Preschoolers rely on visual cues in the interpretation of doubly quantified sentences: Evidence from eye tracking

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Background

English children interpret sentences containing a quantifier and negation in a linear/ isomorphic manner, assigning wide scope to the initial operator (Musolino 2011). Explanation: the isomorphic reading is the default online interpretation of ambiguous sentences, the revision of which is costly cognitively.

We found in a series of experiments that Hungarian preschoolers show no tendency to interpret sentences with two numerical quantifiers isomorphically (É.Kiss, Gerőcs & Zétényi 2012; 2013). This is all the more surprising because scope interpretation in Hungarian adult language is isomorphic. Thus, whereas (1) only has the isomorphic/direct scope interpretation in (a) for adults, **kids sometimes choose the direct (a), and sometimes the inverse (b) reading**.

(2) *Három fiú is két tornyot épít.*
three boy each two tower-ACC builds

    a.'Three boys each are building two towers.'   (3 boys, 6 towers)
    b.'Two towers each are being built by three boys.'   (2 towers, 6 boys)
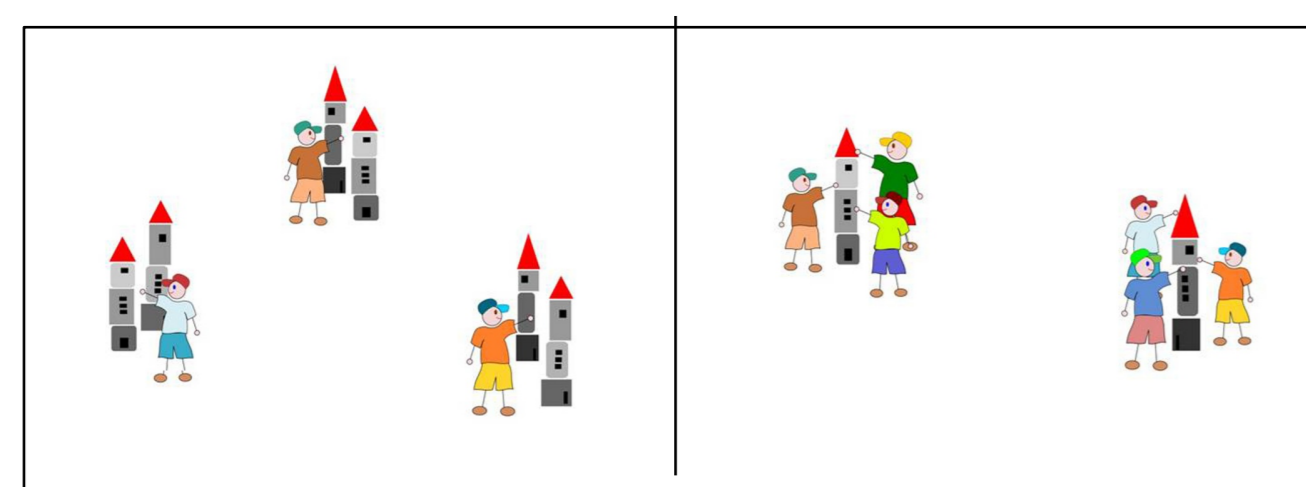
In fact, the default reading of (2) for children, elicited in acting out tasks, is the collective reading in (3) (É. Kiss, Zétényi & Gerőcs 2012), i.e., **kids don't interpret *is* 'each' as a distributive operator.**

    (3) 'A group of three boys are building a group of two towers.' (3 boys, 2 towers)

Hypothesis

If the default reading of a doubly quantified sentence for a child is the collective reading , then the distributive readings – both the direct and the inverse ones – require the revision of the primary, collective interpretation. We tested if behavioral data corroborate the hypothesized revision.

If revision takes place, it **needs more computation during parsing and decision making, and the behavioral measures will reflect the cognitive costs**.

Revision involves no linear order for the quantifiers; **the preferred distributive reading is selected on the basis of visual cues. Chunked representations are preferred to condensed ones, and representations with 2 subevents are preferred to those with 3 subevents.**

Methods

Subjects: 32 preschoolers (17 boys, 15 girls) mean age: 6;3 years
Control group: 23 adults (9 male, 13 female university students) ages 21-25 years.
Stimuli: 48 videos were created from the 24 test picture pairs and 24 filler picture pairs, with a voice-over of the test sentence.
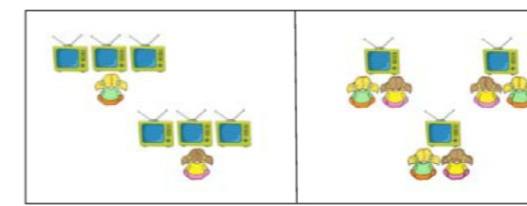*Instrumentation:* Stimuli were presented on a 17' notebook screen by **Tobii Studio 3.1.**
Eye movements were simultaniously recorded by a **Tobii X30-2** portable eye tracker, which was attached under the screen of the notebook.
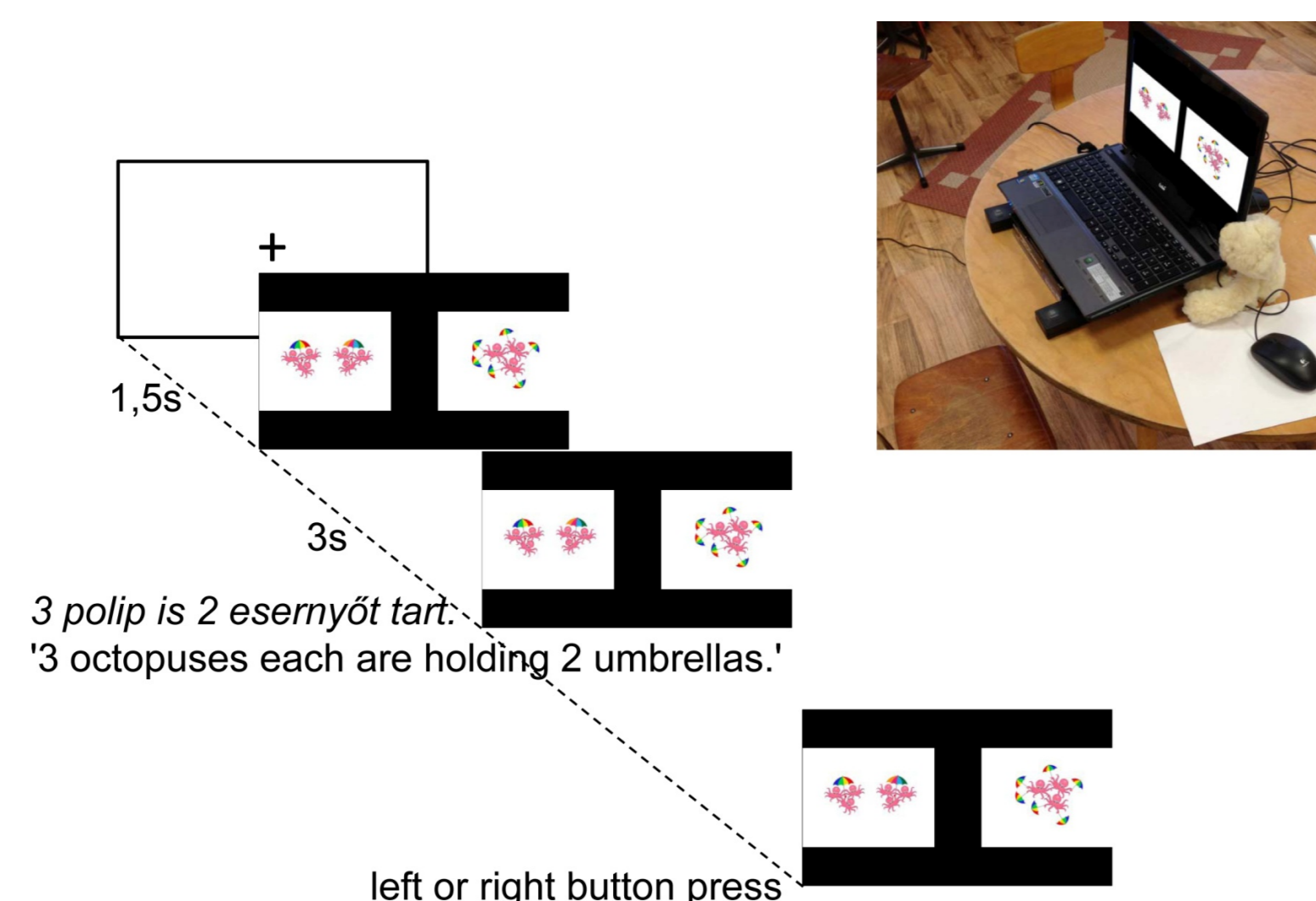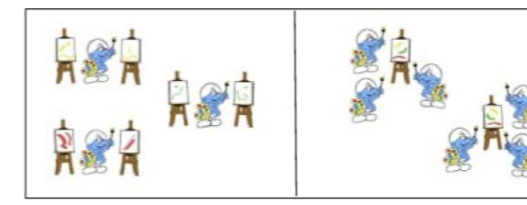

The design of the experiment used 6 conditions:

C1 (a) **isomorphic** vs. (b) **inverse**
    chunked   **chunked**
    2 subevents   **3 subevents**
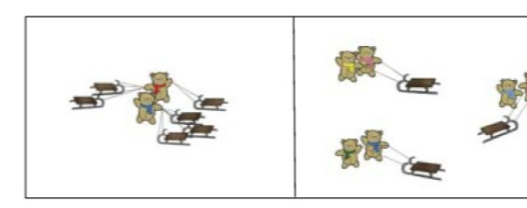
Két lány is három TV-t néz. 'Two girls each are watching three TVs.'

C2 (a) **isomorphic** vs. (b) **inverse**
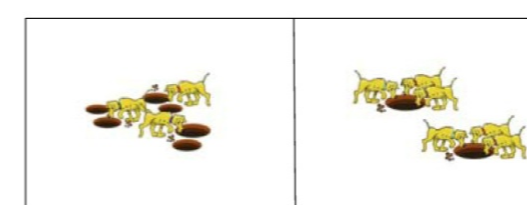   **chunked**   **chunked**
    3 subevents   **2 subevents**

Három törpe is két képet fest.'Three dwarfs each are painting two pictures.'

C3 (a) **isomorphic** vs. (b) **inverse**
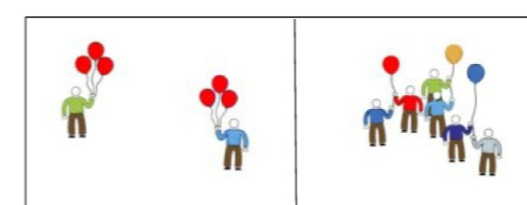   **condensed**   **chunked**
    2 subevents   **3 subevents**

Két maci is három szánkót húz. 'Two bears each are pulling two sledges.'

C4 (a) **isomorphic** vs. (b) **inverse**
    condensed   **chunked**
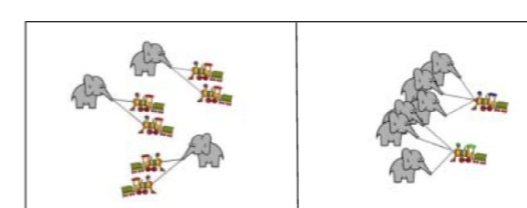   **3 subevents**   **2 subevents**

Három kutya is két gödröt ás. 'Three dogs each are digging two holes.'

C5 (a) **isomorphic** vs. (b) **inverse**
    chunked   **condensed**
    2 subevents   **3 subevents**

Két fiú is három lufit tart. 'Two hoys each are holding three balloons.'

C6 (a) **isomorphic** vs. (b) **inverse**
    chunked   **condensed**
    3 subevents   **2 subevents**

Három elefánt is két vonatot húz. 'Three elefants each are pulling two trains.'

Results

Direct answers %
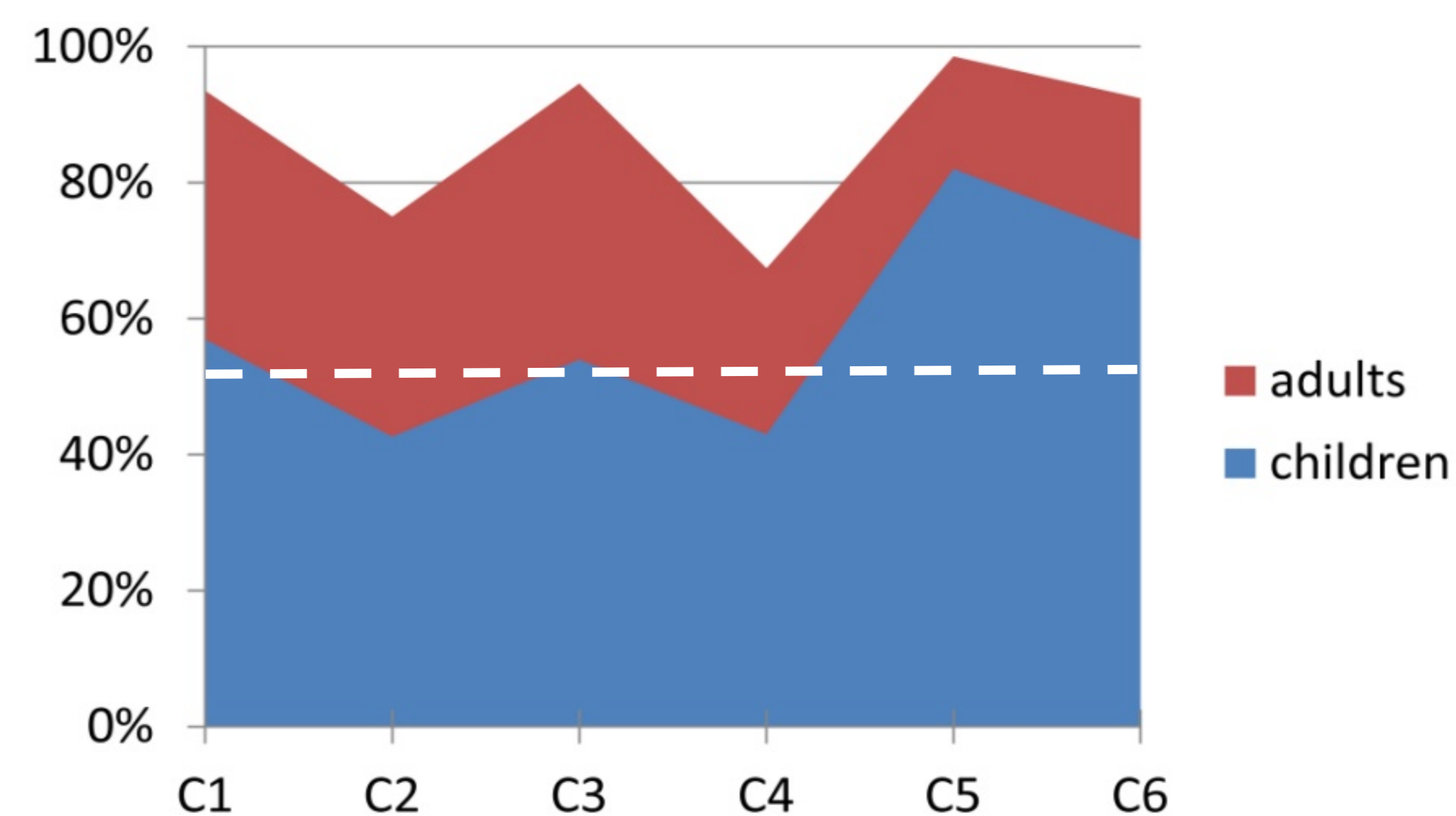
- When both pictures are chunked, **children choose the direct and inverse scope readings at nearly chance level** (Conditions 1, C2).
- **Preference for direct scope is manifest/close to the adult level when the direct scope representation is chunked** into subevents and the inverse representation is not (C5, C6).
- **Pictures with 2 subevents** (C1, C3, C5) **are preferred to pictures with 3 subevents** (C2, C4, C6) in both groups.

Variables	Adults	Children
Reaction time	→	
Left AOI fixations during the first 3s	=	
Right AOI fixations during the first 3s	=	
Total AOI fixations until the answer	←	
More AOI fixations on direct picture	←	
Percentage of AOI fixations on direct picture	→	
Total duration of AOI fixations	→	
More AOI visit duration on direct picture	→	
Percentage of AOI visit duration on direct picture	→	

arrows: significant (min p<0,05), directions: larger values

The reaction time data show that **children need more time to answer** (appr. +700ms) than adults. This seems to corroborate the hypothesis that the task is **computationally more costly** for children.

Eye-tracking data show that **in the first phase** of the session, before the presentation of the test sentence, there is **no difference** between adults' and children's eye movements.

Children had less fixations between the exposition of the test sentence and the answer, but spent **more time** on each side as compared to the adults. They also visited the direct pictures fewer times then the adults. This is not surprising because there is a tendency to watch the picture of choice before pressing the button, and the adults gave more direct answers.

The longer duration of visits may reflect the difficulty of resolving **the conflict that children experience between the default collective interpretation of the sentence and its distributive readings shown in the pictures**.

The total number of children's visits on the direct picture side was greater than the number of their visits on the inverse side, which **shows an emerging tendency towards adult-like interpretation.**

Summary

- **Preschoolers ignore the linguistic cue (the particle *is* 'each') that forces adults to interpret distributive scope online**; their default reading of doubly quantified sentences is the collective reading.
- **When stimuli force children to access a distributive reading, their interpretation** data display **longer reaction times, less fixations and longer durations.**
- Behavioral data reveal that **children 'try harder', presumably first computing the default collective reading, and then revising it.**
- **Of the two distributive readings, they eventually choose the one that is easier to process visually – i.e., they also exploit non-linguistic, visual information.**

References

É. Kiss, K, M. Gerőcs & T. Zétényi (2012) The linguistic roots of multiplication. Ms. Research Institute for Linguistics of the Hungarian Academy of Sciences, Budapest. (http://tinyurl.com/cy8pkgd)
É. Kiss, K, M. Gerőcs & T. Zétényi (2013) Preschoolers' interpretation of doubly quantified sentences. *Acta Linguistica Hungarica* 60, 143–171. DOI: 10.1556/ALing.60.2013.2.2
Musolino, J. (2011) Studying language acquisition through the prism of isomorphism. In: J. de Villiers & T. Roeper (eds.) *Handbook of Generative Approaches to Language Acauisition.* Springer, 319-350.