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Lexical vs. Pragmatically Derived Interpretations of Numerals*

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Abstract. This paper shows that the pragmatically derived interpretations of the numerals such as 'at least N' or 'at most N' and the lexical counterparts are mutually exclusive with respect to language acquisition. Hence, children do not infer the meanings of the pragmatically derived meanings of the numerals based on the lexical counterparts and vice versa.

1 Introduction

In the linguistics literature, researchers have been discussing the mechanisms regarding the interpretations of numerals. That is, while 'two' means 'exactly two', it could mean 'at least two' or 'at most two' if appropriate contexts are provided (pragmatically derived meanings of the numerals) (Carston 1998, Horn 1972, 1992, Kadmon 2001, and Koenig 1991, among others). In developmental studies, researchers have been concerned with children's developmental processes of numerals; however, they assume that 'two' means 'exactly two'. The current study will show at what age children come to know the pragmatically derived meanings of the numerals. Based on the results of our experiments and comparing ours with Musolino (2004), we will conclude that acquisition processes of lexical ones and pragmatic ones are mutually exclusive. Thus, knowledge of the lexical ones does not entail acquisition of the pragmatic ones automatically, and vice versa. This paper is organized as follows. Section 2 briefly reviews the previous research on the acquisition of numerals and the theoretical background behind them. Section 3 shows the design of our experiments and their results. Section 4 presents a

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general discussion based on the data from the experiments. Section 5 contains concluding remarks.

2 Previous Studies

There are primarily two streams of thought with respect to the acquisition of the numerals. On the one hand, although a great deal of controversy has ensued over whether a counting set (see Gelman and Gallistel 1978) precedes acquisition of the meaning of number words or not (see Gelman and Gallistel 1978, Gallistel and Gelman 1992, Briars and Siegler 1984, and Fuson 1988, among others), developmental psychologists investigate how children acquire numerals, uniformly assuming that number words semantically refers to 'exactly N' and claim that children have acquired the meanings of the numerals around 3 or 4 years of age (see Sarnecka and Gelman 2004). For example, as far as the acquisition of Japanese number words is concerned, based on the results of experiments concerning the children's comprehension of quantifiers, numerals, and classifiers[1], Barner et al. (2009b) concludes that Japanese children are delayed in numeral comprehension due to the usage of classifiers compared to that of English speaking children: a significant delay of the acquisition of numerals is observed in Japanese-speaking children at 2 years of age (Japanese = 0.44 and English = 1.14 in ANOVA analysis). Once they reach 3 years of age, this difference between English-speaking and Japanese-speaking children disappears (3 years and 4 years Japanese = 2.62 and 3.89, and 3 years and 4 years English = 2.25 and 3.38, respectively).

On the other hand, in the linguistics literature (see Carston 1998, Horn 1972; 1992, Kadmon 2001, and Koenig 1991, among others), researchers have been concerned with pragmatically derived meanings of numerals, as in the following examples cited from Musolino (2004: 3): while (1) means 'exactly N,' (2) and (3) signify 'at least N' and 'at most N,' respectively.

(1) A: How many mistakes did you make?
B: I made three mistakes.

(2) You need to make three mistakes to be allowed to take the test again.

(3) You can make three mistakes and still pass this test.

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[1] Barner et al. (2009b) employs (i) the Give-Quantifier task, (ii) the Give-Number task, and (iii) the Classifier Match task, which were revised versions of the tasks in Barner at al. (2009a). In (i) and (ii), the experimenter showed the subjects a red circle and asked them to put a quantity /certain number of a specific kind of fruit into it using a quantifier, e.g. 'zenbu (= all),'/ a number word, e.g. 'rokko (= six).'

The theoretical background behind these studies is briefly summarized as follows. Under Grice's maxims restricting the quantity of information in utterances (4), scalar implicatures are said to be derived from conversational implicatures: 'Some of my friends passed the entrance examination' implies 'Not all of my friends passed the entrance examination.' This traditional Gricean approach also claims that the propositions of stronger (= more informative) terms are true in a narrower set of circumstances than those of weaker (= less informative) ones: 'All of my classmates caught a cold' asymmetrically entails 'some of my classmates caught a cold.'

(4) Maxim of Quantity
   a. Make your contribution as informative as required (for the current purposes of the exchange).
   b. Do not make your contribution more informative than is required.
(Grice 1989)

Horn (1972; 1989) attempted to apply the Gricean account to numerals. He suggests that like quantifier cases, 'Linda has three daughters' asymmetrically entails 'Linda has three/two/one daughters' (= 'at least N' interpretation): semantically, numerals are lower-bounded. Adding an upward bounding implicature to this lower bounded semantics, 'Linda has three daughters' will be able to imply 'Linda has exactly three daughters.'

Pointing out two problems with the traditional and neo-Gricean approaches on numerals, Carston (1998) raised an objection to them: one is that an 'at most N' interpretation was not dealt with and that the so-called 'scale reversal' effect (5) could not be accounted for by these strategies. The other is that the three interpretations (6b - d) to (6a), which are set as the conditions of the bet between two people, are conveyed in the utterance and that these interpretations display the truth conditional content of the conversation. Consequently, numerically quantified NPs are taken to be semantically underspecified and to be pragmatically yielded (Carston 1985, Horn 1992 etc.).[2]

(5) a. That golfer is capable of a round of 100 (and maybe even 90/*110).

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[2] Carston (1985) assumes the semantic representation of numerals to be the following.

(i) [X [N]]
X= a variable instantiated by pragmatic enrichment
N = a number word

b. She can counter most of the arguments (and maybe even *some/all).
Sadock (1984:143)

(6) a. There will be 20 people there.
b. There will be at most 20 people there.
c. There will be exactly 20 people there.
d. There will be at least 20 people there. Harnish (1976)

Musolino (2004) and Papafragou and Musolino (2003) attempted to capture how children acquire 'at least N' and 'at most N', which contain a range of entailments and pragmatic effects, as well as 'exactly N.' Papafragou and Musolino's (2003) work concludes that young children treat numeral scales (e.g. 'two' and 'three') differently from quantificational scales (e.g. 'some' and 'all') and aspectual scales (e.g. 'start' and 'finish') unlike adults: the rate of correct responses of numeral scales was lower than that of others. Considering the implications of Papafragou and Musolino's (2003) results, in order to see whether children and adults have the same representation of numerals and whether children's interpretations switch from 'exactly N' to 'non-exactly N (= 'at least/at most N) at some point, Musolino (2004) conducted the Truth Value Judgment Task[3] concerning pragmatically derived 'at least/at most N', overt (= lexical) 'at least/at most N', overt 'more than N' and 'exactly N' on English-speaking young children. Musolino (2004) claims that preschoolers acquire the knowledge of 'non-exact' interpretations, i.e. pragmatically derived 'at least/at most N' interpretations, although there were some difficulties with implementation of the experiments, especially with setting up of proper contexts.[4] As for the interpretations of overt numerals, children behave similarly to adults with respect to 'exactly N' and 'more than N'. Their performance in 'overt at least/at most N' differs from that of adults. Summing up Musolino (2004), English-speaking children tend to acquire pragmatically derived 'at least/at most N' earlier than lexical 'at least/at most

[3] In the experiments with respect to pragmatically derived 'at least/at most N', the first experimenter performs short stories in front of the subjects and then the second experimenter, who has a puppet, states what he thinks happens in the scenario and asks the subject to answer whether his statement is correct or wrong. In the experiments concerning the overt quantified N, exactly N, and more than N, children are presented cards with zero-to- five smiley faces or stars. Then they are asked to answer whether a card meets the puppet's request or not, for example, he likes a card with 'exactly two stars'

[4] According to Musolino (2004), the percentages of correct responses concerning pragmatically derived 'at least N' and 'at most N,' are 35% and 82.5%, respectively. But the percentage of correct responses of the former rose up to 80% under the improved context.

N'. Additionally, the semantic representation of the quantified numerals is the same among children and adults.
In the following section, we designed some experiments in order to explore cross-linguistic differences in the acquisition of overt and covert quantified numeral expressions between Japanese-speaking and English speaking preschoolers.

3 Experiments

3.1 Experimental Design

The purpose of this experiment is to find out (i) whether or not adult speakers of Japanese are able to assign non-exact semantics of numerals (i.e., 'at least N' or 'at most N'); and (ii) 5-6 year-old speakers of Japanese can assign non-exact semantics of numerals. In addition, we would like to investigate whether 5-6 year-olds can understand the meanings of the overt counterparts such as *sukunakutomo* 'at least' and *seizei* 'at most'. To achieve this experiment, we had to create contexts in which numerals could be naturally understood 'at least N' or 'at most N' interpretations. For example, it is plausible to interpret *nuta-tu* 'two' as 'at least two' in the context where a child would be given an ice cream if s/he ate two pieces of broccoli. In this situation, *s/he ate two pieces of broccoli* can be naturally interpreted as 'at least two pieces of broccoli.' Example (7a) is the Japanese counterpart of this example. On the other hand, *huta-tu* 'two' can be understood 'at most two' in the context where a child can eat two pieces of broccoli if s/he is able to. In this example, *two pieces of broccoli* should be most plausibly interpreted as 'at most three'. Example (7b) is the Japanese counterpart.

(7) a. Burokkorii-o huta-tu tabe-tara,
broccoli-ACC *two*-CL *eat-if*
aisukuriimu-o ageru.
ice-cream-ACC *give*
'I can give you an ice-cream if you eat (at least) two pieces of broccoli.'

b. Boku-wa tabe-rare-temo
I-TOP *eat-can-even if*
(burokkori-wa) huta-tu danaa.
broccoli-TOP *two*-CL *probably is*
'I can eat (at most) two pieces of broccoli even if I can eat it.'

3.2 Participants, Method and Procedure

We tested 32 Japanese-speaking children (16 boys and 16 girls) between the ages of 5.10 and 6.11 (mean 6.3 year-olds). We chose children of this age group based on Barner et al. (2009a), which reports that by this age, children have already acquired numerals.[5] These children were recruited at Takachiho Kindergarten in Tokyo. As a control group, we tested 31 adults who are students and faculty members at Takachiho University. To investigate Japanese children's interpretations of non-exact semantics of numerals, we used the Truth Value Judgment Task (TVJT, Crain and Thornton 1998). In the TVJT, two experimenters are generally required; one tells the story of each experiment with dolls or visual aids and the other plays the role of a puppet that listens to the story with the participant. By the end of each story, the puppet gives a statement of each story to the participant and the role of the participant is to say 'true' or 'false' to the statement of the puppet. As a follow-up, the participants are questioned to verify their answers by accounting for why they think that the puppet is right or wrong.[6] To test Japanese participants, we created stories and made the relevant PowerPoint visual aids so that children could understand the situation and the relevant meanings of numerals. Two experimenters told stories and the third experimenter acted as the puppet.

Before conducting individual tests, we started with a group test as a pre-test. The pre-test is made of three control stories. If children could answer these tests appropriately, then they could hear 12 more stories including 'at least N' or 'at most N' numerals. The order of the 'true' or 'false' answers is randomized so that children cannot predict answers. For adult speakers, we used a videotaped version of the stories, which were the same ones used with the children. They provided answers on a score sheet after watching each story.

3.3 Materials

Our experiments had four conditions: two of them were designed for non-exact semantics ('at least N' and 'at most N') that are pragmatically derived.

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[5] We also chose this age group to compare with that of English-speaking counterparts (Musolino 2004). Musolino conducts the same experiments to find out whether or not English-speaking children are able to understand non-exact semantics of numerals.

[6] It is reported that multilingual children do not have trouble understanding the procedures of the TVJT (English children – Crain and Thornton 1998, Musolino 2004, Musolino, Crain and Thornton 2000; Greek children – Papafragou and Musolino 2003; Kananda (Dravidian) – Lidz and Musolino 2002, among others).

The other two experiments were to investigate whether or not Japanese children could understand the overt counterparts of the pragmatically derived 'at least N' or 'at most N'; *sukunakutomo* 'at least' and *seizei* 'at most'. In our stories, Pikachu and Potyama (both are characters from Pocket Monster) talk about something. A puppet, Wanwan, who is a character of a popular TV program for Japanese kids, gives a statement to the subject. Below are representative examples of pragmatically derived 'at least N' in (8) and the overt counterparts in (9):

(8) Pragmatically derived 'at least N'
Pikachu: Boku-wa burokkori-ga kirai.
I-TOP *broccoli*-NOM *don't-like*
'I don't like broccoli.'
Potyama: Demo, tabe-nakya dame dayo.
but *eat-must* *bad* *it is*
Huta-tu tabe-tara, aisukuriimu-o ageru.
two-CL *eat-if* *ice cream cone*-ACC *give*
'But you have to eat them.' 'If you eat two pieces of broccoli, I will give you an ice cream cone.'
Then, Pikachu eats three pieces of broccoli.
Puppet: Pikachu-wa aisukuriimu-ga moraeru kana?
pikachu-TOP *ice cream cone*-*NOM* *get-can* *wonder*
'Can Pikachu get an ice cream cone?'

(9) Overt word *seizei* 'at least'
Pikachu: Boku-wa burokkori-ga kirai
I-TOP *broccoli*-NOM *don't-like*
'I don't like broccoli.'
Potyama: Demo, tabe-nakya dame dayo.
but *eat-must* *bad* *it is*
'But you have to eat them.'
Sukunakutomo huta-tu tabe-
at least *two*-CL *eat-if*
tara, aisukuriimu-o ageru.
if *ice cream cone*-ACC *give*
'If you eat at least two pieces of broccoli, I will give you an ice cream cone.'
Then, Pikachu eats three pieces of broccoli.
Puppet: Pikachu-wa aisukuriimu-ga moraeru kana?
pikachu-TOP *ice cream cone*-NOM *get-can* *wonder*
'Can Pikachu get an ice cream cone?'

Note that the minimum difference between (8) and (9) is the existence of the overt *sukunakutomo* 'at least'.[7]

3.4 Results

The interpretations of the pragmatically derived numerals by adults were 96.7%. Hence, adults had no problem with interpreting a sentence such as (8). The adults' interpretations of the overt *seizei* 'at most' and *sukunakutomo* 'at least' were 100%. On the other hand, the children's interpretations were different from those of the adults. In the analysis below, we show whether the true proportion of students getting the pragmatically derived 'at least N' or 'at most N' correct is equal to the true proportion of students getting overt counterparts (*sukunakutomo* 'at least' and *seizei* 'at most') correct. The alternative hypothesis is that the true proportion of students getting pragmatically derived 'at least N' and 'at most N' correct is less than that of those getting the overt counterparts correct. Based on the difference in a proportion z-test, we found that the proportion of children correctly interpreting pragmatically derived 'at least N' or 'at most N' is significantly less than the proportion of students correctly interpreting overt, with a p-value less than .001. Therefore, our study indicates that Japanese 5-6 year-olds children seem to understand the meanings of *sukunakutomo* 'at least' and *seizei* 'at most', while they appear not to have acquired the pragmatically derived 'at least' and 'at most' interpretations of numerals.

4 Discussion: Cross-Linguistic Differences and Implications of Acquisition Processes

The current study reveals a striking difference between English- and Japanese-speaking children with respect to the acquisition processes of pragmatically derived 'at least N' and 'at most N' of numerals. Musolino (2004) conducts experiments to find out whether or not 5-6 year-old children whose native language is English are able to interpret pragmatically derived 'at least N' and 'at most N' meanings of the numerals. The experimental method is TVJT. The relevant example is as follows:

(10) Goofy said that the Troll had to put two hoops on the pole in order to win the coin. Does the Troll win the coin? (Musolino 2004: 16)

[7] The example of *seizei* 'at most' is given at Appendix.

It turns out that these children in Musolino's study can understand the pragmatically derived meanings of the numerals. To determine whether those children could infer the pragmatically derived meanings of the numerals from the explicit counterparts (i.e., 'at least' and 'at most'), Musolino conducted experiments to find out whether or not children understood the explicit 'at least' and 'at most'. The results were that these children did not know the explicit meanings of 'at least' and 'at most'. Hence, Musolino assumes that the knowledge of the pragmatically derived 'at most' and 'at least' is not available in the environment:

(11) Goofy said that the Troll had to put at least two hoops on the pole in order to win the coin. Does the Troll win the coin?

One of the claims that Musolino makes is that children and adults have the same semantic representation for the numerals. Furthermore, Musolino assumes that children do not learn these implicit meanings of the numerals from the environment, but that the knowledge of the implicit meanings of the numerals is innately specified. However, Musolino's study does not show what would happen if children already know overt 'at least' or 'at most' vocabulary. Would they still interpret pragmatically derived meanings of 'at least' or 'at most' of the numerals as well as the explicit counterparts? Our study reveals that children who have already acquired 'at least' or 'at most' vocabulary seem to push back the acquisition of pragmatically derived meanings of the numerals. In other words, knowing the explicit vocabulary such as *sukunakutomo* 'at least' or *seizei* 'at most' does not guarantee or entail that children know the pragmatically derived meanings of the numerals. The difference of the acquisition processes of pragmatically derived meanings may not be surprising given the fact that the acquisition of the numerals is delayed in Japanese-speaking children due to the existence of the numeral classifier (Barner et al. 2009a). We do not know what causes the acquisition processes of the pragmatically derived meanings of the numerals to differ among languages. However, we do know that the learning processes of both pragmatically derived meanings of the numerals and the explicit ones are distinct and are not mutually helpful to each other. In other words, although the conceptual meanings are similar, they are independent of each other. Hence, our results support Musolino's experiments: acquiring the pragmatically derived meanings of the numerals has nothing to do with knowing the lexical counterparts. In the same line of thinking, our results show that knowing the explicit lexical words such as *sukunakutoko* 'at least' and *seizei* 'at most' has no effect on acquiring the pragmatic counterparts. We do not know what causes one language (such as Japanese) to delay the acquisition of

the pragmatic meanings of the numerals and vice versa in English. This implies the autonomy of semantics and pragmatics in our language system.

4 Conclusions

In this study, we argued that children do not infer the lexical meanings of 'at least' or 'at most' based on the pragmatic counterparts, and vice versa. Hence, it is implied that the domains of semantics and pragmatics are independent in the children's mind at this age. We are not sure why Japanese-speaking children cannot get access to the pragmatically derived meanings of the numerals at an early age, while the accessibility of the pragmatically derived ones is easier for English-speaking children. We also do not know what the situation is with children of other languages. We will reserve the study of this topic for our future research.

Appendix:

Pragmatically derived *seizei* 'at most'
Pochama: Burokkori-o tabe-nakya dame.
broccoli-ACC$_j$ *eat-must not good*
'You must eat broccoli.'

Burokkori-o tabe-tara, keeki-o ageru.
broccoli-ACC *eat-if* *cake*-ACC *be-given*
'If you eat broccolis, you will have a piece of cake.'

Picachu: Tabe-rare-temo huta-tu da naa.
eat-can-even if two-CL *is wonder*
'I can eat at most three if I am able to.'

Pochama: Sorezyaa dame.
If so *not good*
'If so, I will not give you a piece of cake.'

Picachu eats two pieces of broccoli. Can he eat a cake?

Overt *seizei* 'at most'
Pochama: Burokkori-o tabe-nakya dame.
broccoli-ACC$_j$ *eat-must not good*
'You must eat broccolis.'

Burokkori-o tabe-tara, keeki-o ageru.
broccoli-ACC *eat-if* *cake*-ACC *be-given*
'If you eat broccoli, you will have a piece of cake.'

Picachu: Tabe-rare-temo seizei huta-tu da naa.
eat-can-even if at most two-CL *is wonder*
'I can eat at most three if I am able to.'

Pochama: Sorezyaa dame.
If so *not good*
'If so, I will not give you a piece of cake.'

Picachu eats two pieces of broccoli. Can he eat a cake?

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