a. 'There are two guys are that Donald didn't find.'
  - b. 'It is not the case that Donald found two guys.'

Whereas adults can access both interpretations, preferring the non-isomorphic (2a), children display a strong bias for the isomorphic reading in (2b).

The question whether operator scope for children is determined by the linear order of operators or their hierarchical (c-command) relation was clarified by Lidz & Musolino (2002). They tested children's scope interpretation in Kannada, a left-branching language, where the linear order of operators is the opposite of their structural prominence relation (the right-hand side quantifier is higher in syntactic structure). They found that children's scope interpretation is isomorphic with the structural hierarchy of operators.

Musolino (1998) and Musolino, Crain & Thornton (2000) traced back the difference between children's and adults' scope interpretation to differences in their grammars. Musolino (1998) claimed that children cannot yet generate the complex structures that correspond to non-isomorphic interpretations. He adopted Hornstein's (1995) theory distinguishing two types of quantified NPs, those which assume scope via movement and are interpreted in their surface position, and those which can assume scope both via movement and also by some other mechanism, e.g., by choice function interpretation. Languages may differ in whether they have both types of quantified NPs, like English, or only the former type, like Chinese. As a consequence of the Semantic Subset Principle (see, e.g., Crain & Thornton 1998), children initially make the assumption that allows the narrower range of

options. (If they started out with the hypothesis that allows the wider range of options, they would have no negative evidence to realize that some of them are incorrect.) Hence children assume that in the respect of scope interpretation, English is a Chinese-type language, where all quantified NPs obtain scope via overt movement, isomorphically.

### 2.2. *Isomorphism as consequence of parsing difficulties*

If preschoolers' grammar cannot generate structures supporting non-isomorphic readings, then non-isomorphic interpretations are not expected to occur at all. However, Musolino & Lidz (2003), Gualmini (2004), and Musolino & Lidz (2006) found that children can access the non-isomorphic reading of sentences like (1) if it is supported by the context, e.g., if (1) is uttered in a situation in which first all the horses jumped over a log, but only two of them managed to jump over the fence.

So as to account for these new findings, Musolino & Lidz (2003; 2006) proposed a new explanation for the observed isomorphism of preschoolers. They claimed that the scopal ambiguity of sentences containing negation and quantification represents a kind of „garden-path” situation, which might necessitate the revision of the initial interpretation. In sentences with two operators, the default strategy of interpretation is the assumption of isomorphism; it is surface scope that is theoretically, psychologically, and statistically privileged (cf. the Gennari & MacDonald 2005/2006), and the interpretation of which is least costly computationally (cf. Reinhart 2006). If the initial reading proves to be inappropriate, adults will revise it, and compute inverse scope; preschoolers, however, have difficulties with revising their initial commitments – as shown by Trueswell, Sekerina, Hill, and Logrip (1999). Hence children mostly maintain their original isomorphic interpretation.

According to Gennari & MacDonald (2005/2006), children use probabilistic constraints to resolve ambiguities. They are sensitive to the distributional patterns of language use, and their experience shapes their comprehension of scope. Adults rarely use sentences like *Every horse didn't jump over the fence* with a non-isomorphic interpretation in contexts like those of the stories used in the experiments. That is why this interpretation is often not accessible to children, who resort to the reading that corresponds to the most frequent pattern.

### 2.3. *Isomorphism as a pragmatic epiphenomenon*

Gualmini (2004; 2008), and Gualmini, Hulsey, Hacquard & Fox (2008) argue that isomorphism is an illusion. Children's interpretation of an ambiguous sentence is determined by pragmatic conditions. In Gualmini's theory, every sentence is understood as an answer to a

question. The Question-Answer Requirement (QAR) requires that a sentence be a 'good answer' to the Question under Discussion (QUD), entailing either a Yes or a No. If both interpretations of an ambiguous sentence are good answers to the QUD, the Principle of Charity makes children choose the interpretation that corresponds to a Yes answer.

Gualmini claims that the „garden-path” theory of isomorphism cannot explain why (4) and (5) are interpreted differently in one and the same situation, where the QUD is the question in (3). Whereas in the case of (4), children accept both the isomorphic reading in (4a) and the inverse reading in (4b), (5) only has the inverse reading in (5b) for the majority of children.

(3) Did the Troll deliver all the pizzas?

(4) The Troll didn't deliver some pizzas.

- a. 'It is not the case that the Troll delivered some [= any] pizzas.'
- b. 'There are some pizzas that the Troll didn't deliver.'

(5) The Troll didn't lose some pizzas.

- a. 'It is not the case that the Troll lost some [= any] pizzas.'
- b. #'There are some pizzas that the Troll didn't lose.'

Gualmini's theory correctly predicts that both (4a) and (4b) are good answers to the QUD, and the Principle of Charity makes children choose the inverse (4b), which corresponds to a Yes answer. As for (5), reading (5b) is not a good answer to the QUD, as it does not entail either a Yes or a No answer to (3) – as opposed to (5a), which entails a No. The fact that (5a) happens to be the isomorphic interpretation is claimed by Gualmini to be accidental. This theory has been criticized on theoretical and empirical grounds, e.g., for the *ad hoc* – in fact, *post hoc* – way of identifying the QUAD (see Viau, Lidz and Musolino 2010, Musolino 2011).

### **3. Scope interpretation in Hungarian doubly quantified sentences**

#### *3.1. Scope interpretation in adult language*

Hungarian is an interesting testing ground for theories of children's scope interpretation because – as has been amply discussed in the literature (cf. Hunyadi 1986, É. Kiss 1991, 2002, 2009, 2010, Szabolcsi 1994, 1997, Szabolcsi and Brody 2003, Surányi 2002, 2006a,b, Olsvay 2000, Puskas 2000, 2006, Szabolcsi 2010, etc.) – Hungarian systematically

disambiguates quantifier scope. No other language encoding logical relations so consistently has been described in the linguistic literature.

The isomorphism of Hungarian follows from the fact that quantified noun phrases overtly move into positions in which they precede and c-command their scope. Distributive quantifiers, among them universals, numerical quantifiers supplied with the distributive particle *is*, and *sok* 'many, much' phrases under their proportional reading, undergo overt Quantifier Raising. In the Hungarian sentence, divided into a topic phrase and a predicate phrase, the landing sites of Quantifier Raising are the functional layers of the predicate phrase: Tense Phrase, Negation Phrase, and in focus constructions, Focus Phrase.

In neutral sentences, a distributive quantifier – whether subject, object, or adjunct – will land between the Tense Phrase (TP) and the Topic Phrase (TopP). (The specifier of TP in Hungarian is filled by a predicative element, usually a verbal particle – see Piñón (1992), É. Kiss (2008), (Surányi 2009)).

(6) a. [<sub>TopP</sub> Mari [<sub>TP</sub> **minden könyvet** /**két könyvet** **is** [<sub>TP</sub> el olvasott]]]  
 Mary every book-ACC /two book-ACC DIST PRT read  
 'Mary read every book/two books.'

b. [<sub>TopP</sub> A könyvet [<sub>TP</sub> **minden lány/két lány is** [<sub>TP</sub> el olvasta]]]  
 the book-ACC every girl /two girl DIST PRT read  
 'The book, every girl/two girls read.'

In focus constructions, the Tense Phrase is subsumed by a Focus Phrase. The specifier of the Focus Phrase is occupied by a [+exhaustive] focus constituent, which attracts the verb.<sup>1</sup> The landing site of Quantifier Raising is either the left edge of the Focus Phrase (7a,b), or the left edge of the Tense Phrase (8a,b). In the former case, the quantifier has scope over the focus; in the latter case, the quantifier is in the scope of focus:

(7) a. [<sub>FocP</sub> **Minden könyvet** /**két könyvet** **is** [<sub>FocP</sub> MARI olvasott [<sub>TP</sub> el *t<sub>V</sub>*]]]  
 every book-ACC two book-ACC DIST Mary read PRT  
 'Every book was such/two books were such that it was Mary who read them.'

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<sup>1</sup> In the examples below, the focus constituent is spelled in small capitals.

- b. [<sub>FocP</sub> **Minden lány /két lány is** [<sub>FocP</sub> a LANGUAGE AND MIND-ot olvasta [<sub>TP</sub> el *t<sub>V</sub>*]]  
 every girl /two girl DIST the Language and Mind-ACC read PRT  
 ‘Every girl was such/two girls were such that it was Language and Mind that they read.’

- (8) a. [<sub>FocP</sub> MARI olvasta [<sub>TP</sub> **mindkét könyvet** [<sub>TP</sub> el *t<sub>V</sub>*]]<sup>2</sup>  
 Mary read both book-ACC PRT  
 ‘It was Mary who read both books.’

- b. [<sub>FocP</sub> A LANGUAGE AND MIND-ot olvasta [<sub>TP</sub> **minden lány /két lány is** [<sub>TP</sub> el *t<sub>V</sub>*]]  
 the Language and Mind-ACC read every girl /two girl DIST PRT  
 ‘It was Language and Mind that every girl/two girls read.’

Monotonically decreasing and non-monotonic quantifiers (e.g., phrases modified by *kevés* ‘few’, *legfeljebb öt* ‘at most five’, *pontosan öt* ‘exactly five’) must be moved to the specifier of the Focus Phrase. If the sentence contains a distributive quantifier, as well, its scope relative to the focussed quantifier will depend on whether it is adjoined to FocP, preceding the focus (9a) or is adjoined to TP, where it is preceded by the focus (9b).

- (9) a. [<sub>FocP</sub> **Minden könyvet** [<sub>FocP</sub> KEVÉS LÁNY olvasott [<sub>TP</sub> el *t<sub>V</sub>*]]  
 every book-ACC few girl read PRT  
 ‘Every book was such that few girls read it.’

- b. [<sub>FocP</sub> KEVÉS LÁNY olvasott [<sub>TP</sub> **minden könyvet** [<sub>TP</sub> el *t<sub>V</sub>*]]  
 few girl read every book-ACC PRT  
 ‘Few girls read every book.’

The Hungarian sentence has two NegP projections, one above TP, and another one above FocP. Both are landing sites of Quantifier Raising. A universal quantifier adjoined to NegP is subject to negative concord. In (10a) the universal quantifier precedes, c-commands, and has

<sup>2</sup> Postverbal word order is subject to Behaghel’s Law of Growing Constituents (Behaghel 1932), as a consequence of which the most unmarked PF realization of (8a) is that in (i):

- (i) MARI olvasta el mindkét könyvet a vizsgára.  
 Mary read PRT both book-ACC the exam-for  
 ‘It was Mary who read both books for the exam.’

scope over negation, whereas in (10b) negation precedes, c-commands, and has scope over the universal quantifier.

(10)a. [<sub>NegP</sub> **Senki** [<sub>NegP</sub> nem [<sub>FocP</sub> KÉT KÖNYVET olvasott [<sub>TP</sub> el ]]]]  
 everybody not two book-ACC read PRT  
 'Nobody was such that it was two books that (s)he read.'

b. [<sub>NegP</sub> Nem [<sub>NegP</sub> **mindenki** [<sub>FocP</sub> KÉT KÖNYVET olvasott [<sub>TP</sub> el ]]]]  
 not everybody two book-ACC read PRT  
 'Not everybody was such that (s)he read two books.'

Quantifier Raising can be iterated:

(11)a. [<sub>TP</sub> **Legtöbb lány** [<sub>TP</sub> **három könyvet** is [<sub>TP</sub> el olvasott]]]  
 most girl three book-ACC DIST PRT read  
 'Most girls were such that they read three books.'

b. [<sub>TP</sub> **Három könyvet** is [<sub>TP</sub> **legtöbb lány** [<sub>TP</sub> el olvasott]]]  
 three book-ACC DIST most girl PRT read  
 'Three books were such that most girls read them.'

The surface order of quantifiers corresponds to their scope order in these sentences, as well.

(11a) means that in a large subset of all the girls in a given domain, each girl read three possibly different books. In the case of (11b), each one of three books was read by a possibly different (though presumably overlapping) large subset of all the girls.<sup>3</sup>

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<sup>3</sup> None of the sentences in (6)-(11) are ambiguous; their surface structure fully determines their interpretation. Ambiguity can appear in rare, marked constructions. Postverbal word order in Hungarian is free; hence if a doubly quantified construction like (11a) or (11b) is preceded by a focus or a negative particle, which attracts the verb across the quantifiers adjoined to TP, the scope order of the two postverbal quantifiers cannot be unambiguously determined:

(i) Melyik vizsgára olvasott el **legtöbb lány több könyvet** is?  
 which exam-for read PRT most girlseveral book-ACC DIST  
 'For which exam did most girls read (a possibly different set of) several books?'  
 'For which exam were several books read by most girls?'

Universal quantifiers can also occur as contrastive topics – see (13), pronounced with a fall-rise, in which case they appear to have narrow scope with respect to a subsequent operator:

(12) a. *Minden könyvet* nem olvasott el Mari a vizsgára.  
every book-ACC not read PRT Mary the exam-for  
'Every book, Mary didn't read for the exam.'

b. *Minden könyvet* csak KÉT LÁNY olvasott el a vizsgára.  
every book-ACC only two girl read PRT the exam-for  
'Every book, only two girls read for the exam.'

These sentences appear to be exceptions to the strict isomorphism of the preverbal section of the Hungarian sentence. However, É. Kiss and Gyuris (2003) claim that their inverse scope reading is apparent. A quantifier functioning as a contrastive topic is individuated by being set into contrast, as a result of which it can be interpreted as a semantic object (a property) which the rest of the sentence predicates a (higher-order) property about. A quantifier functioning as a contrastive topic denotes a property of plural individuals, and its apparent narrow scope arises from the fact that it is considered to be a predicate over a variable inherent in the lexical representation of the verb. In any case, the numerically modified NP + distributive *is* complex occurring as the initial quantifier in our test sentences cannot be understood as a contrastive topic (it is presumably the distributive particle that blocks its contrastive topic interpretation).

### 3.2. Hungarian children's interpretation of quantifier scope

Since scope interpretation has been found by Musolino (1998) and others to be more isomorphic in child language than in adult language, and since Hungarian adult language is known to be isomorphic (at least in the preverbal section of the sentence), we expected Hungarian children to display isomorphic scope interpretation in most cases. This was not what we found. We examined in a series of experiments how children interpret doubly

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As a marked option, Q-Raising can also be realized as right-adjunction to TP or FocP. Multiple right-adjunction – which is even more marked and rare – also results in ambiguity. If we only test preverbal quantifiers as we did, these potential sources of ambiguity are eliminated.



quantified sentences, and we only attested a mild bias towards isomorphic interpretation; inverse scope was accepted, even preferred, in many cases. We present here two of our experiments.

### 3.2.1. Experiment 1: Truth value judgement of doubly quantified sentences

*Objective:* We carried out the experiment with the aim of testing whether preschoolers can access the distributive readings of sentences with two numerical quantifiers, and whether they display a preference for isomorphic interpretation.

*Participants:* We tested 46 children, 27 males and 19 females, in the big kids' groups of three Budapest kindergartens. Their mean age was 6;5 years, SD=4 months.

*Materials:* The children listened to 15 sentences, each of which was presented together with a picture shown on a computer screen. They had to decide whether or not the sentence was a true description of the situation represented visually. The 15 sentences included four test cases and eleven fillers. The test cases involved the doubly quantified sentences in (14) and (15). Both sentences were presented twice, coupled with two different pictures, showing their direct (isomorphic) and inverse scope readings. The test cases represented four conditions, namely:

Condition 1: Subject–Object–Verb (SOV) sentence with direct scope:

(13) *Három maci is két autóval játszik.*

three bear DIST two car-with plays

'Three teddy bears each are playing with two cars.'



Picture 1

Condition 2: SOV sentence with inverse scope:

(14) *Három maci is két autóval játszik.*

'Three teddy bears each are playing with two cars.'



Picture 2

Condition 3: OSV with direct scope:

- (15) *Két tornyot is három fiú épít.*  
 two tower-ACC DIST three boy-NOM builds  
 'Two towers (each), three boys are building.'



Picture 3

Condition 4: OSV with inverse scope:

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



Picture 4

*Procedure:* The children were tested individually. The child, the experimenter, and a helper were seated at a table in front of a laptop in a quiet room. The helper had a hedgehog puppet

on her hand. The experimenter told the child that they would look at pictures on the computer screen together, and the hedgehog, who had weak eyes, was going to tell the child what she saw in the picture. When a picture appeared on the screen, the experimenter said: „Let's listen to what the hedgehog sees in the picture”, and then asked the child if the hedgehog was right or wrong. The experiment began with two fillers, the first clearly true, the second clearly false – in order to make the child realize that the hedgehog is sometimes right and sometimes wrong. The child received positive feedback („Well done”) after each answer. The experimenter marked the answers on a sheet. The experiment was videorecorded.

The experiment was also carried out with an adult control group, consisting of 91 young adults, 47 females, 44 males, mean age 29.44, SD=6.37.

*Results:* The *yes* answers were coded as 1, and the *no* answers were coded as 0.

#### **Children's results:**

SOV:	Mean	SD	
C1 (direct)	0.91	0.28	
C2 (inverse)	0.63	0.49	$t_{\text{paired}}=3.82$ ( $df=1/45$ ) $p>0.001$

OSV:	Mean	SD	
C3 (direct)	0.67	0.47	
C4 (inverse)	0.41	0.49	$t_{\text{paired}}=3.08$ ( $df=1/45$ ) $p=0.004$

Direct: C1 (SOV) - C3 (OSV)  $t_{\text{paired}}=3.09$  ( $df=1/45$ )  $p=0.003$

Inverse: C2 (SOV) – C4 (OSV)  $t_{\text{paired}}=2.88$  ( $df=1/45$ )  $p=0.006$

#### **Adults' results:**

SOV:	Mean	SD	
C1 (direct)	0.80	0.40	
C2 (inverse)	0.11	0.31	$t_{\text{paired}}=13.55$ ( $df=1/90$ ) $p>0.001$

OSV:	Mean	SD	
C3 (direct)	0.64	0.48	
C4 (inverse)	0.01	0.10	$t_{\text{paired}}=12.02$ ( $df=1/90$ ) $p>0.001$

Direct: C1 - C3  $t_{\text{paired}}=3,30$  ( $df=1/90$ )  $p>001$

Inverse: C2 – C4  $t_{\text{paired}}=2.82$  ( $df=1/90$ )  $p=0.006$

### Comparing children and adults:

	Children		Adults		
	Mean	SD	Mean	SD	
C1	0.91	0.28	0.80	0.40	$t=1.57$ ( $df=1/135$ ) n.s.
C2	0.63	0.49	0.11	0.31	$t=7.55$ ( $df=1/135$ ) $p>001$
C3	0.67	0.47	0.65	0.48	$t=0.30$ ( $df=1/135$ ) n.s.
C4	0.41	0.50	0.01	0.10	$t=6.,58$ ( $df=1/135$ ) $p>001$

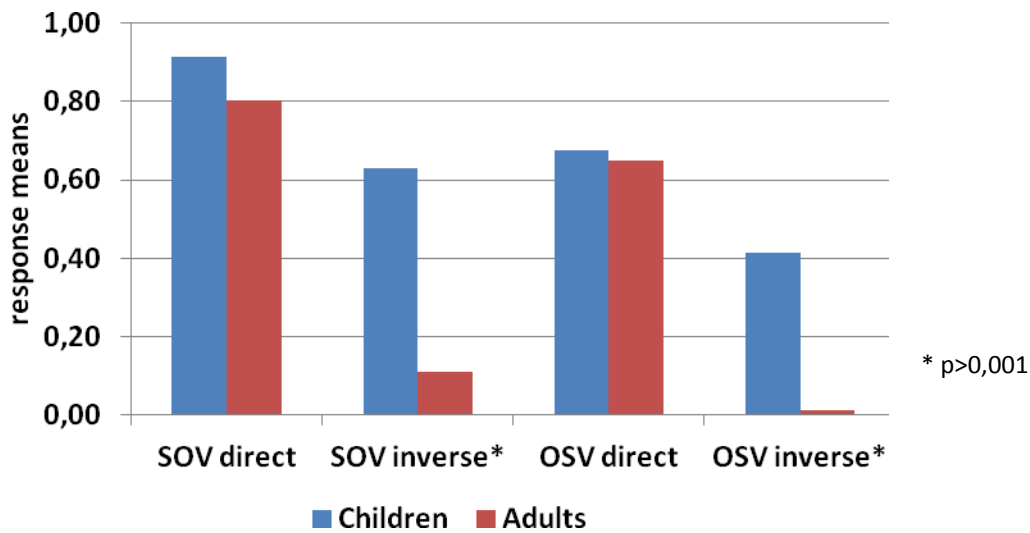


Figure 1: Acceptance of the direct and inverse scope in Exp. 1

*Discussion:* The experiment showed that the distributive readings of doubly quantified sentences are accessible to Hungarian preschoolers. Children’s acceptance rate of direct scope does not significantly differ from adults’ acceptance of rate direct scope. However, children and adults differ significantly in the acceptance of inverse scope. Our adult subjects rejected the inverse readings nearly unanimously (at the rate of 89% in the case of SOV sentences, and at the rate of 99% in the case of OSV sentences), as predicted by the linguistic literature on Hungarian scope marking cited above in Section 3.1. Children, on the contrary, accepted about half of all the inverse readings; they only showed a mild bias towards isomorphism. Although their acceptance rate of the direct scope reading was significantly higher than their acceptance rate of the inverse reading in the case of both the SOV and the OSV word orders

(91% versus 63%, and 67% versus 41%), the acceptance of the SOV sentence with an inverse interpretation (63%) was close to the acceptance of the OSV sentence with an isomorphic reading (67%). In sum: whereas English children's scope interpretation was found to be more isomorphic than that of English adults, Hungarian preschoolers' scope interpretation is less isomorphic than that of Hungarian adults.

The acceptance rate of the isomorphic readings was lower than predicted by the linguistic literature among adults, as well (80% in the case of SOV sentences, and 65% in the case of OSV sentences). The explanation of this fact became clear only after further experiments. The particle *is* is ambiguous in Hungarian; it functions both as a distributive particle and as an additive particle, the equivalent of *too*. Whereas for most adults, the additive meaning of *is* is only elicited in a particular context, and the default reading of an *is* associated with a number phrase is its distributive reading, some adults interpret it additively also out of context. For them, the default reading of doubly quantified sentences is the collective reading; thus the sentence *Három maci is két autóval játszik* 'Three bears each/too play with two cars' describes a situation involving three bears and two cars altogether.

### 3.2.2. Experiment 2: Forced-choice sentence–picture matching

*Objective:* The results of Experiment 1 indicated that surface order is not the only factor determining Hungarian children's scope interpretation strategies. The literature on the scope preferences of English adults (e.g., Ioup 1975, Micham et al. 1980, Kurtzman & McDonald 1983, Gillen 1991) and the literature on scope interpretation by Chinese children (Lee 2003) suggested that the theta roles of the subject and the object may influence scope assignment; children tend to assign wide scope to the element that is higher in the following hierarchy:

(17) agent > non-human actor > theme > location

Experiment 2 aimed to test this hypothesis.

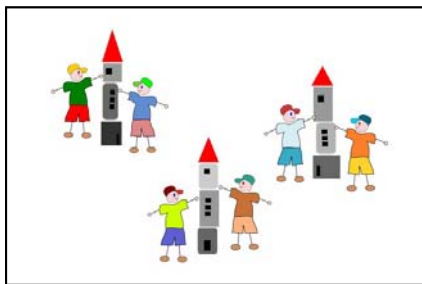
*Participants:* We tested 41 children, 22 males and 19 females. They were recruited from the same three kindergartens as in Experiment 1. The mean age of the subjects was 6;5 years (SD=4 months).

*Materials:* The children listened to 20 sentences, including 8 doubly quantified test sentences and 12 fillers. Each sentence was accompanied by a pair of pictures (two A5-size, 148 mm x

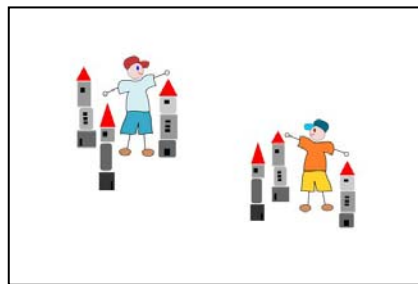
210 mm drawings placed on the table side by side). The pictures associated with the doubly quantified sentences represented their direct and inverse distributive readings. The test sentences are listed under (18a,b)-(21a,b). The (a) and (b) sentences, representing the SOV and OSV variants of the same proposition, were accompanied by the same pairs of pictures. The order of the sentence–picture pairs, and the left versus right hand side positions of the direct and inverse scope representations were randomized.

(18) a. Két fiú is három tornyot épít.  
 two boy DIST three tower-ACC builds  
 'Two boys each are building three towers.'

b. Három tornyot is két fiú épít.  
 three tower-ACC DIST two boy builds  
 'Three towers each, two boys are building.'



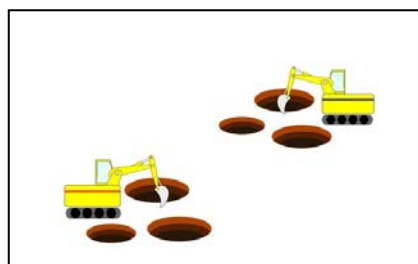
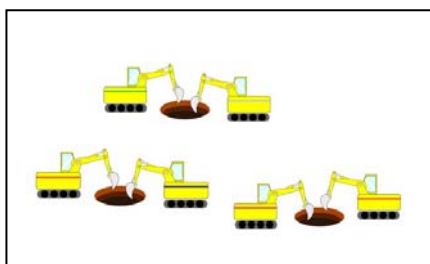
*Picture 5*



*Picture 6*

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

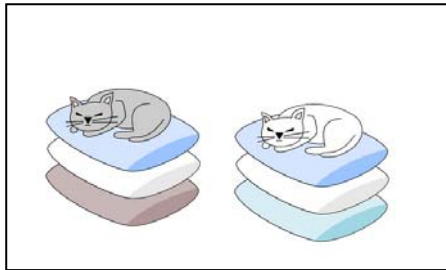
b. Három gödröt is két markoló ás.  
 three hole- ACC DIST two excavator digs  
 'Three holes each, two excavators are digging.'



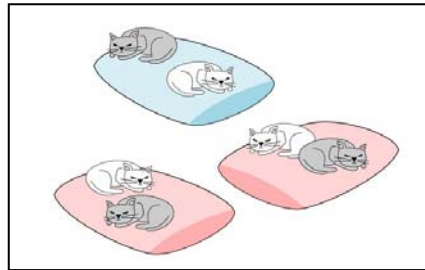
*Picture 7*

*Picture 8*

- (20) a. Két cica is három párnán alszik.  
two cat DIST three pillow-on sleeps  
'Two cats each are sleeping on three pillows.'
- b. Három párnán is két cica alszik.  
three pillow-on DIST two cat sleeps  
'On three pillows each, two cats are sleeping.'

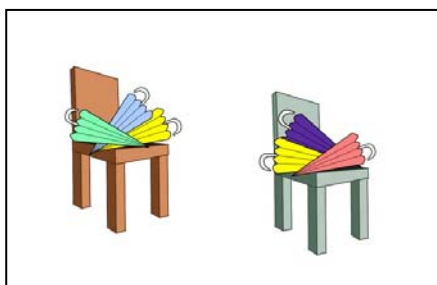


*Picture 9*

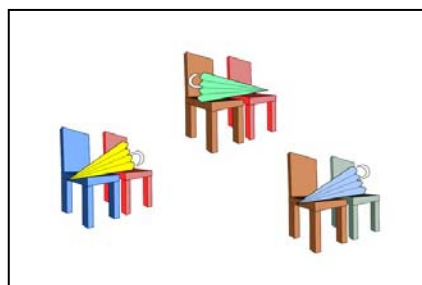


*Picture 10*

- (21) a. Két széken is három esernyő van.  
two chair-on DIST three umbrella is  
'On two chairs each, there are three umbrellas.'
- b. Három esernyő is két széken van rajta.  
three umbrella DIST two chair-on is on  
'Three umbrellas each are (placed) on two chairs.'



*Picture 11*



*Picture 12*

*Procedure:* The child, the experimenter, and a helper were seated at a table in a quiet room of the kindergarten. The helper had a hedgehog puppet on her hand. The experimenter told the child that they were going to play a game. The child and the hedgehog would be shown pairs of pictures. The hedgehog would say what she saw in one of the two pictures, and the child had to find out which of the pictures the hedgehog was talking about. Upon placing a pair of pictures on the table, the experimenter asked the child to look at both pictures carefully. After 4-5 seconds, the hedgehog uttered a sentence (with the helper avoiding looking at either of the pictures), and the experimenter asked the child which of the two pictures (s)he thinks the hedgehog spoke about. The child pointed at one of the two pictures, and the experimenter recorded his/her choice on a sheet. After giving the child some positive feedback, the experimenter removed the pictures, and put the next pair on the table.

We repeated the experiment with an adult control group, consisting of 44 subjects, 17 males, 27 females, mean age 22.02, SD=1.81.

*Results:* The test sentences in (18a,b)-(21a,b) represent the conditions listed below. Our child and adult subjects associated them with the pictures corresponding to their isomorphic direct scope readings at the following rates:

<b>Direct scope choices:</b>	<b>Children:</b>	<b>Adults:</b>
C1: Agent > Patient: <sup>4</sup>	78 %	98%
C2: Patient > Agent:	59 %	86%
C3: Actor > Patient:	85%	91%
C4: Patient > Actor:	22%	84%
C5: Agent > Location:	80%	98%
C6: Location > Agent:	32%	86%
C7: Location > Patient:	78%	100%
C8: Patient > Location:	24 %	80%

Among children, the proportion of direct choices was significantly higher in the case of OSV sentences than in the case of SOV sentences:<sup>5</sup> OSV Mean 2.68 SD=0.93; SVO Mean 1.90 SD=0.94; the relationship is  $t_{\text{paired}}=3.35$  (df=1/40)  $p=0.002$ . Adults' scope preferences were

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<sup>4</sup> 'Agent > Patient' is to be read as 'The agent argument precedes the patient argument'.

<sup>5</sup> O means here Object or Oblique (locative) complement.



not affected by the SOV vs. OSV order: OSV Mean 3.57 (SD=0.62); SVO Mean 3.66 (SD=0.60); the relationship is  $t_{\text{paired}}=0.70$  (df=1/43) n.s.

The adult–child comparison shows that adults chose the direct representations significantly more times than children:

**OSV** (sum of the direct answers to the four OSV sentences):

adults Mean 3.57 (SD=0.62)

children Mean 1.90 (SD=0,94) forditva volt

ANOVA  $F=93.27$  (df=1/83)  $p>0.001$

**SOV** (sum of the direct answers to the four SOV sentences):

adults Mean 3.66 (SD=0.60)

children Mean 2.68 (SD=0.93)

ANOVA  $F=33,07$  (df=1/83)  $p>0,001$

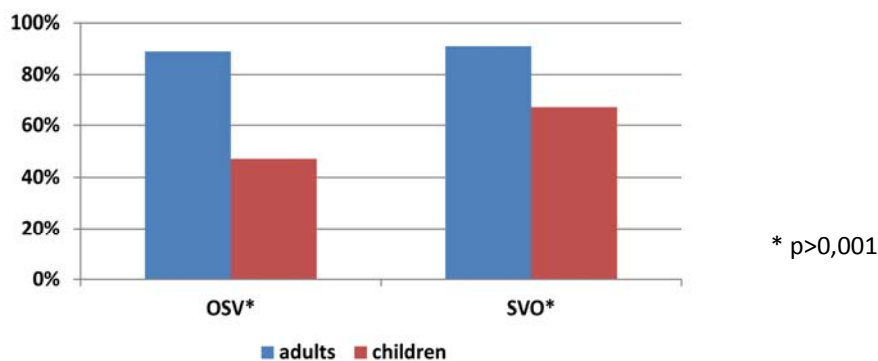


Figure 2: Direct scope choices in Exp. 2:

*Discussion:* Children displayed strong preference for direct scope only in four of the eight conditions (in C1, C3, C5 and C7). In three conditions (C4, C6, C8), they strongly preferred inverse scope. In one case (C2), the results were close to chance level. The preferences could not be derived from the theta role hierarchy in (17). E.g., in the preferred inverse scope reading in Condition 4, the patient argument was assigned wide scope over the actor, and in the preferred inverse scope reading of Condition 8, the location was assigned wide scope over the patient. The sum of these results is a mild preference for inverse scope: of the 328 choices that the children made, 57% represented direct/isomorphic scope, and 43% represented inverse scope. These results are markedly different from those of the adults, who chose the direct scope representation in 90% of all the cases. That is, Hungarian children’s scope interpretation proved to be significantly less isomorphic than that of adults.

These results have been confirmed by other experiments. In a forced choice sentence–picture matching experiment reported in É. Kiss, Zétényi, & Gerőcs (2013), 27 preschoolers (mean age: 6;5) had to choose between the visually represented direct and inverse distributive readings of doubly quantified sentences of type (18)-(21). Each sentence was associated with two picture pairs, which differed in the relative visual salience of the members of the sets denoted by the quantified expressions. It turned out that relative visual salience doesn't affect relative scope. What is important for us in the present context is the lack of strong isomorphism. In the case of OSV sentences, the preferred reading was the inverse scope reading in 58% of cases.

Another forced choice sentence–picture matching experiment reported in É. Kiss, Gerőcs, and Zétényi (2013) tested the hypothesis that children having to choose between the visual representations of the two distributive scope interpretations of a doubly quantified sentence choose the representation that is easier to segment into subevents. 39 preschoolers (mean age 6;5 years) participated in the experiment. The results basically supported the hypothesis: in most cases, children chose the visual representation that was more clearly chunked into subevents, irrespective of whether it represented the direct or inverse scope reading of the sentence. Among the preferred interpretations, direct scope readings constituted a small majority, 55% of the test cases.

In sum: all the available data concerning Hungarian children's scope interpretation point to the same conclusion. Hungarian children displays a slight bias towards isomorphism; however, they are far from being unanimously isomorphic. This is all the more surprising because scope interpretation in Hungarian adult language is isomorphic.

#### **4. Scope interpretation in doubly quantified sentences across languages**

The facts summarized in section 2, obtained mostly from English preschoolers, and the Hungarian facts summarized in section 3 appear to be in contradiction: whereas English children's scope interpretation is more isomorphic than that of English adults, Hungarian children's scope interpretation is less isomorphic than that of Hungarian adults. Crucially, however, the constructions tested in English and those tested in Hungarian are not identical. Whereas the English experiments that led to the observation and subsequent confirmation of isomorphism involve the scope relation of a quantifier and negation, the Hungarian test sentences all involve two numerical quantifiers.

We are aware of two experiments carried out in languages other than Hungarian investigating scope interpretation in doubly quantified sentences: Musolino's (2009) experiment with English preschoolers, and Lee's (2003) experiment with Chinese children.

Musolino (2009) tested the interpretations of sentences like (22a,b).

- (22) a. Three boys are holding two balloons.  
b. Three boys are holding each balloon.

Both sentences were associated with four pictures, representing their direct, inverse, collective and cumulative readings. (The latter two readings involve 3 boys and 2 balloons. In the collective reading, each boy is holding the same two balloons; in the cumulative one, two boys hold the same balloon, and the third boy holds a balloon by himself.) The sentence-picture pairs were judged both by adults and by children (mean age 5;0). It is not obvious that English children's scope interpretation of these doubly quantified sentences is more isomorphic than that of adults. In the case of (22a), the acceptance of direct scope was somewhat lower among children than among adults (78,1% vs. 82,8%). Crucially, the acceptance rate of inverse scope was much higher among children than among adults: 28.1% vs. 7.8%. What the data about (22b) show is that *each* is a wide scope distributive quantifier for adults; children, however, do not seem to know this property of *each*. 100% of adults accepted (22b) under the inverse reading, with wide scope assigned to the *each* phrase in object position, and only 31.2% of them accepted it under the direct reading. For children, the direct and inverse readings of (22b) were both acceptable; the acceptance rate of the direct reading was 90.6%; the acceptance rate of the inverse reading was 84.3.

Chinese is known to be a language where scope interpretation is to a large extent isomorphic (cf. Huang 1982, Aoun and Li 1993). Lee (2003), examining scope interpretation in doubly quantified sentences, found that Mandarin child language is less isomorphic than adult Mandarin. He tested the interpretations of sentences like (23a,b) in truth value judgement tasks. (23a) contains an agent subject and a theme object, and (23b) contains a theme subject and a goal or location complement.

- (23) a. You *liangge shushu tiaozhe sange/suoyoude/meige shuitong*.  
have two-CL uncle carry-ASP three- CL /all/every- CL water-bucket  
'Two men are carrying three/all the/every water-bucket(s)'

- b. You *liangtiao tanzi liangzai sangen/suoyoude/meigen zhuganrshang.*  
 have two- CL blanket hang-on three- CL /all /every- CL bamboo-pole-on  
 'Two blankets are hanging from three/all the/every bamboo pole(s)'

As the data below show, children accept inverse readings in much higher proportions than adults. The percentage of inverse readings is gradually decreasing by age, with one exception. the assignment of inverse scope in sentences containing a *mei* 'every' phrase in object position is lowest at the age of 8. Whereas adults do not allow inverse scope if the object is a *suoyou* 'all' phrase, many of them are willing to accept it if the object is a *mei* 'every' phrase.

### Percentage of acceptance of inverse scope by Mandarin-speaking children & adults

SENTENCE TYPE:	'Agent – theme'			'Theme – location/goal'		
	OBJECT Q: Numeral	<i>Suoyou</i> 'all'	<i>Mei</i> 'every'	Numeral	<i>Suoyou</i> 'all'	<i>Mei</i> 'every'
4 year-olds	22.2	33.3	44.4	50	61.1	69.4
5 year-olds	21.4	33.3	45.2	40.5	40.5	64.3
6 year-olds	16.7	26.2	35.7	47.6	47.6	54.8
7 year-olds	2.8	16.7	38.9	33.3	33.3	66.7
8 year-olds	0	2.8	8.3	28.8	25	38.9
Adults	5.1	0	20.5	10.3	15.4	59

In sum: the observation that children are inclined to isomorphic scope interpretation in sentences containing quantification and negation does not seem to extend to sentences containing two quantifiers. In Hungarian and Chinese, the scope interpretation of doubly quantified sentences is less isomorphic in child language than in adult language. In English child language, the interpretation of doubly quantified sentences is less biased towards isomorphism than the interpretation of sentences containing quantification and negation. At the same time, Hungarian and English children, and to some extent, Chinese children, as well, seem to ignore the distributivity/wide scope tendency of certain types of quantifiers (those supplied with the particle *is* in Hungarian, those associated with the determiner *each* in English, and those involving *mei* in Chinese).

## 5. Why children's scope interpretation of doubly quantified sentences is not isomorphic

### 5.1. Non-explanations

The theories of children's scope interpretation surveyed in section 2 are not specific to particular scope bearing elements and to particular languages, hence they should be extendable to Hungarian doubly quantified sentences, as well.

Musolino's (1998) original assumption, according to which isomorphism is a grammatical epiphenomenon, does not fare well with our experimental results. If English and Hungarian grammars represent two different values of the parameter of scope assignment, and the scope possibilities in Hungarian represent a subset of those in English, then the Semantic Subset Principle predicts both Hungarian and English children to set out with the assumption of a Hungarian type grammar, i.e., with the assumption of isomorphism. This is not what we attested; Hungarian children seem to assume that their language is of the English type, allowing both isomorphic scope and inverse scope.

The „grammatical” approach to isomorphism seems to suggest that children prefer the scope interpretations whose underlying syntactic structures are easier to generate. If that were the case, then Hungarian children would assign isomorphic scope to every operator. In Hungarian, overt Quantifier Raising is the same type of leftward movement rule as topicalization, an operation involved in the derivation of nearly every Hungarian sentence, hence it is unlikely to cause any syntactic problems.

According to Gennari and MacDonald's theory (2005/2006), children are sensitive to the distributional patterns of language use, and their bias towards isomorphic scope reflects their experience. This explanation does not carry over to Hungarian, either. The overwhelming majority of sentences with two operators that Hungarian children hear from adults are isomorphic, so the reason for children's use of inverse scope must be sought for elsewhere.

Gualmini (2004; 2008), and Gualmini et al. (2008) relate scope interpretation to pragmatics, claiming that children opt for the scope readings that represent a good answer to the Question Under Discussion. If both interpretations are good answers, the Principle of Charity makes children choose the interpretation that corresponds to a Yes. This theory does not seem to be relevant for the doubly quantified sentences we tested. In lack of a context, we can construct a Question under Discussion just as easily for both scope readings. Hence it is unlikely that children's scope interpretation in doubly quantified sentences should be determined by the pragmatic considerations identified by Gualmini.

### *5.2. A potential explanation: the kindergarten-path effect*

The most promising theory of children's apparent isomorphism for us is the approach of Musolino & Lidz (2003; 2006), who assume – relying on the experimental results of

Trueswell et al. (1999) – that preschoolers are reluctant, or unable, to revise their original interpretation of an ambiguous sentence. In sentences involving a quantifier and negation, the default reading (which is more frequent, and whose generation and processing is less costly) is the isomorphic reading. Hence this is the first choice for preschoolers, which they give up only if the pragmatic conditions force them to do so. Thus the inverse reading of sentences with two operators is inhibited by the same „kindergarten-path effect” that also blocks the revision of children’s initial commitments in other ambiguous sentence types.

If the isomorphic reading is the default interpretation of sentences involving quantification and negation, shouldn’t it also be the default option in the case of doubly quantified sentences? We claim – based on the results of our Experiment 3 to be presented below – that the default reading of doubly quantified sentences, including sentences containing the distributive particle *is* ’each’, is the collective reading for preschoolers. Hence both the isomorphic and the inverse distributive readings are secondary options, obtained by „turning back on the garden-path”.

### *5.3. Experiment 3: Acting out the primary meaning of doubly quantified sentences*

*Objectives:* Experiments 1 and 2 focussed on the distributive interpretations of doubly quantified sentences; they tested whether preschoolers can access them, and if they can, how they determine the scope order of the two quantifiers. However, doubly quantified sentences also have readings in which the two quantifiers do not enter into a scope relation. Thus a doubly quantified sentence of the type *Two teddy bears are playing with three cars* can also describe situations involving two bears and three cars altogether, i.e., a situation in which a group of three bears is playing with a set of two cars (collective reading), or a situation in which a bear is playing with two cars, and another bear is playing with one car (cumulative reading). Experiment 3 aimed to clarify by act-out tasks whether the distributive or the collective/cumulative readings are primary for Hungarian children.

*Participants:* 48 subjects, 25 males and 23 females participated in the experiment. They were recruited from the same kindergartens as in Experiments 1 and 2. The mean age of the subjects was 6;5 years (SD=4 months).

*Materials:* Participants were provided with 6 identical toy bears, 6 identical toy cars, 6 identical toy boats, 6 candies, and 2 little benches. They were asked to act out the following test sentences (and some fillers, as well):

(24) Három maci is két hajóval játszik.  
three teddy-bear DIST two boat-with plays  
'Three teddy bears each are playing with two boats.'

(25) Két autóval is három maci játszik.  
two car-with DIST three teddy-bear plays  
'With two cars each, three teddy bears are playing.'

(26) Három maci is két cukorkát kapott.  
three teddy-bear DIST two candy-ACC received  
'Three teddy bears each received two candies.'

(27) Két padon is három maci ül.  
two bench-on DIST three teddy-bear sits  
'On two benches each, three teddy bears are sitting.'

(24) and (25) describe actions which are equally plausible collectively or distributively (the players can play together or individually, and the toys can be shared or can be assigned to individual players). We assumed that the relation established by the verb *kap* 'receive' between the receivers and the objects received in (26) is more likely to be distributive; different receivers can easily be assigned different sets of objects (although receiving objects collectively is also conceivable). *Ül* 'sit' in (27) expresses an even more obviously distributive relation between locations and agents (the most likely scenario involving a set of benches and a set of sitting persons is such that different benches host different sets of persons).

*Procedure:* The child, the experimenter, and a helper were seated at a table in a quiet room of the kindergarten. The helper had a hedgehog puppet on her hand. The child had a 25 cm x 20 cm mat in front of her/him, surrounded by the arrays of little bears, toy cars, toy boats, candies, and toy benches. The experimenter explained that that was a kindergarten for little bears. The bears like to play on the mat, and their favorite toys are little cars and little boats. When they are tired, they sit down on the benches. Good little bears receive candies. The child and the hedgehog were going to play a game; the hedgehog would tell the child what

she would like to see on the mat, and the child should set up the situation. The child had to set up 12 situations, 4 test cases and 8 fillers. Each one started with the experimenter asking the hedgehog what she would like to see on the mat. The hedgehog uttered a sentence, which the child acted out with the toys on the table. When ready, (s)he received some positive feedback; then (s)he was asked to move the bears and toys back to their original places. The experimenter recorded whether the scenes set up represented the distributive or the collective/cumulative readings of the test sentences. The experiment was videotaped.

We repeated the experiment with a control group of 22 university students, males=13; females=9, Mean age =24,32 (SD=3,86).

*Results:* Despite the presence of the distributive particle *is 'each'*, (24) and (25) were interpreted collectively (or cumulatively) by each and every child. In the case of (26), 25% of the children chose the distributive reading, and in the case of (27), 65% of them opted for the distributive interpretation. When acting out (26), children noticed the difficulty of sharing 2 candies among 3 bears, and they tried to arrange the bears and candies fairly – e.g., placing one candy between bear 1 and bear 2, and placing the other candy between bear 2 and bear 3. The 35% of children acting out the collective reading of (27) defied pragmatic plausibility: many of them attached pairs of benches in various ways, and seated the three bears on them so that the bears should be sitting on both benches simultaneously.

Adults acted out distributive readings at significantly higher rates. Compare:

**The percentage of acting out the collective/cumulative readings:**

	Children:	Adults:
(24):	100%	81%
(25):	100%	68%
(26):	65%	22%
(27):	25%	22%



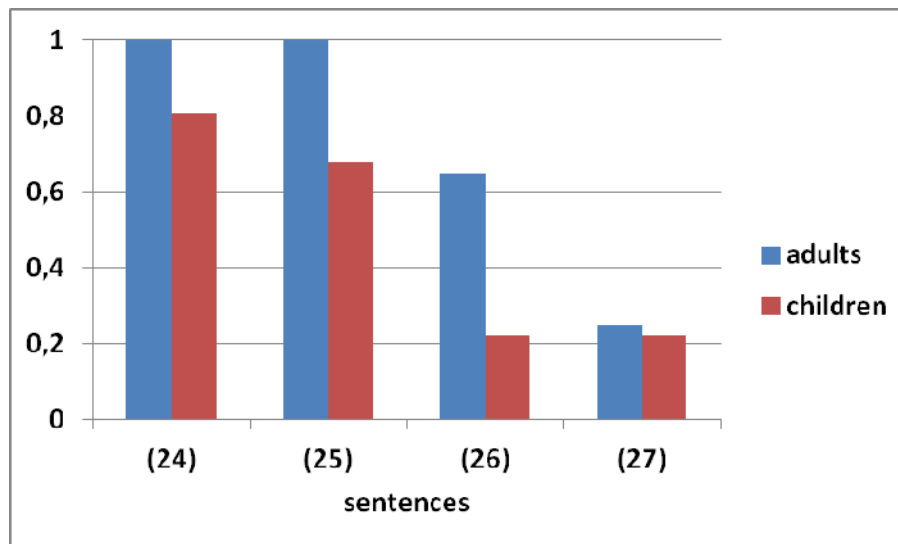


Figure 3: Collective responses in Exp. 3

The comparison of children's and adults' total responses shows that adults gave significantly more distributive answers than children:

Adult Mean 2.05 (SD=1.25)

Children's Mean 0.90 (SD=0.69)

ANOVA  $F=24.46$  ( $df=1/68$ )  $p>0.001$

*Discussion:* The participants of this experiment were the same preschoolers that accepted the distributive readings of doubly quantified sentences in truth value judgement tasks. That is, they could access the distributive readings at least passively. Nevertheless, the most easily available, default reading was the collective reading for them.

These children either ignored the distributive *is*, or interpreted it as an additive particle. *Is* has both a distributive and an additive function (i.e., it is ambiguous between 'each' and 'too'). The distributive function that it assumes when attached to a numerically modified phrase is apparently unknown to preschoolers. The problem may be more than just a lexical gap; recall that 90.6% of English children accepted the narrow scope reading of an *each* phrase in object position, and 8 year-old Chinese children were also more willing to accept the narrow scope reading of an object modified by *mei*, the Chinese distributive universal quantifier, than Chinese adults.

A large proportion of adults must also have interpreted the particle *is* additively – despite the fact that the additive *is* requires an antecedent, which was absent in the test sentences. That the distributive function of *is* adjoined to a numerically modified noun phrase is clear to

adults was shown by É. Kiss, Geröcs, Zétényi (2013: 149). 44 university students listened to the following two sentences:

(28) a. Az előadáson hat sorban is 14 hallgató ült.

the talk-at six row-in DIST 14 listener sat

'At the talk, there were 14 listeners sitting in each of six rows.'

b. Az előadáson 14 hallgató ült hat sorban.

the talk-at 14 listener sat six row-in

'At the talk, there were 14 listeners sitting in six rows.'

After each sentences, the students had to answer the question „How many listeners were there?” 93% of them answered „84” after (28a), and 90% of them answered „14” after (28b), i.e., the distributive interpretation of (28a) was almost unanimous. Apparently, the minimal pair in (28) helped elicit the distributive function of *is*; a preceding number phrase in itself is not sufficient for 22% of adults.

If the default reading of doubly quantified sentences is the collective reading for preschoolers, then a doubly quantified sentence describing a distributive situation always represents a garden-path problem, where the child accesses a distributive reading only at the second attempt. Since the distributive readings are thus dissociated from the flow of speech, the scope order of the two quantified constituents is not necessarily determined by their linear order but can be determined by other strategies, e.g., on the basis of their ranking in the hierarchy of grammatical functions or in the hierarchy of theta roles. Or children may choose a distributive reading on the basis of non-linguistic, visual cues. The experimental results of É. Kiss, Geröcs, and Zétényi (2013) indicate that a visual representation chunked into identical subevents is more likely to be selected than a condensed representation, and a visual representation consisting of two subevents (e.g., two boats, each surrounded by three bears, corresponding to the inverse scope reading of (24)) is more likely to be selected than a representation consisting of 3 subevents (e.g., 3 bears, each having two boats, corresponding to the direct scope reading of (24)).

Although we have no direct evidence testifying that preschoolers accessing the distributive interpretation of a doubly quantified sentence face a garden-path problem, a fourth experiment has provided evidence that the computation of distributive readings requires significantly more time than the computation of collective readings. (This is the type of evidence that

supports the assumption of a garden-path effect, i.e., the assumption of a two-step interpretation, in the ambiguous sentences of adult language – see Anderson (2004)).

#### 5.4. Experiment 4: Measuring the reaction times of collective and distributive interpretations

*Objectives:* The aim of the experiment was to compare the reaction times of the truth value judgments of sentence–picture pairs consisting of a doubly quantified sentence and the visual representation of its collective, direct distributive, and inverse distributive interpretation.

*Participants:* We tested 23 preschoolers (mean age 5;11, SD: 0,29), 11 females, 12 males, recruited from a Budapest kindergarten.

*Materials:* The children had to judge the truth value of the doubly quantified sentences in (29)-(32) under their collective, direct distributive, and inverse distributive readings. The test sentences differed in the relative order and the cardinality of their subject and object. Each sentence was presented three times, accompanied by three different pictures. Picture A represented the collective interpretation, picture B represented the direct distributive interpretation, and picture C represented the inverse distributive reading. The order of the sentence–picture combinations was randomized, and the 12 test cases were separated by fillers.

C1: SOV,  $2 > 3$

(29) Két lány is három virágot locsol.

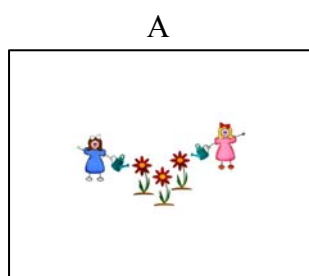
two girl DIST three flower-ACC waters

‘Two girls each are watering three flowers.’

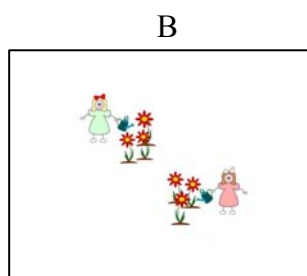
Picture A: 2 girls, 3 flowers

Picture B: 2 girls, 6 flowers

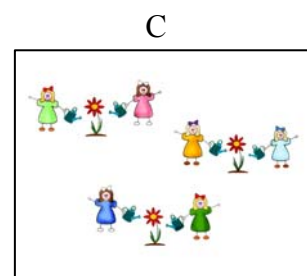
Picture C: 6 girls, 3 flowers



Picture 13



Picture 14



Picture 15

C2: SOV, 3 > 2

(30) Három maci is két autóval játszik.

three teddy-bear DIST two car-with plays

'Three teddy bears each are playing with two cars.'

Picture A: 3 bears, 2 cars

Picture B: 3 bears, 6 cars

Picture C: 6 bears, 2 cars

C3: OSV, 2 > 3

(31) Két szánkót is három maci húz.

two sled-ACC DIST three teddy-bear pulls

'Two sleds each are being pulled by three teddy bears.'

Picture A: 2 sleds, 3 bears

Picture B: 2 sleds, 6 bears

Picture C: 6 sleds, 3 bears

C4: OSV, 3 > 2

(32) Három tornyot is két fiú épít.

three tower-ACC DIST two boy builds

'Three towers each are being built by two boys.'

Picture A: 3 towers, 2 boys

Picture B: 3 towers, 6 boys

Picture A: 6 towers, 2 boys

*Procedure:* The child, the experimenter, and a puppet were seated at a table in a quiet room of the kindergarten. The child was facing a computer screen. The experimenter explained that they would see pictures, and the puppet would tell them what he saw in each picture.

However, the puppet had weak eyes, therefore he would ask the child if he was right, and the child should answer him by *yes* or *no*. Then a picture appeared on the computer screen. After 3 seconds, a recorded voice (allegedly the voice of the puppet) asked a question containing a test sentence or a filler embedded under the matrix clause *Jól láttam?* 'Have I seen correctly?'. For example:

- (33) a. Jól láttam, hogy két lány is három virágot locsol?  
 well saw-I that two girl DIST three flower-ACC waters  
 'Have I seen correctly that two girls each are watering three flowers?'
- b. Jól láttam, hogy három maci is két autóval játszik?  
 well saw-I that three teddy-bear DIST two car-with plays  
 'Have I seen correctly that three teddy bears each are playing with two cars?'
- etc.

The experiment was also repeated with an adult control group consisting of 25 university students recruited from various undergraduate courses (10 males, 15 females, mean age: 21.5, SD=2,20).

The sessions were recorded for later analysis. The subjects' *yes* answers were coded as 1, and their *no* answers were coded as 0. The reaction times were measured by the duration of pause between the offset of the recorded question and the onset of the subject's answer, i.e., the length of the time the subject needed to compute the answer.

*Results:* The test sentences were accepted as true of the visual representations of the collective (Picture A), direct distributive (Picture B), and inverse distributive readings (Picture C) at the following rates:

**Acceptance rates by pictures:**

	Children:		Adults:	
	Mean	SD	Mean	SD
Picture A	0.97	0.18	0.70	0.46
Picture B	0.62	0.49	0.66	0.48
Picture C	0.46	0.50	0.31	0.46

Almost every child accepted the test sentences as true of Pictures A, the collective readings – ignoring the distributive function of the particle *is*. Children's rejection rate increased significantly in the case of Pictures B and Pictures C ( $F=36.07$  ( $df=2/273$ )  $p>0.001$ ). Adults accepted the test sentences as true of Pictures A and Pictures B at similar rates (66-70%). (For those rejecting the collective reading, the quantificational context elicited the distributive role of *is*.) Adults' rejection rate of Pictures C was significantly higher than that of Pictures A and Pictures B ( $F=21.09$  ( $df=2/297$ )  $p>0.001$ ).

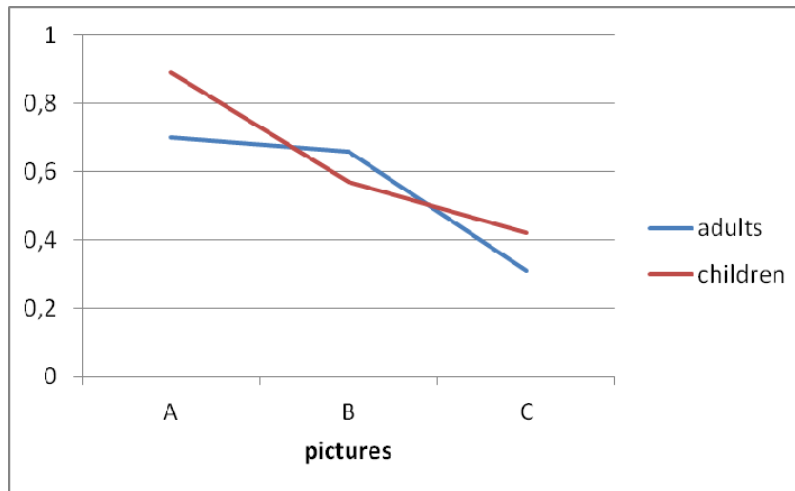


Fig. 4: Acceptance of collective (A), direct distributive (B), and inverse dist. (C) readings

Subjects needed the following average reaction times to evaluate the sentence–picture combinations:

**Reaction times by pictures:**

	Children:		Adults:	
	Mean	SD	Mean	SD
Picture A	1065	863	1290	1642
Picture B	1629	1624	1355	1457
Picture C	2149	1904	1558	1235

Children’s answers to the test stimuli show half a second increases in reaction time from the collective Picture A to the direct distributive Picture B and from Picture B to the inverse distributive Picture C ( $F=11.58$  ( $df=2/273$ )  $p>0.01$ ). For adults, there is no difference between the reaction times by the pictures ( $F=0.93$  ( $df=2/297$ ) n.s.).

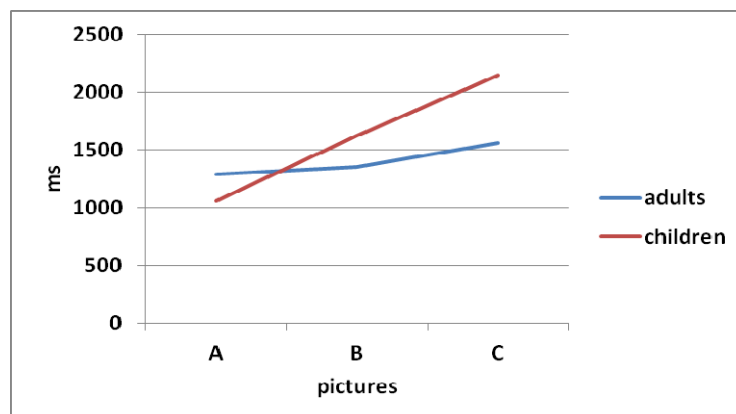


Fig. 5: Reaction times of collective (A), direct dist. (B) and inverse dist. (C) readings

Whereas children's acceptance rates do not differ significantly by the sentences, their acceptance of the direct and inverse distributive readings shows a highly variable distribution.

**Children's acceptance of the direct and inverse distributive readings by sentences:**

	Direct distributive	Inverse distributive
C1: SOV 2 > 3	96%	22%
C2: SOV 3 > 2	70%	57%
C3: OSV 2 > 3	52%	26%
C4: OSV 3 > 2	36%	78%

Mean<sub>Direct distributive</sub>=0.61 (SD=0.49): Mean<sub>Inverse distributive</sub>=0,45 (SD=0.50)  $F_{Direct/Inverse}=5.00$  ( $df=1/182$ )  $p<0.027$ .

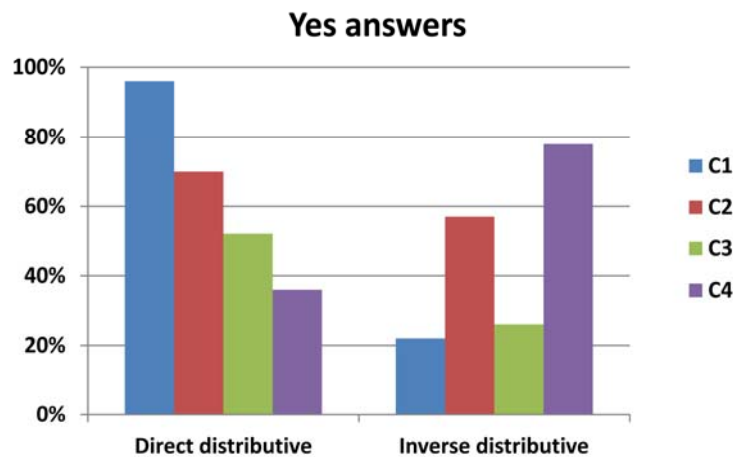


Figure 6: Variability of the acceptance of distributive readings

The reaction times needed to evaluate the four test sentences under the direct and inverse distributive readings yielded similarly high variability:

**Children's reaction times of the direct and inverse distributive readings by sentences:**

	Direct distributive readings	Inverse distributive readings
C1 2 Agents > 3 Patients:	1257 ms	2848 ms
C2 3 Agents > 2 Patients:	1667 ms	1563 ms
C3 2 Patients > 3 Agents:	1868 ms	2609 ms
C4 3 Patients > 2 Agents:	1722 ms	1575 ms

Mean<sub>Direct distributive</sub>=1629 (SD=1624): Mean<sub>Inverse distributive</sub>=2149 (SD=1904)  $F_{Direct/Inverse}=3.98$  ( $df=1/182$ )  $p<0.048$ .

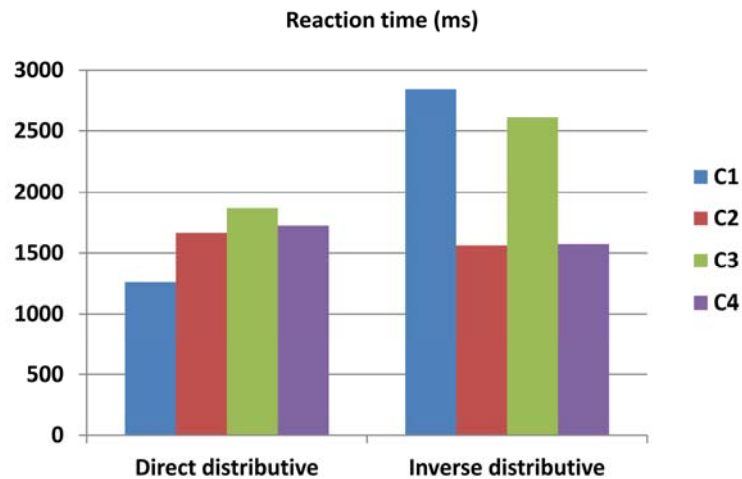


Figure 7: Variability of the reaction times of distributive readings

*Discussion:* Children’s average reaction time of evaluating the collective readings proved to be significantly ( $p < 0.001$ ) shorter than their average reaction time of evaluating the distributive readings – as predicted if children accessing a distributive reading face a garden-path situation, and make two rounds of interpretation. Naturally, the longer reaction time of the distributive interpretations could also be the consequence of the greater complexity of the distributive readings. However, this assumption would not explain the great variability of the reaction times and the *yes/no* answers that we attested within the distributive interpretations in the four conditions. This great variability is expected in case the default, online, incremental interpretation of doubly quantified sentences, based on the linear order of constituents, fails, and speakers attempting a second, offline interpretation can choose from a set of alternative strategies. They can rely either on the linear order of the constituents, as in the online attempt, or on their functional or thematic hierarchy, or on the relative cardinality of the quantifiers, or they can base the interpretation on some visual cue.

The primary factor determining our subjects’ preferred distributive scope was the relative cardinality of the sets denoted by the quantified expressions. In each of the four conditions, the interpretation where 2 had scope over 3 was accepted by more children and was judged in a shorter time than the interpretation where 3 had scope over 2.

Another factor affecting children's interpretation of distributive scope was the grammatical function/thematic role of the quantified elements. In conditions 1, 2, and 4, more children accepted the subject-wide-scope reading than the object-wide-scope reading, although the



reaction times of the TVJs of subject-wide-scope sentences were shorter only in conditions 1 and 4, where the cardinality of the subject was smaller than the cardinality of the object.

The third factor affecting children's judgments was linear order (i.e., surface structure hierarchy). In conditions 1, 2, and 3, significantly more children accepted direct scope than inverse scope. The average reaction time children needed to evaluate the direct readings was significantly shorter than the average reaction time they needed to evaluate the inverse readings ( $p < 0.048$ ), even if the assignment of direct scope took a shorter time than the assignment of inverse scope only in conditions 1 and 3, where the initial quantifier has smaller cardinality.

In sum: the results of Experiment 4 support the claim that the computation of the distributive interpretation of a doubly quantified sentence involves significantly more cognitive load than the computation of the collective interpretation. This is in line with the hypothesis that the derivation of distributive readings represents a garden-path situation, where children discard their initial interpretation and compute a second reading. Children's truth value judgements of the direct and inverse scope readings of doubly quantified sentences, and the reaction times of their answers show great variability depending on the relative cardinality, the thematic role/grammatical function, and the linear order of the two quantified expressions, which suggests that the dissociation of the interpretation from the linear flow of speech in garden-path situations gives way to interpretive strategies determined by structures other than linear order.

## **6. Conclusion**

This paper has aimed to answer the question why the strong tendency for isomorphism in children's interpretation of the relative scope of quantification and negation is absent in the interpretation of double quantification; and whether the competing approaches proposed to account for the isomorphism of sentences with quantification and negation are compatible with the lack of isomorphism in doubly quantified sentences. The discussion has primarily been based on evidence from Hungarian child language, but reference has also been made to converging results of experiments testing English and Chinese children's interpretation of doubly quantified sentences.

Facts of Hungarian child language are particularly interesting for the evaluation of theories of isomorphism because Hungarian adult language is isomorphic, with quantifiers overtly moved to scope positions. In the interpretation of doubly quantified sentences, Hungarian child language has been found to be considerably less isomorphic than the adult input. This

fact immediately excludes as a potential explanation of isomorphism Gennari and MacDonald's (2005/2006) theory, according to which children's scope interpretation strategies are determined by the distributional patterns of adult language use. The fact that Hungarian adult language is more isomorphic than Hungarian child language is also incompatible with the „grammatical” approach of Musolino (1998), claiming that the initial assumption that children set out with is isomorphic scope marking, which they only give up if they meet with evidence to the contrary. Gualmini's (2004; 2008) alternative theory, according to which children's scope preferences are determined by pragmatic conditions, has proved to be irrelevant for the experiments surveyed, which tested minimal pairs not differing in any pragmatically meaningful way.

The theory that has proved to be compatible with the lack of isomorphic bias in Hungarian doubly quantified sentences is the theory of Lidz and Musolino (2003, 2006). Lidz and Musolino argue that children interpreting scopally ambiguous sentences (those involving negation and quantification) face a garden-path problem. The default reading that is immediately accessible to them is the direct, isomorphic interpretation. When pragmatic conditions render the isomorphic reading implausible, children have to reanalyze their initial incorrect interpretation. However, the reanalysis of initial commitments is a difficult process for children – because of their weaker inhibitory control and/or reduced working memory capacity according to Joseph and Liversedge (2013) – hence they tend to hold on to their initial isomorphic interpretation.

As the experiments presented in this paper showed, the default reading of doubly quantified sentences for Hungarian preschoolers is the collective reading. Although in truth value judgement tasks they can access the distributive readings, in acting-out tasks they choose the collective interpretation. A distributive particle attached to the initial quantifier elicits the isomorphic distributive interpretation for the majority of Hungarian adults; children, however, ignore this particle. Consequently, if the situation associated with a doubly quantified sentence is incompatible with the collective reading, children have to turn back on the garden path, and have to produce a second interpretation – as suggested by the fact that the distributive interpretation of a sentence takes a significantly longer time than the collective interpretation of the same sentence.

Since the reanalysis of a misanalyzed sentence is dissociated from the flow of speech, it is not necessarily determined by the linear order of scope bearing elements. Experimental results indicate that scope order may also be determined by the ranking of quantified elements in the hierarchy of grammatical functions and theta roles, and/or by the relative cardinality of the

two sets, and/or by the visual grouping of the participants, which often result in inverse scope interpretations.

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