How do Hungarian preschoolers interpret number words?

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In addition to their ‘exactly *n*’ interpretation, numerals can receive non-exact readings, like ‘at least *n*’. Since in Hungarian the interpretation of numerals is claimed to be determined by their syntactic position we carried out three experiments with Hungarian preschoolers to verify whether they can make use of structural information when interpreting numerals. We found that irrespective of syntactic structure, they strongly preferred the upper-bounded interpretation and the lower-bounded reading was not (or hardly) accessible to them. We conclude that the findings provide support for the view that the default meaning of numerals is in fact ‘exactly *n*’.

1. Introduction

This paper reports on three experiments in which we investigated how Hungarian preschoolers interpret numerals in sentences such as (1a) and (1b).

(1) a. Kapjanak cukorkát azok a macik, akiknek három málnája van.
Get-IMP candy-ACC those the bear-PL who-PL three raspberry-POSS have
‘Those bears shall get a candy who have THREE RASPBERRIES.’
b. Kapjanak cukorkát azok a macik, akiknek van három málnája.
Get-IMP candy-ACC those the bear-PL who-PL HAVE three raspberry-POSS
‘Those bears shall get a candy who have three raspberries.’

Under the standard generative analysis the sentences above have different meanings due to the different syntactic structure of the relative clauses. In (1a) the numeral appears in the position immediately preceding the verb (referred to as focus position in the Hungarian literature) and therefore it can only mean ‘exactly three’. In contrast, in (1b) the numeral appears post-verbally and its meaning is ‘at least three’, though it can be supplemented with an upper-bounding implicature (‘and not more’), as a result of which the ‘exactly three’ reading also becomes available. The underlying assumption behind this analysis is that numerals have a lower-bounded (‘at least’) semantics by default and the upper-bounded (‘at most’) reading emerges as a consequence of focusing, i.e. movement of the numeral into the pre-verbal slot. According to the most recent views (É. Kiss 2006a, 2010), the function of this designated focus position is to identify the maximal set of individuals to whom the predicate holds

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excluding all other alternatives. Applying this operation to the number scale results in converting the lower-bounded (‘at least’) meaning of a numeral into the upper-bounded (‘exactly’) meaning. Thus, in Hungarian the distinction between the ‘at least’ and ‘exactly’ reading of numerals is claimed (É. Kiss 2006a, 2006b) to be grammaticalized.

Given this analysis, our first research question was whether Hungarian preschoolers can distinguish the meanings of sentences like (1a) and (1b), and if they can, whether they make use of the information structure of the sentence or if there are other cues they rely on.

It is, however, far from being obvious that the default meaning of numerals is ‘at least *n*’. Many argue (Horn 1992, Geurts 2006, Breheny 2008) that the primary meaning of numerals is in fact ‘exactly *n*’ and all other readings can be derived from this meaning. Investigating the acquisition path of numerals can help settle this debate. Since children’s pragmatic knowledge is considered to be more ‘fragile’ than that of adults (e.g. Crain & Thornton 1998), it is reasonable to assume that it is the default (literal) meaning that is more accessible to them. Related to this assumption, our second research question was how our results contribute to the semantic discussion on the default meaning of numerals.

2. On the meaning of numerals

It is a well attested fact (Horn 1972, 1989) that numerals give rise to three different interpretations, depending on the context in which they are used. Consider the following examples:

(2) a. - How many mistakes did you make?
   - I made three mistakes.
  b. If you make three mistakes you will fail the test.
  c. If you make three mistakes you can still pass the test.

In (2a) the number word *three* is most naturally interpreted as ‘exactly three’. In (2b), however, *three* means ‘at least three’, since one will also fail if one made more than three mistakes. Similarly, in (2c) *three* here means ‘at most three’, since one can also pass the test if one made fewer than three mistakes.

In any proper semantic analysis of numerals this meaning alternation must be accounted for. Though it would be possible to treat the different meanings as distinct lexical items, such a treatment would not conform to economy requirements. Therefore, it is more reasonable to assume that there is one default meaning from which all the other interpretations can be derived. Most semantic theories agree on this point (Horn 1972, Levinson 2000). However, on the question of which meaning is the default and how the other readings emerge, no consensus has yet been reached.

2.1. The neo-Gricean Approach

One of the mainstream approaches to the analysis of the meaning of numerals follows Gricean traditions (e.g. Levinson 2000). This approach claims that the default meaning of numerals is ‘at least *n*’ and that the ‘exactly *n*’ reading is a scalar implicature. In the Gricean framework scalar implicatures fall into the category of generalized conversational implicatures. They are triggered by scalar expressions, hence the term ‘scalar’. Scalar expressions are expressions in natural languages that can be ordered into scales according to their semantic strength. Typical examples can be seen in (3).

(3) <a, some, many, most, all>; <or, and>

In a scale, the stronger (more informative) expression entails the weaker one; for example if it is true that John ate all the cookies, then it is also true that John ate some of the cookies. This entailment, however, holds only in one direction, i.e. the weaker term does not entail the stronger one.

Scalar implicatures typically arise when the use of a weaker term implies that the use of the stronger term from the same scale would result in a false statement. This is illustrated in (4).

(4) John: Are the cakes ready?
Mary: Some of them are.

Mary's answer is most naturally interpreted as meaning that it is not true that all the cakes are ready, though Mary's statement would also be (logically) true in a situation where in fact all the cakes are ready. According to Gricean reasoning the listener assumes that Mary observes the Maxim of Quantity (i.e. she is sufficiently informative) and draws the conclusion that it is not true that all the cakes are ready, because if it were, Mary would have said so (Grice 1975).

It is important to note that scalar implicatures (and implicatures in general) do not necessarily follow from the literal meaning and they can be cancelled (5).

(5) John ate some of the cakes – in fact, he ate all of them.

From a neo-Gricean viewpoint, the behaviour of numerals is similar to that of scalar expressions. The comparison is rather convenient considering the fact that number words also form a scale and exhibit the same entailment pattern as scalar expressions: if it is true that John ate five cookies, then it is also true that John ate four, three, etc. cookies. In other words, the sentence *John ate four cookies* is true in a situation as well, where in fact John ate five cookies. More formally stated: if a predicate P holds for a set of cardinality x, then the same P predicate holds for the set of cardinality x+*n*. Consequently, the default meaning of numerals must be 'at least *n*'.

In (6) the scalar expression *some* has been replaced with a numeral.

(6) John: Are the cakes ready?
Mary: Three of them are.

In this situation *three* is most naturally interpreted as 'exactly three', which is a scalar implicature. The reasoning here is the same as in the previous case: assuming that Mary is sufficiently informative, the listener concludes that it is not true that more than three cakes are ready, otherwise she would have said so.

Thus, advocates of neo-Gricean theory argue that numerals behave similarly to 'ordinary' scalar expressions. By default numerals have a lower-bounded ('at least *n*') semantics and the upper-bounded ('exactly *n*') interpretation is a scalar implicature arising as a result of inferential processes. If the implicature is cancelled, the default lower-bounded meaning returns.

2.2. Alternative analyses

The neo-Gricean approach has been subject to much criticism in recent years in the semantic and psycholinguistic literature (see Geurts 2006, Papafragou & Musolino 2003). The biggest concern of those disfavouring this approach is that numerals do not behave similarly to other scalar expressions. It has been observed that scalar implicatures triggered by scalar expressions consistently disappear in downward entailing contexts, e.g. in the scope of negation, as in (7).

(7) a. Fred didn't read many of the books Wilma gave him.[1]
b. Fred didn't read all the books Wilma gave him.

In (7a) the implicature ('but not all') triggered by *many* has been cancelled, i.e. the upper bound has been removed. It is indicated by the fact that (7a) entails (7b). If numerals behaved similarly to scalar expressions we would expect that (8a) also entails (8b). This is, however, not the case, as indicated in (8).

(8) a. Fred didn't read two of the books Wilma gave him.
b. Fred didn't read three of the books Wilma gave him.

In (8a) the implicature is not cancelled, i.e. the number word *two* still means 'exactly two'. The negation wide scope reading explains why (8a) does not entail (8b).

The examples cited above are intended to prove that no parallel can be drawn between the behaviour of scalar terms and numerals. In his later works even Horn reconsiders his earlier views on this topic; see Horn (1992). Furthermore, the fact that the downward entailing context has no effect on the interpretation of numerals raises the possibility that the default meaning of numerals is in fact 'exactly n'. Geurts (2006) and Breheny (2008) both argue for this latter assumption.

Geurts first points out that numerals have a quantifier (9a) and predicate (9b) meaning that should be treated separately.

(9) a. Five cows mooed.
$\exists x\ [\#x = 5\ \&\ cow\ (x)\ \&\ moo\ (x)]$
b. These are five cows.
$\#these = 5\ \&\ cow(these)$

While in (9a) the numeral appears in argument position and the proposition is bounded by an existential quantifier, in (9b) the numeral itself is the predicate. These two types of meaning can be converted into each other by type-shifting operations (namely Existential Closure and Quantifier Lowering). As regards the lower versus upper-bounded interpretation, Geurts (2006) simply proposes polisemy. He considers the upper-bounded quantifier meaning as default, and suggests that the different readings can be accessed via type-shifting.

Breheny's (2008) account has much in common with Geurt's (2006), although Breheny argues that the aforementioned type-shifting operations take place in the domain of pragmatics. Thus, the default meaning of numerals is 'exactly *n*' and the 'at least' reading emerges as a result of inferential processes. For example, the sentence *John ate three cookies*

[1] Citing examples (9) and (10) of Geurts (2011: 54).

can be interpreted as *There are three cookies such that John ate them*, which is actually the lower-bounded meaning, given that it is true also in a situation where John in fact ate four cookies.

No theory proposes that the default meaning of numerals is ‘at most *n*’. For this reason we do not discuss this interpretation in detail, although its acquisition is undoubtedly worth investigating.

To sum up so far, theories opposing the neo-Gricean approach argue that the interpretation of numerals is different from that of ‘ordinary’ scalar expressions and that their default meaning cannot be ’at least *n*’ (as is claimed on the neo-Gricean view, see Horn 1972, 1989, Levinson 2000, among others). As an alternative it is becoming increasingly accepted that the default meaning is ‘exactly *n*’ and all other readings can be derived from it (as has been suggested by Geurt 2006 or Breheny 2008).

3. Hungarian data

Hungarian deserves special attention in this discussion because in Hungarian the distinction between the lower-bounded and upper-bounded meanings of numerals is claimed to be grammaticalized (É. Kiss 2006b, 2010). Thus, if the numeral is focussed, it can only mean ’exactly *n*’, otherwise the meaning is ’at least *n*’. The following section provides a review of the basis for these claims.

Focus marking in Hungarian involves syntactic rearrangement, i.e. the focussed constituent moves to the position immediately preceding the tensed verb (focus position). This is illustrated in (10a), where the constituent *két doboz sört* ‘two cans of beer’ is focussed and appears pre-verbally. In (10b), however, the constituent *két doboz sört* is not focussed, consequently it does not move but appears in its argument position.

(10) a. János [két doboz sört]$_{Foc}$ iszik meg minden nap.
John two can beer-ACC drinks PRT every day
‘John drinks (exactly) two cans of beer every day.’
b. János megiszik [két doboz sört]$_{Foc}$ minden nap.
John PRT-drinks two can beer-ACC every day
‘John drinks (at least) two cans of beer every day.’

The widely accepted view in the Hungarian theoretic literature is that in (10a) *two cans* means ‘exactly two cans’ i.e. this sentence is not true if John drinks less or more beer every day. As opposed to this, in (10b) *two cans* means ‘at least two cans’, i.e. the sentence will be also true if John in fact drinks three or even more cans of beer every day. It is important to note that the ‘exactly’ reading can arise in (10b) as well, but in this case we are dealing with a scalar implicature that can be derived from Grice’s maxims (see point 2.1). In other words, while in (10a) the ‘exactly’ reading is compulsory, in (10b) pragmatic factors decide whether the precise reading arises or not.

The analysis sketched above has two basic assumptions: (i) numerals have a lower-bounded semantics by default (following Horn 1972), and (ii) Hungarian pre-verbal focus expresses exhaustive identification. Assumption (i) can be easily supported by examples such as that in (11).

(11) Aki fel-nevelt két gyereket, az 15% nyugdíjemelésre jogosult.[2]
who up brought two children (s)he 15% pension-raise-to entitled-is
'Who(ever) has brought up (at least) two children is entitled to a 15% pension raise.'

It is obvious that in terms of (11), those having more than two children are also entitled to receiving a pension raise. It must be noted, however, that theories which cast doubt on the validity of (i) do not claim the opposite, either. Instead they suggest that (11) can be transformed into an existential statement ('if there are two children such that *y* raised them') whose truth conditions do not depend on whether *y* has *at least two* or *exactly two* children (see point 2.2).

Assumption (ii) can be traced back to the work of Szabolcsi (1980, 1981). She claims that Hungarian pre-verbal focus bears a special semantic feature, namely, it expresses 'exhaustive listing'. This means that pre-verbal focus provides an exhaustive list of the referents for which the statement expressed by the sentence is true. The fact that the sentences in (12) contradict each other is a good indicator of this exhaustivity feature.

(12) a. [Péter]$_{Foc}$ aludt a padlón.
Peter sleep-PAST the floor-on
'PETER was sleeping on the floor.'
b. [Péter és Pál]$_{Foc}$ aludt a padlón.
Peter and Paul sleep-PAST the floor-on
'PETER AND PAUL were sleeping on the floor.'

According to É. Kiss's (2006a) account in (12b) the conjoined NP appearing in the focus position exhaustively specifies the set denoted by the background ('who slept on the floor', namely Peter and Paul), thereby excluding any other possible alternatives. The same procedure takes place in (12a), although here Peter is the only element of the set. The contradiction stems from the fact that the elements of these sets are not identical. É. Kiss (2006a) analyses the pre-verbal element as a specificational predicate that takes the VP as its subject and claims that exhaustivity arises as a semantic consequence of the predicate referentially specifying the set determined by the subject. Other theories (e.g. Horváth 2005) presume that an abstract semantic operator (dubbed either an 'exhaustivity operator' or 'maximality operator') is responsible for the exhaustive interpretation associated with pre-verbal focus in Hungarian. Its function is to exhaustively identify the maximal subset of the set of alternatives for which the predicate holds. Thus according to this view, exhaustivity also arises as a result of identification.

In the case of numerals, the alternatives to a number *n* are all the other numbers on the number scale not being equal to *n*. That is, numbers that are not equal to *n* form the set of alternatives on which the focus operates, thus identifying the maximal subset for which the statement expressed by the sentence holds. As a result of this identificational mechanism, numbers not being equal to the value denoted by focussed number are excluded, thereby narrowing down the lower-bounded meaning to the upper-bounded one. Consequently (13a) and (13b) cannot be true at the same time because in (13a) the alternatives to the number word *fifteen* (including the numbers greater than *15*) are excluded due to focussing.

[2] Citing example (24) of É. Kiss (2010: 77).

(13) a. János [tizenöt palacsintát]$_{Foc}$ evett meg.
John fifteen pancakes-ACC eat-PAST PRT
'John ate (exactly) fifteen pancakes.'
b. János [tizenhat palacsintát]$_{Foc}$ evett meg.
John sixteen pancakes-ACC eat-PAST PRT
'John ate (exactly) sixteen pancakes.'

By contrast, (14b) entails (14a) since the number word *fifteen* is not focussed and therefore the lower-bounded meaning is preserved.

(14) a. János meg-evett tizenöt palacsintát.
John PRT-eat-PAST fifteen pancakes-ACC.
'John ate (at least) fifteen pancakes.'
b. János meg-evett tizenhat palacsintát.
John PRT-eat-PAST sixteen pancakes-ACC.
'John ate (at least) sixteen pancakes.'

In sum, according to standard analyses (É. Kiss 2006b, 2010), in Hungarian it is the information structure of the sentence that determines how a numeral is interpreted. If it is focussed (which is also marked by its syntactic position), it is interpreted as 'exactly *n*', in all other cases as 'at least *n*'. The 'exactly' interpretation is a consequence of the function of focus, namely that it expresses that the denotation of the focussed constituent and the set denoted by the rest of the sentence are identical. Owing to this identificational mechanism the upward expanding 'at least' reading is blocked.

4. Developmental background

In order to have a comprehensive overview of how children interpret numerals it is important to briefly present the findings of related research in the fields of language acquisition and pragmatics. The following section discusses how children acquire the meaning of numbers, how they cope with scalar implicatures and finally, whether Hungarian children are sensitive to the exhaustive feature of identificational focus.

4.1 The acquisition of number words

The first step in the acquisition process of numerals is to learn what quantity each number word refers to. In order to do so, the logic of the number system must be understood, namely that each number word refers to a distinct quantity and that two successive numbers on the number scale have a difference of one. Wynn (1990, 1992) discerns four stages of this learning process: by the age of two and a half children are able to distinguish *one* and *many*. This means that in a task where they are supposed to pick the number of objects matching the number uttered by the experimenter they consequently pick one if they are asked for one, and more than one if they are asked for two, three or more (Give-N Task). By the age of three they learn the meaning of two and by the age of three and a half they have already learned the meaning of three. At the age of four they understand the relationship between counting and cardinality, i.e. they are able to form sets of four, five, six, etc. elements by counting.

Although there is no agreement in the literature on how exactly this learning process takes place (see Carey 2001), it is widely accepted that by the age of five the mapping between numerals and the quantities denoted by them is already solid and children use numbers in the lower range (up to six) quite confidently (see Wynn 1990, 1992). This is important, because it excludes the possibility that children might not access the 'exactly *n*' and 'at least *n*' meaning components of numerals because of their immature numerical knowledge.

4.2 The interpretation of scalar implicatures

In the last decade a large number of experiments has been carried out investigating how children interpret scalar implicatures (see Noveck 2001; Papafragou & Musolino 2003; Musolino 2004; Huang & Snedeker 2009; Huang et al. 2013). Most of these studies aimed specifically at comparing the interpretation of numerals and other scalar expressions and revealed the same tendency as Papafragou & Musolino (2003) did. They used a Truth Value Judgement Task in which participants were presented short scenes involving three horses jumping over a fence. After presenting the scene the experimenter asked the participant if the statement in (15) was true or false.

(15) Some of the horses jumped over the fence.

While adults overwhelmingly rejected this sentence (92%) on the basis that all the horses jumped over the fence not just some of them, the majority of children (88%) accepted it willingly. These results indicates that in the case of children the implicature *but not all* has not been triggered. In a follow-up experiment Papafragou & Musolino (2003) modified the test sentence by replacing the scalar expression *some* with the numeral *two*, as in (16).

(16) Two of the horses jumped over the fence.

When the sentence contained a numerical expression, children's judgements were much more similar to those of adults: only 35% of the children accepted (16), and the majority (65%) rejected it on the basis that all three horses jumped over the fence, not just two of them. Children therefore preferred the upper-bounded interpretation of the numeral, which in the neo-Gricean framework is considered to be a scalar implicature. If we were to accept this view, the previous results should lead us to conclude that while in the case of numerals they obviously can calculate scalar implicatures, in the case of other scalar expressions they clearly can not. This explanation would be rather hard to defend, so the authors cited above are of the opinion that the default meaning of numerals is actually 'exactly *n*'.

4.3 The interpetation of Hungarian identificational focus

Few experimental data have been provided so far regarding the interpretation of Hungarian pre-verbal identificational focus. In 2011 Pintér conducted an experiment with Hungarian preschoolers and adults using a Truth Value Judgement Task. Participants were shown pictures depicting two characters who were involved in the same activity, e.g. a bunny and a bear sitting on a chair. After presenting the picture the experimenter uttered a test sentence of representing one of the two types provided in (17).

(17) a. A maci felült a székre.
the bear up-seat-PAST the chair-on
'The bear sat on the chair.'

b. [A maci]$_{Foc}$ ült fel a székre.
the bear seat-PAST up the chair-on
'THE BEAR sat on the chair.'

The information structure of the test sentence was varied: the subject (the bear) was either focussed (17b) or non-focussed (17a). In this instance focussing is marked by the inversion of the verbal particle *up* and the verb. Adults overwhelmingly rejected (17b) because the bunny was also sitting on the chair and therefore the exhaustivity requirement of focus has not been fulfilled. By contrast, children did not detect the semantic difference between the two sentences, and so judged (17b) to be true to the same extent as (17a). Kas & Lukács (2013) extended this investigation so as to also include object focus, obtaining similar results. It would appear, therefore, that Hungarian children are not sensitive to the exhaustive feature of identificational focus.

5. Experiments

The general purpose of the experiments we conducted was to investigate how children interpret number words in different syntactic positions. Previous research (Kas & Lukács 2013) has shown that children are not sensitive to the exhaustive feature of Hungarian identificational focus. If the default meaning of numerals is indeed 'at least *n*' and children's grammar also lacks the mechanism producing the upper-bounded ('exactly *n*') reading (namely exhaustive identification), then the logical consequence would be that children only have access to the 'at least' interpretation. In the first experiment we wanted to test whether this assumption proves to be borne out.

5. 1. Experiment 1

5.1.1. Participants

22 Hungarian speaking children participated in the experiment (10 girls and 12 boys) between the ages of 4;3 and 6;8 (mean age 5;6). Children were recruited at a public kindergarten in Budapest. None of them had received any mathematical training before. The results of two participants were removed from the final analysis owing to their poor performance on the filler trials testing numeric knowledge. The control group consisted of 17 adult native speakers of Hungarian.

5.1.2. Materials

In the experiment we had two independent variables: the syntactic position of the numeral and the type of the verb. Both variables had two values: in focus position or out of focus position and possessive verb or activity verb, respectively. Thus, the two variables gave rise to the following four conditions.

(i) non-focussed numeral, activity verb

Kapjanak cukorkát azok a macik, akik szedtek három málnát.
Get-IMP candy-ACC those the bear-PL who-PL pick-PAST three raspberry-ACC
'Those bears shall get a candy who picked three raspberries.'

(ii) focussed numeral, activity verb

Kapjanak cukorkát azok a macik, akik [három málnát]$_{Foc}$ szedtek.
Get-IMP candy-ACC those the bear-PL who-PL three raspberry-ACC pick-PAST
'Those bears shall get a candy who picked THREE RASPBERRIES.'

(iii) non-focussed numeral, possession verb

Kapjanak cukorkát azok a macik, akiknek van három málnája.
Get-IMP candy-ACC those the bear-PL who-PL is three raspberry-POSS
'Those bears shall get a candy who have three raspberries.'

(iv) focussed numeral, possession verb

Kapjanak cukorkát azok a macik, akiknek [három málnája]$_{Foc}$ van.
Get-IMP candy-ACC those the bear-PL who-PL three raspberry-POSS is
'Those bears shall get a candy who have THREE RASPBERRIES.'

The type of the verb was added as a variable because in Hungarian possession is expressed by an existential structure involving the verb *van* 'be'. In this case it is explicitly marked that the numeral is in the scope of an existential quantifier, which might facilitate the 'at least' reading (see point 2.2).

Each condition was represented by four items, which resulted in 16 critical trials. The test items were divided into three sections and presented in a pseudo-randomized order. At the beginning of each section there was a filler trial, whose purpose was to test the child's numerical knowledge.

5.1.3. Procedure

The experiment was conducted by two experimenters. One of them told the child short stories about a group of toy bears who had to perform different tasks, e.g. pick raspberries. The bears showed Hedgehog (a puppet acted by the other experimenter) how many raspberries they had picked. Each bear had a card in front of him depicting a set of raspberries ranging from 2 to 6. Hedgehog gave candy to the bears as a reward and she told the child which bears were able to receive a candy, i.e. she uttered the test sentence containing a number word, as in (18).

(18) Kapjanak cukorkát azok a macik, akik szedtek három málnát
Get-IMP candy-ACC those the bear-PL who-PL pick-PAST three raspberry-ACC
'Those bears shall get a candy who picked three raspberries.'

The child then had to give a candy to the bears who matched the puppet's description. (NB. The number of candies available was always more than the number of bears.) If the child gave a candy only to the bears who had exactly three raspberries, then it indicated that she interpreted the numeral as 'exactly *n*' (see Figure 1). However, if she rewarded the bears who also had more than three raspberries, this indicated that she interpreted the numeral as 'at least *n*' (Figure 2).

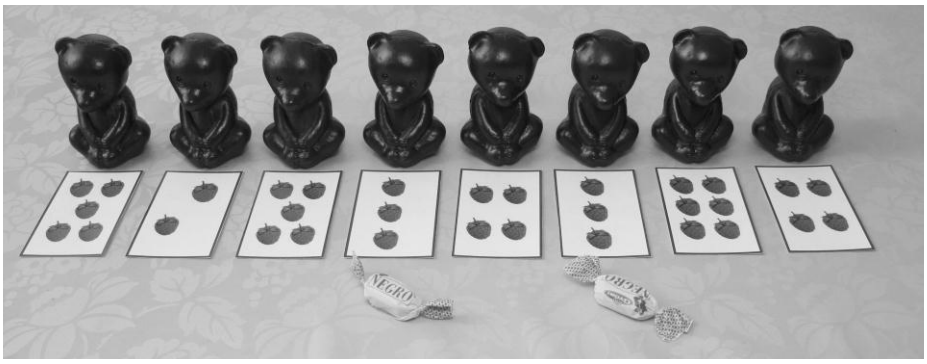

Figure 1: Critical trial in Experiment 1 – 'exactly' interpretation

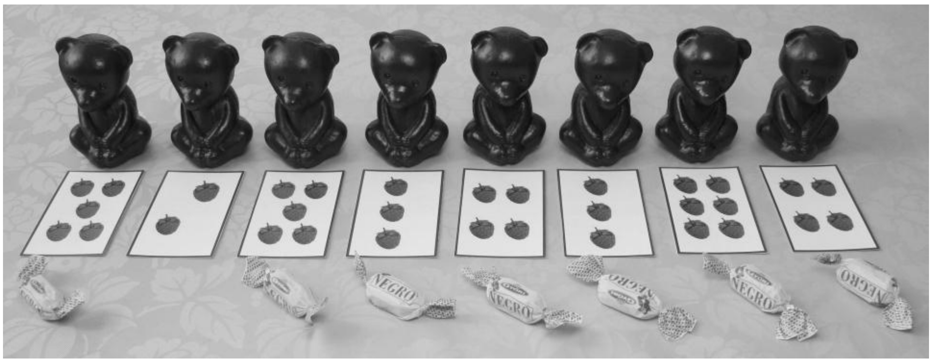

Figure 2: Critical trial in Experiment 1 – 'at least' interpretation

Adult participants were given test papers with illustrations of the settings presented in the children's test sentences (Figure 3). The experimenter read out the test sentences one by one and the participants had to mark the bears they would give a candy to. In the experiment we recorded how many times the participant interpreted the numeral as 'at least *n*' and how many times as 'exactly *n*'.

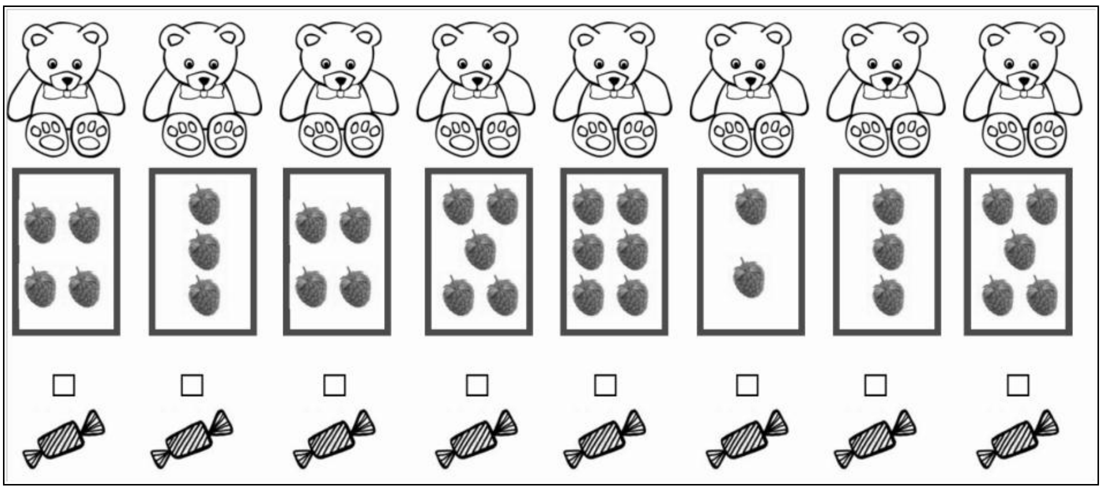

Figure 3: The test paper for adult participants

5.1.4. Results

Adults responded as predicted by the standard view (É. Kiss 2006b, 2010) which claims that the information structural role of numerals determine their interpretation. Performing a statistical analysis on the data has revealed that the rate of upper-bounded interpretations was significantly higher if the number word was focussed (χ^2 = 99.5, df = 3, ***p = .0001***). In the case of the children, there was no difference in the interpretation of numerals appearing in and out of focus; they preferred the upper-bounded reading in every single trial. The type of the verb did not have a significant effect on interpretation in either age group.

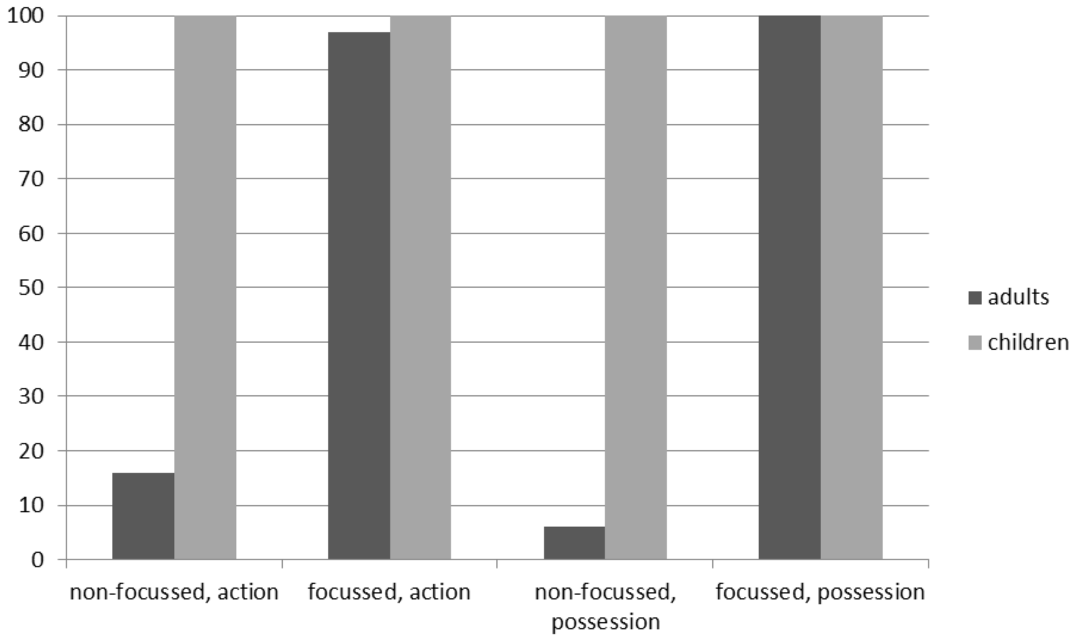

Figure 4: The rate of 'exactly n' interpretations in Experiment 1

One way of interpreting the result is that children's interpretation of numerals is unaffected by the information structure of the sentence, which is marked by syntactic means in Hungarian. Since they strongly prefer the upper-bounded reading of numerals, one could suggest that this is the default meaning. These findings also cast doubts on the claims that numerals receive an upper-bounded interpretation in focus position as a result of exhaustive identification, given that children have been shown not to be sensitive to exhaustivity. However, the question remains open as to whether the 'at least' reading is not available at all, or it is available but simply needs more pragmatic support. To test this latter assumption, we carried out two follow-up experiments. Our aim was to create a context that is biased toward the 'at least' interpretation in order to check whether this reading can be elicited by manipulating the pragmatic environment.

5. 2. Experiment 2
5.2.1. Participants

18 Hungarian speaking children participated in this experiment (9 girls and 9 boys, mean age 5;6 years). They were recruited from the same group tested in the first experiment. This time

we did not have an adult control group since the results of Experiment 1 confirmed that adults can assign both readings to numerically modified expressions.

5.2.2. Materials and Procedure

In addition to providing pragmatic support for the ‘at least’ reading of the numeral, we tried to make children more motivated by involving them in some sort of competition. We arranged a game that had two participants, the child and Hedgehog (a puppet acted by one of the experimenters). The children had a pile of cards in front of them depicting different objects, e.g. flowers and butterflies. Their task was to sort the cards, grouping together those that pictured the same object, i.e. all the cards with flowers or all the cards with butterflies. The number of cards of the two types was carefully arranged in advance, so after finishing sorting out the cards the child ended up having two more cards than the puppet (e.g. child: 6 cards, Hedgehog: 4 cards; *Figure 5*).

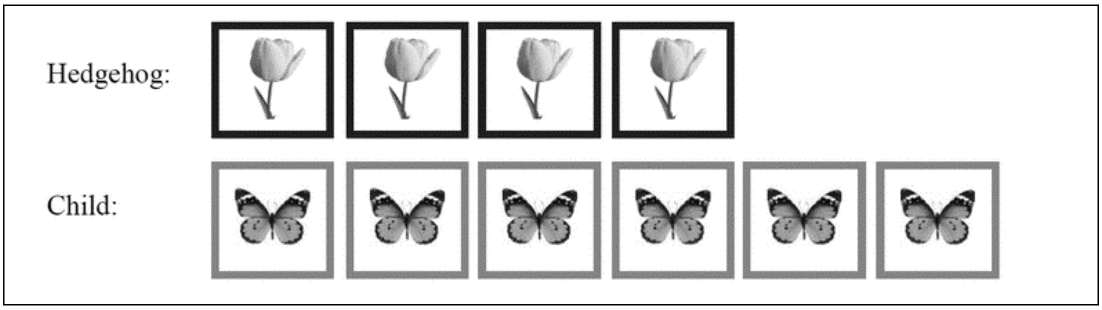

Figure 5: Critical trial in Experiment 2

The experimenter then put a number of balloons on the table and told the child the terms of getting one of them (19).

(19)	Elvehet	egy	lufit	az,	akinek	van	öt	kártyája.
	PRT.can get	a	balloon.ACC	that	who.DAT	is	five	card.POSS

‘If anybody has five cards, he or she can take a balloon.’

Crucially, in (19) – which was actually the test sentence – the numeral appears out of focus so it is compatible with both the ‘at least’ and ’exactly’ readings. The test trials could have two outcomes: if the child interpreted the numeral as ‘at least *n*’, she took a balloon; if not, neither the child nor Hedgehog took a balloon. In the filler trials either the child or Hedgehog had exactly as many cards as mentioned in the test sentence (but not more); this meant that either the child or Hedgehog took a balloon. Both the test trials and the filler trials were repeated twice, with different cards and number settings. The winner of the game was the participant who had the most balloons in the end. However, owing to the equal number of test trials and filler trials the game ended either with the child winning or with a draw. During the experiment we recorded how many times the child took a balloon indicating that she interpreted the numeral as ‘at least *n*’.

5.2.3. Results

Only 28% of the children took a balloon in the test trials (i.e. when they had more cards than mentioned in the test sentence) and out of them only 11% did consistently so, i.e. they took a balloon on both occasions. Most of them (72%) took a balloon only in the filler trials, i.e. when they had exactly as many cards as mentioned previously (see Figure 6).

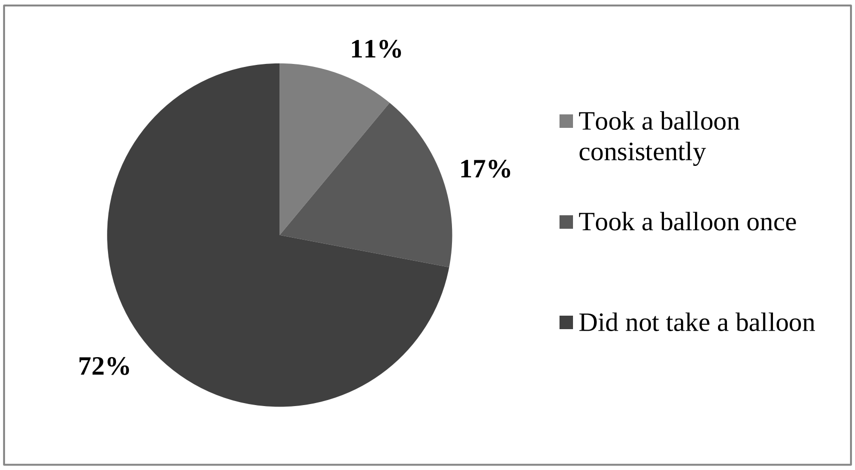

Figure 6: Results of Experiment 2

Children who refused to take the balloon gave the following explanations: *"I don't have five"*, *"I have only* (!) *six"*, *"If this one was not here, I could have a balloon*" (while he was covering one of his cards with his hand).

So it seems that the lower-bounded interpretation of numerals cannot be easily elicited even if the context clearly supports it. These results are in line with Musolino's (2004) findings in an experiment he carried out with English speaking children using the Truth Value Judgment paradigm.[3] It is important to mention, however, that in the same study Musolino (2004) reports on another experiment in which he managed to elicit the lower-bounded interpretation at a considerably high rate (about 80%). He developed stories in which one of the characters (Goofy) needed to borrow or obtain a specific number of items (i.e. two cookies) from another character (the Troll), who owned more than the required number. Musolino (2004: 22) suggests (referring to Kadmon 2001) that in situations such as this, the lower-bounded reading of the numeral is the most felicitous one since in terms of Goofy's needs it is irrelevant whether the Troll has exactly two or more than two cookies. In our third experiment we wanted to test if using a similar context would make the 'at least' reading more accessible to Hungarian children.

[3] In this experiment Musolino used numerals to describe the performance of a character involved in a game or a competitive activity. For example the child was told that *the Troll had to put two hoops on the pole to win* and then she had to decide whether the Troll actually won the game in a situation where there were four hoops on the pole. The majority of the children (about 75%) answered 'no', highlighting the fact that the Troll did not put two hoops on the pole, he in fact put four on it.

5. 3. Experiment 3
5.3.1. Participants

This time 17 children (9 girls and 8 boys, mean age 5;7 years) participated in the experiment. They were recruited from the same group as in the first experiment. There was no adult control group.

5.3.2. Materials and Procedure

In the experiment children were told short stories about Hedgehog, who was involved in some kind of activity and needed a certain amount of items to do so, e.g. she was baking a pie and she needed four more apples to be able to finish it. Hedgehog's friends (three other puppets) were also present, and each of them had a certain number of the items Hedgehog needed in front of them. In the critical trials one of them had more relevant items than Hedgehog needed, e.g. 2 apples, 3 apples and 5 apples, respectively; see Figure 7.

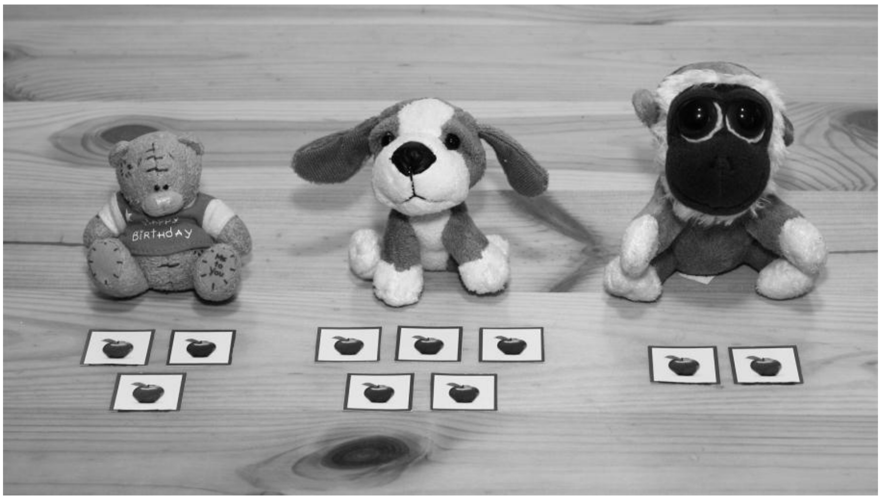

Figure 7: Critical trial in Experiment 3

The experimenter then asked the child whether there was anyone who had the number of items that Hedgehog needed (20).

(20)	Van	valaki,	akinek	van	négy	almája?
	is	someone	who-DAT	has	four	apple-POSS

‘Is there anyone, who has four apples?’

Again, in (20) – which was actually the test sentence – the numeral appeared out of focus so in theory it was compatible with both the upper-bounded and lower-bounded interpretation of the numeral. There were four critical trials and six filler trials presented in a pseudo-randomized order. In the filler trials either none of Hedgehog's friends had the required number of items or no numbers were involved at all (e.g. Hedgehog needed a bicycle, which her friends didn't possess). In the experiment we recorded the number of ‘yes’ responses in the critical trials, which indicated that the child interpreted the number word as ’at least *n*’.

5.3.3. Results

The results we obtained did not differ much from the results of Experiment 2. Only 23% of the participants answered 'yes' consistently to the experimenter's question, pointing at the puppet who had at least as many items as Hedgehog needed. The majority of the children (65%) did not think at all there was anyone who had as many items as Hedgehog needed (Figure 8). The 'no' answer was often justified by the explanation that "*I can see only three and five, not four"*.

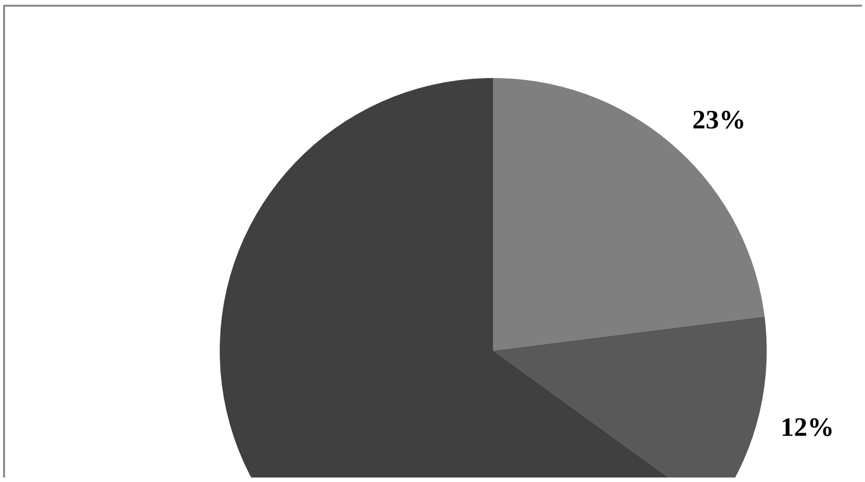

Figure 8: Results of Experiment 3

As the results show, the number of 'exactly n' interpretations has slightly increased compared to Experiment 2, but we did not manage to evoke such a robust effect as Musolino (2004) did. It is not clear whether this is due to the flaws of the experimental design or whether it is more closely connected to the fact that in Hungarian there is a very common competing structure, namely where the numeral appears in focus position (21).

(21) Van valaki, akinek [négy almája]$_{Foc}$ van?
is someone who-DAT four apple-POSS has
'Is there anyone, who has FOUR APPLES?'

In (21) the numeral cannot be interpreted as *at least four* – either because of the exhaustivity feature of focus, as suggested by the standard analysis but disconfirmed in Experiment 1, or for other reasons. The presence of this alternative structure in children's grammar might create interferences that block the availability of the lower-bounded interpretation of numerals in other positions.

6. Discussion

Experiment 1 tested if Hungarian children can differentiate between the lower-bounded ('at least *n*') and upper-bounded ('exactly *n*') readings of numerals and, if they can, whether it is indeed the information structure of the sentence that determines the interpretation. We presumed that if the default meaning of numerals is 'at least *n*' and children are not sensitive to the exhaustive feature of Hungarian pre-verbal focus (which is claimed to be responsible for the ‘exactly’ interpretation, as e.g. É. Kiss 2010 argues), then it must be the ‘at least *n*’ reading they can more easily access. The results we obtained, however, disproved this hypothesis: children always preferred the ‘exactly *n*’ interpretation, i.e. in both the situations corresponding to (1a) and (1b), they rewarded only those bears who had exactly *n* raspberries. This, in itself, does not exclude the possibility that the lower-bounded interpretation is also available to them; it might well be the case that it is elicited by pragmatic factors which simply did not occur in the first experiment. Nevertheless, it has been confirmed that information structure (indicated also by word order in Hungarian) has no effect on how children interpret numerals. While in the case of adults there was a significant difference between the interpretation of numerals appearing in and out of focus, in the case of children no such difference could be detected.

In experiment 1 we also tested if using a possession verb (*who has three strawberries*) instead of an activity (*who picked three strawberries*) has some effect on the interpretation. In Hungarian, possession is expressed by an existential structure involving the verb *van* ‘be’. In this case it is explicitly marked that the numeral is in the scope of an existential quantifier and therefore the assertion concerns the existence of a set of *n* elements. Since the truth conditions of this existential statement are unaffected by whether there are exactly three or more than three strawberries, we presumed that in the case of non-focussed numerals the verb *van* ‘be’ would make the ‘at least’ reading more accessible. We found, however, that, irrespective of the type of the verb, children preferred the ‘exactly’ reading virtually without exception.

In experiments 2 and 3 we tested whether the lower-bounded reading of numerals can be elicited by manipulating the pragmatic environment. We tried to create a context that provides better support for the ‘at least’ interpretation and motivates children to make pragmatic inferences. We found, however, that making pragmatic cues more salient yielded no difference compared to the results of experiment 1: the majority of the children preferred the ‘exactly’ interpretation, suggesting that the lower-bounded reading is indeed not available to them.

When it comes to the question of how our findings contribute to the discussion concerning the default meaning of numerals, the answer is rather complex. On the one hand, the results we obtained are in favour of the view that the default meaning of numerals is ‘exactly *n*’. As we saw, children interpret non-focussed numbers as ‘exactly *n*’ to the same extent as numbers appearing in focus position. If, however, the upper-bounded meaning is not a consequence of the identificational mechanism associated with Hungarian pre-verbal focus, then it is plausible to assume that this meaning is actually not derived, but is rather the default.

On the other hand, children’s behaviour can be explained in several other ways. One possibility is that they misunderstood the task and thought that they were being tested on their counting. Therefore they simply looked for the sets that matched the number word uttered and once they found it, they did not bother considering the actual meaning of that number word. This might have been the case in experiment 1, but in experiment 2 it was clear that the goal of the game was to collect balloons and not to demonstrate how good they were at counting. So the fact that the majority of the children failed to interpret the numeral as ‘at least five’ strongly suggests that this reading is indeed not available to them at this age.

Another possibility is that at this age children are not able to decompose sets into smaller subsets, which is a prerequisite to the comprehension of the ‘at least’ meaning component. This means that they treat the set of, for example, three raspberries as an atomic unit and they do not access its elements through the set. This would be in line with Pica & Lecomte’s (2008) claims based on their investigations of the Amazonian Munduruku tribe. It has been observed that the Munduruku lack consistent use of numbers beyond five and, perhaps as a consequence, Munduruku speakers perform quite poorly on numerical tasks. For example, they have difficulty in precisely repeating more than three knocks, or to pick a number of nuts matching the number of nuts already present. In Pica's account these difficulties can be attributed to the fact that the Munduruku cannot decompose a set into subsets, which he claims to be an intermediate stage of numerical cognition. It is possible that children, similarly to the Munduruku, are at this stage and hence why they cannot assign non-exact interpretations to numerals.

The results raise some further questions. Assuming that the 'at least' reading of numerals is available to children as well, it is not clear why their behaviour is different from that of adults. In other words, what kind of changes occur in the course of language acquisition as a result of which the interpretation of numerals becomes a function of information structure? Furthermore, if the default meaning of numerals is 'exactly *n*', what consequences will this have for the analysis of Hungarian pre-verbal focus? If the default meaning were indeed 'exactly *n*', what we need to account for is not how the 'exactly' reading arises in focus position, but rather how the 'at least' reading can be derived in all other positions. If we accept the proposal of the alternative approach, namely that the upper-bounded reading arises as a result of existential closure, it remains to be explained why this transformation is not possible if the numeral is focussed. Answers to these questions can be hoped to be obtained in future research studies.

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