《Article》

Children's Difficulty in Interpreting Japanese Differential Comparatives[*]

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This paper introduces new experimental data in order to pin down the source of children's difficulty in solving a comparison problem, i.e., "A boy has three apples and a girl has two apples. How many more apples does the boy have than the girl?" Even young school children wrongly answer the number of the boy's apples, three, instead of answering the differential between the two sets of apples, namely one. By investigating Japanese-speaking children, this paper first shows that children as young as four years old can determine a differential between two sets by using either one-to-one correspondence strategies or subtraction operation. Next, it shows that children wrongly interpret a differential verbal expression like "The number of the boy's apples has increased by two." as "The number of the boy's apples is two." in the same way as a differential comparative. So, it concludes that whatever properties of the two constructions cause their non-adult-like interpretation (linguistic or cognitive), children have difficulty in mapping a numeral phrase to a differential between two sets.

Keywords: children's non-adult-like interpretation, differential comparatives, differential verbal expressions, measure phrases, numeral classifier phrases, one-to-one correspondence strategies, subtraction operation, cognitive development, linguistic development

1. Introduction

As shown in (1) and (2), Japanese does not have adjectival inflection indicating comparatives like *-er* in English and comparative and non-comparative adjectives have the same morphology.[1]

(1) a. Kono biru-wa takai/hikui.
this building-Top high/low
'This building is high/low.'
b. Kono biru-wa ano biru-yori takai/hikui.
this building-Top that building-than higher/lower
'This building is higher/lower than that building.'

(2) a. Otokonoko-no ringo-wa ooi/sukunai.
boy-Gen apple-Top many/few
Literal meaning: 'The boy's apples are many/few.'
Intended meaning: 'The boy has many/few apples.'
b. Otokonoko-no ringo-wa onnanoko-no-yori ooi/sukunai.
boy-Gen apple-Top girl-Gen-than more/fewer
Literal meaning: 'The boy's apples are more than the girl's ones.'
Intended meaning: 'The boy has more apples than the girl.'

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[1] The abbreviations used in this paper are: Cl= Classifier, Comp=Complementizer, Excl=Exclamation, Gen=Genitive, Non=Nominative, Q=Question Particle, Top=Topic

Especially when they are preceded by a numeral phrase, adjectives have only a comparative interpretation as shown in (3).

(3) a. Kono biru-wa 20-meetoru takai/hikui.
this building-Top 20-meter higher/lower
'This building is 20 meters higher/lower.'
b. Otokonoko-no ringo-wa ni-ko ooi/sukunai.
boy-Gen apple-Top two-Cl more/fwer
Literal meaning: 'The boy's apples are two more.'
Intended meaning: 'The boy has two more apples.'

We will call this type of comparatives as a differential comparative because a differential between two sets is overtly expressed. Arii (2010, 2011, 2012a, 2012b, to appear) has reported that Japanese-speaking children aged five-to-six years interpret these differential comparatives in a non-adult-like way. They wrongly interpret them as *absolute*. For instance, they interpret *20 meetoru* '20 meters' in (3a) not as the differential between two objects but as the height of this building, i.e.,'This building is 20 meters tall.' In the same way, they misinterpret (3b) as 'The boy has two apples.'

One may think that Japanese-speaking children's absolute interpretation is due to lack of comparative morphology in Japanese. However, previous studies in mathematical education (Gibb (1956), Hudson (1983), Riley et al. (1983), and Nunes and Bryant (1996)) have reported that English-speaking children also interpret a differential comparative as absolute. When English-speaking children are given a comparison problem like "John has five apples and Tom has three apples. How many more apples does John have than Tom?" they wrongly interpret the differential comparative as absolute and answer the total number of apples that John has, namely, five. Therefore, we cannot conclude that Japanese-speaking children's absolute interpretation is due to lack of comparative morphology in Japanese.

Concerning children's non-adult-like interpretation of differential comparatives, two kinds of hypotheses have been proposed: Linguistic Hypothesis and Cognitive Hypothesis. Hudson (1983) argues that children's difficulty in solving a comparison problem is a consequence of their difficulty in understanding the meaning of *more* and *less*. On the other hand, Nunes and Bryant (1996) argue that it is due to their immature cognitive resources.

This paper does not argue that the source of children's difficulty in solving a comparison problem is either linguistic or cognitive. Instead, in order to pin down the source of the difficulty, it introduces new experimental data. A first experiment shows that Japanese-speaking children as young as four years of age answer a correct differential between two sets when problems that involve comparing sets are expressed not with a differential comparative but as an equalizing problem as shown in (4).

(4) Situation: A dog has three candies and a cat has two candies. Beside them, there are a box of candies.
Instruction: "Jaa onaji-ni shite."
then the same-at make
'Make the same (the number of the two animals' candies).'
Expected reaction: They give the cat one more candy or get a candy away from the dog.

This confirms that in order to determine a differential between two sets, they are able either to do subtraction or to use one-to-one correspondence strategies, both of which are necessary to solve a comparison problem. When we solve a comparison problem like "How many more apples does John have than Tom?" we have to determine a differential between cardinal values of the two sets (i.e., John's apples and Tom's apples). In order to calculate it, we use either subtraction operation or one-to-one correspondence strategies.

The next experiment examines Japanese-speaking children's interpretation of a differential verbal expression like (5).

(5) Onnanoko-no keiki-wa ni-ko fue-ta-yo.
girl-Gen *cake-Top* *two-Cl* *increase-Past-Excl*
'The number of girl's cakes has increased by two.'

A differential verbal expression contains an incremental verb, *increase* and a numeral phrase expresses how much/many target object(s) has/have increased. The experiment reveals that although they understand the meaning of *fueru* 'increase,' Japanese-speaking children aged five-to-six years also interpret a differential verbal expression as absolute (e.g., Children misinterpret (5) as 'The girl has two cakes.'). Moreover, the experiment also reveals that there is a loose correlation between their interpretation of differential comparatives and differential verbal expressions. Therefore, whether the source of children's difficulty in solving a comparison problem is linguistic or cognitive, we can conclude that their absolute interpretation is not specific to static comparison expressed with a differential comparative and that children have difficulty in mapping a numeral phrase to a differential between two sets.

The organization of this paper is as follows. Section 2 reviews Arii's studies on Japanese-speaking children's interpretation of differential comparatives. Section 3 reviews two kinds of hypotheses on children's difficulty in solving a comparison problem: Linguistic Hypothesis and Cognitive Hypothesis. Section 4 introduces an experiment which shows that Japanese-speaking children can answer a correct differential between two sets when problems that involve comparing sets are expressed not with a differential comparative. Section 5 presents an experiment which shows that Japanese-speaking children also interpret a differential verbal expression as absolute and that there is a loose correlation between their interpretation of a differential verbal expression and a differential comparative. Based on the results, we suggest that it is difficult for children to map a numeral phrase to a differential between two sets. Section 6 shows a way to tease apart the two possible sources of their absolute interpretation: linguistic or cognitive. Section 7 concludes.

2. Previous Studies on Japanese-Speaking Children's Interpretation of a Differential Comparative

Arii has investigated Japanese-speaking children's interpretation of a differential comparative in many ways. Before seeing new experimental data on it, we will review her study.

2.1 Measure Phrase Comparatives

Arii (2010, 2011, 2012b, to appear) has reported Japanese-speaking children aged five-to-six years interpret measure phrase (MP) comparatives like (6) as absolute.

(6) Panda-wa ichi-*kirari* takai/hikui-yo.
panda-Top *one-kiraritaller/shorter-Excl*
'The panda is one *kirari* taller/shorter.'

(6) includes a novel unit of length, *kirari*. Using a novel unit of measurement makes it possible to present children with a stimulus sentence which does not require them to have prior knowledge about the specific words for the units of measurements such as *meter*, *kilogram*, etc. Arii (2012b) conducted two kinds of experiments on children who had been confirmed to have an ability to do simple arithmetic: *takai* 'taller' and *hikui* 'shorter' experiments.

In the *takai* 'taller' experiment (subjects: n= 15, 5;4-6;3, mean age: 5;10), an experimenter showed the picture in Figure 1 to children and pointed to the horse with a red tie, saying that the height of this horse is one *kirari*. Then, she gave children the stimulus sentence in (7) as a question.

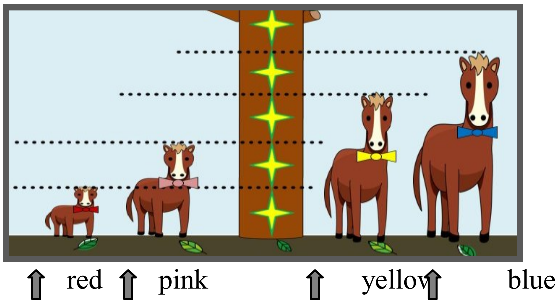

Figure 1. The picture used in the experiment of Arii (2012b)

(7) Ni-*kirari* takai-no-wa dore?
two-kirari taller-one-Top which
'Which one is two *kiraris* taller?' (intended meaning: 'Which horse is two *kiraris* taller than this horse?')

Responding to it, Japanese-speaking adults choose the horse with a yellow tie, which is two *kiraris* taller than the red one. On the other hand, children correctly chose the yellow one 35.5% (32/90) of the time. Only four children behaved in an adult-like way. Many children chose the pink one ,which is two *kiraris* tall.

The same kind of responses from children was found in the *hikui* 'shorter' experiment (subjects: n= 16, 5;2-6;3, mean age: 5;9). In this experiment, an experimenter showed children Figure 1 and pointed to the horse with a yellow tie, saying that the height of this horse is three *kiraris*. Then, she gave children the stimulus sentence in (8) as a question.

(8) Ni-*kirari* hikui-no-wa dore?
two-kirari shorter-one-Top which
'Which one is two *kiraris* shorter?' (Intended meaning: 'Which horse is two *kiraris* shorter than this horse?')

Responding to it, Japanese-speaking adults choose the horse with a red tie, which is two *kiraris* shorter than the yellow one. On the other hand, children correctly chose the red one 45.8% (44/96) of the time. Only six children behaved in an adult-like way. Many children chose the pink one, which is two *kiraris* tall. Both in the *takai* 'taller' and *hikui* 'shorter' experiments, most children's interpretation of MP comparatives was consistent.

Moreover, Arii (2010, 2011) reports that the presence of an explicit standard comparison such as a *yori* 'than'-phrase does not improve children's performance when they perform poorly on truncated comparatives like (9a).

(9) a. Panda-wa ichi-*kirari* takai-yo.
panda-Top one-kiraritaller-Excl
'The panda is one *kirari* taller.'
b. Panda-wa hoka-no doubutsu-yori ichi-*kirari* takai-yo.
panda-Top other-Gen animal-than one-kiraritaller-Excl
'The panda is one *kirari* taller than the other animals.'

Arii (2010, 2011) has found that Japanese-speaking children (5;9-6;3, mean age: 6;0) interpret the differential comparatives in (9a) and (9b) as absolute to the same extent.[2]

[2] Previous studies on English-speaking children have reported that English-speaking children also neglected an overt *than*-phrase and interpret a differential comparative as absolute (Ehri (1976), Sinclair de Zwart (1967), Townsend

2.2 Numeral Classifier Phrase Comparatives

Japanese-speaking children also interpret numeral classifier phrase (NCP) comparatives like (10) as absolute.

(10) Kuma-no ringo-wa ni-ko ooi/sukunai.
bear-Gen apple-Top two-Cl more/fewer
'The bear has two more/fewer apples.'

NCP comparatives do not include an MP and there is no need for children to learn to measure unlike the experiments on MP comparatives. Instead, the NCP comparative in (10) includes the NCP, *ni-ko* 'two-CL.' In Japanese, numeral phrases usually consist of a numeral and a classifier like other East and Southeast Asian languages. The classifier *-ko* (a shape-specific classifier for three dimensional objects) is general and emerges before other specific classifiers like *-hiki* (a classifier for small animals and insects), *-mai* (a classifier for two dimensional objects), etc. According to Yamamoto and Keil (2000), children start producing the classifier *-ko* by the age of four.

Arii (2012a) conducted two kinds of experiments on Japanese-speaking children in order to investigate their interpretation of NCP comparatives: *ooi* 'more' and *sukunai* 'fewer' experiments. All of child participants had been confirmed to have an ability to do simple arithmetic and understand the meaning of *ooi* 'more' and *sukunai* 'fewer.' The Truth Value Judgment Task (TVJT) (Crain and Thornton (1998)) was adopted. The TVJT involved two parts. First, an experimenter told a story by using a power-point presentation on a lap-top computer. At that time, a puppet watched the slides alongside children. Next, at the end of the story, the puppet was asked a question (a stimulus sentence) about the story and he answered it. Then, children were asked to judge whether the puppet's statement was 'right,' in which case the puppet got a strawberry as a reward, or it was 'wrong,' in which case he got a green pepper as a punishment. When children rejected the puppet's statement, they were invited to supply justification for their rejection.

In the *ooi* 'more' experiment (subjects: n=16, 3;10-6;6, mean: 5;3), stimulus sentences such as (11) were given after a story where two animals compete with each other for the number of objects such as fish.[3, 4]

(11) Inu-no-wa nan-ko ooi-kana?
dog-Gen-Top how-many-Cl more-Q
'How many more fish does the dog have?'

A representative test story and the talk between the experimenter and the puppet are described in (12)

(12) Story: A dog and a cat compete with each other for fishing. The dog catches three fish and the cat catches two fish.
Experimenter: "Pikachu, which one has more fish?" [translated into English]
Pikachu: "The dog!"
Experimenter: "That's right. Then, how many more fish does the dog have?"
Pikachu: "one (comparative condition)/ two (neutral condition)/ three (absolute condition)!"

(11) corresponds to the underlined sentence in (12). Three kinds of conditions were used: a comparative condition, an absolute condition and a neutral condition. In the comparative condition, the puppet answered the right

(1974), etc.).

[3] Data from three additional children were excluded due to excessive failure on filler tasks.

[4] Donaldson and Wales (1970) observe that young children use comparatives when talking about visible objects, or in 'competitive discourse' situations. On the basis of their finding, Arii (2012a) adopted a competitive story.

difference between the number of fish the dog and the cat catch, that is, "one." The target sentence in (11) is comparative and this answer is correct. In the absolute condition, the puppet answered wrongly, saying the number of fish the dog catches, that is, "three." Japanese-speaking adults reject this answer, but if children interpret (11) as absolute, they would accept it. Lastly, in the neutral condition, the puppet answered wrongly, saying the number of the cat's fish, that is, "two." Neither the comparative nor the absolute reading of (11) makes the answer true, and every subject would reject it. By asking their justification for their rejection, we can know the subject's interpretation of (11).

In the same way as MP comparatives, many children were found to interpret NCP comparatives like (11) as absolute. Table 1 shows children's acceptance rates of stimulus sentences in each condition.

Comparative cnd.	Absolute cnd.	Neutral cnd.
39.9% (19/48)	79.1% (34/48)	2.1% (1/48)

Table 1. The rates of acceptance for stimulus sentences in the *ooi* 'more' experiment

In the comparative condition, children correctly accepted stimulus sentences 39.9% of the time. Children who rejected them explained that the puppet's statement was wrong because the dog catches not one but three fish (*absolute reason*). In the absolute condition, they wrongly accepted them 79.1% of the time. Children who appropriately rejected them explained that the statement was wrong because the dog catches not three but one more fish than the cat (*comparative reason*). In the neutral condition, only one child was inattentive to a trial and wrongly accepted the test sentence once. So, the acceptance rates of the test sentences in this condition was 2.1%. As depicted in Table 2, in the neutral condition, children rejected stimulus sentences for the comparative reason 27.1% (13/48) of the time and for the absolute reason 72.9% (35/48) of the time. Most children's interpretation was consistent.

"comparative reason"	"absolute reason"
27.1% (13/48)	72.9% (35/48)

Table 2. The rates of rejection for comparative and absolute reasons in the neutral condition in the *ooi* 'more' experiment

The same kind of absolute responses from children were found in the *sukunai* 'fewer' experiment (subjects: n=16, 3;10-6;6, mean age: 5;3).[5, 6] Stimulus sentences such as (13) were introduced after a story.

(13) Neko-no-wa nan-ko sukunai-kana.
cat-Gen-Top how-many-Cl fewer-Q
'How many fewer fish does the cat have?'

A representative test story and the talk between the experimenter and the puppet are described in (14).

(14) Story: A dog and a cat compete with each other for fishing. The dog catches three fish and the cat catches two fish.
Experimenter: "Pikachu, which one has fewer fish?"
Pikachu: "The cat!"
Experimenter: "That's right. Then, <u>how many fewer fish does the cat have?</u>"
Pikachu: "one (comparative condition)/ two (absolute condition)/ three (neutral condition)!"

[5] Data from one additional child was excluded due to excessive failure on filler tasks.
[6] 15 of the children participated in the *ooi* 'more' experiment, too. The interval between the two experiments was more than a week.

(13) corresponds to the underlined sentence in (14). In the same way as the *ooi* 'more' experiment, three kinds of conditions were used: a comparative condition, an absolute condition and a neutral condition. Table 3 shows children's acceptance rates of stimulus sentences in each condition.

Comparative cnd.	Absolute cnd.	Neutral cnd.
31.2% (15/48)	68.8% (33/48)	2.1% (1/48)

Table 3. The rates of acceptance for stimulus sentences in the *sukunai* 'fewer' experiment

In the comparative condition, children correctly accepted stimulus sentences 31.2% of the time. Children who rejected them explained that the puppet's statement was wrong because the cat catches not one but two fish (absolute reason). In the absolute condition, they wrongly accepted them 68.8% of the time. Children who appropriately rejected them explained that the statement was wrong because the cat catches not two but one fewer fish than the cat (comparative reason). In the neutral condition, only one child was inattentive to a trial and wrongly accepted a test sentence once. So, the acceptance rates of the stimulus sentences in this condition was 2.1%. As depicted in Table 4, in the neutral condition, children rejected stimulus sentences for the comparative reason 31.9% of the time and for the absolute reason 68.1% of the time. Most children's interpretation was consistent.[7, 8]

"comparative reason"	"absolute reason"
31.9% (15/47)	68.1% (32/47)

Table 4. The rates of rejection for comparative and absolute reasons in the neutral condition in the *sukunai* 'fewer' experiment

To sum up, many Japanese-speaking children aged five-to-six years interpret differential comparatives such as MP comparatives and NCP comparatives as absolute. Some children justified their answer, not saying only a numeral phrase but saying a differential comparative itself as shown in (15). Therefore, we cannot say that their absolute interpretation is caused by paying their attention only to a numeral phrase.

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[7] One child did not make justification and we cannot know why he rejected the puppet's statement. So, his data is not included in Table 4.

[8] During the experiment, Arii (2012a) found that three Japanese-speaking children (3;10, 4;5, 4;8) seemed to misinterpret *ooi* 'more' as *sukunai* 'less/fewer.' When they were asked a question like (i), they consistently pointed to a character who had fewer objects.

(i) Docchi-ga ooi?
which-Nom more
'Which has more <objects>?'

On the other hand, when they were asked a question like (ii), they correctly pointed to a character who had fewer objects.

(ii) Docchi-ga sukunai?
which-Nom fewer
'Which has fewer <objects>?'

Moreover, when an adverb, *takusan* 'more' was used instead of *ooi* 'more' in a question as indicated in (iii), they correctly pointed to a character who had more objects.

(iii) Docchi-ga takusan motteru?
which-Nom more have
'Which has more <objects>?'

This is the opposite of the previous finding that children seem to interpret *less* as *more* (cf. Carey (1978), Clark (1970), Donaldson and Balfour (1968), Donaldson and Wales (1970), and Ehri (1976)). We leave this issue for future research.

(15) Some children's justification in the neutral condition of the *ooi* 'more' experiment (absolute reason)

"Chigau-yo. Datte san-ko ooi-kara."
wrong-Excl because three-Cl more-because
Literal meaning: 'He is wrong because the dog has three more fish.'
Intended meaning: 'He is wrong because the dog has three fish.'

3. Two Kinds of Hypotheses on Children's Absolute Interpretation of a Differential Comparative

In mathematical education, a comparative problem is notoriously difficult for children to solve. Children as young as five (even some four-year-olds) can solve simple addition and subtraction problems with the support of blocks and fingers.[9] For example, they can correctly answer to these problems with the support of visual objects: "A bear has one red block and two blue blocks. How many blocks does the bear have?" and "A bear has three strawberries and eats some of them. Given that he has two strawberries left, how many strawberries did he eat?" On the other hand, even young school children have difficulty in solving a comparison problem like "John has three apples and Tom has two apples. How many more apples does John have than Tom?" So, the comparative problem has been an intriguing topic in the field of mathematical education. This section reviews two previous studies on children's difficulty in solving a comparison problem in mathematical education: Hudson (1983) and Nunes and Bryant (1996). While the former argues that the source of the difficulties is linguistic, the latter argues that that is cognitive.

3.1 Hudson (1983): Linguistic Hypothesis

Hudson (1983) shows that when problems that involve comparing sets are expressed without using a comparative, children can solve them. He presented 28 English-speaking children (6;6-7;8, mean age: 7;0) with a picture where two sets of items were depicted (e.g., children and balloons), as shown in Figure 2.

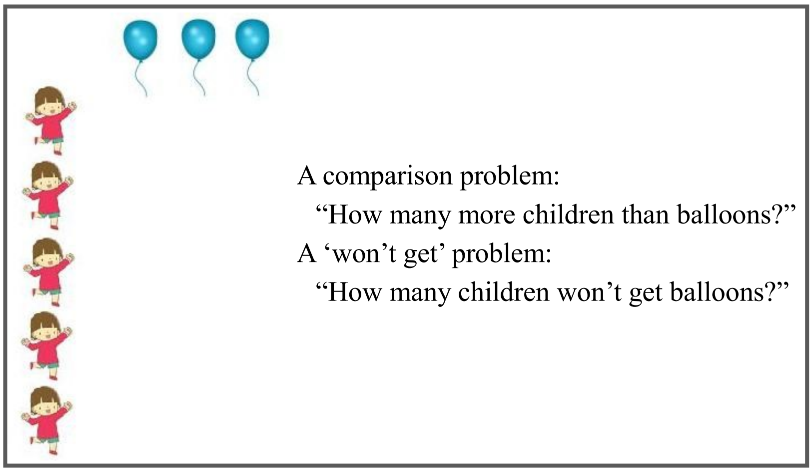


Figure 2. Simplified depiction of pictures used in Hudson (1983)

The items were positioned in order not to form an obvious visual pairing of the items in the two sets. Each picture showed two sets of items whose numerical difference was either one, two, or three. Two random orders of the eight number pairs (3 2, 4 3, 5 4, 5 4, 3 1, 5 3, 4 1, and 5 2) were used to form the two sequences of set sizes. Half of the problems were presented as a comparison problem (e.g., "How many more children than balloons?") and

[9] Wynn (1992) reports that 5-month-old infants can calculate the results of simple arithmetical operations on small numbers of items. Infants represent that adding a single object to a second occluded object results in two objects rather than one or three, and that removing a single object from two occluded objects results in one object rather than two. For more detail, see Wynn (1992).

the other half were presented through a question that suggested to the children the idea of using one-to-one correspondence strategies (e.g., “If all the children race and try to get a balloon, how many children won’t get balloons?”). Hudson (1983) observed that while 100% of the children responded correctly in the *Won’t Get* task, only 64% of the children responded correctly to the *More* task. Many children *absolutely* answered to the *More* question: they said five, the number of the children in Figure 2. Hudson (1983) conducted another experiment where items of two sets in a picture were aligned in order to visually highlight one-to-one correspondences between the sets. Even in the experiment, many children showed absolute responses to the *More* task. Based on these findings, Hudson (1983) argues that since children displayed an ability to establish correspondences between two sets in the *Won’t Get* task, their failure in the *More* task involved their difficulty in understanding the meaning of *more.*[10] This argument is consistent with previous findings indicating that the range of cognitive abilities elicited by cognitive-assessment tasks can be significantly affected by the language employed in those tasks (cf. Donaldson (1979), Gelman and Gallistel (1978), and Siegel (1978)).

3.2. Nunes and Bryant (1996): Cognitive Hypothesis

Nunes and Bryant (1996) present a different explanation for children’s difficulty in solving a comparison problem. Children’s initial conceptions of addition and subtraction are based on increasing or decreasing a quantity. So, in change problems, where things are added or taken away, children can easily understand what actions they need to carry out to solve them with the support of blocks or their fingers. On the other hand, when problems involve static comparisons, the connection between the situation and an operation on symbolic objects that would lead to problem solution is not clear because nothing is added or taken away from either of the sets unlike change problems.

Considering that six- and seven-year-olds can correctly respond to “Who has more/less?,” Nunes and Bryant (1996) question Hudson’s (1983) conclusion. Moreover, they argue that unlike the *More* task in Hudson (1983), in the *Won’t Get* task there is a clear indication of what children need to do with the objects to answer the question, “How many children won’t get balloons?” They need to make two matching sets and count out the remaining objects in the larger set. This is exactly how children successfully solve the question. According to Hudson (1983), who analyzed children’s strategies in solving it, most of them either established correspondences across the sets of objects and then counted the objects left without a pair in the other set or counted out the smaller set, counted an equivalent number in the second set (that is, created a corresponding set within the larger set), and then counted out the remaining objects. These one-to-one correspondence strategies are cued by the *Won’t Get* task but are unlikely to be connected with children’s notions of addition and subtraction because nothing is added or taken away from either of the sets. On the other hand, in order to solve a comparison problem, the one-to-one correspondence strategies and the notion of addition and subtraction are needed. When they come to see the relationship between them, they should be able to relate a comparison problem to the operations of addition and subtraction.[11] So, Nunes and Bryant (1996) argue that the source of children’s difficulty in solving a comparison problem is not linguistic.

3.3 Interim Discussion

As we have reviewed, Nunes and Bryant (1996) disagree with Hudson’s (1983) argument that children who

[10] Besides *more*, Hudson (1983) investigated children’s reactions to other comparative adjectives: *less*, *taller*, *longer*, and *older*. Children showed absolute responses to these comparative adjectives, too.

[11] Nunes and Bryant (1996) show experimental evidence that after they learn the relationship between one-to-one correspondence strategies and the operations of addition and subtraction, Brazilian children come to be able to solve a comparison problem. After they received a training where they were led to establish a connection between their understanding of one-to-one correspondence strategies and the operations of addition and subtraction as a means of quantifying the static relation in a comparison problem, children performed significantly better than before in the question. For more detail, see Nunes and Bryant (1996).

cannot solve a comparison problem do not understand the meaning of *more* because 6- and 7-year-olds can correctly respond to "Who has more/less?" However, we cannot abandon Hudson's (1983) linguistic hypothesis because it is possible that children do not have the adult-like syntactic/semantic representations of a differential comparative itself, where a differential is expressed with a numeral phrase as indicated in (16).

(16) a. This building is *20 meters* higher than that building.
b. The bear has *two* more apples that the cat.

Moreover, many researchers have converged on a conclusion that children undergo stage-like development in acquiring adult-like usage and interpretation of comparatives (cf. Carey (1978), Clark (1970), Donaldson and Balfour (1968), Donaldson and Wales (1970), Ehri (1976), Sinclair de Zwart (1967), Syrett (to appear), Townsend (1974), etc.). Compared with other grammatical constructions, it takes long for children to acquire comparatives. For instance, there is a stage where children seem to interpret *less* as *more*, which lasts about five years (cf. Carey (1978), Clark (1970), Donaldson and Balfour (1968), Donaldson and Wales (1970), and Ehri (1976)) (see footnote 8).[12] Besides, as we have seen in section 2.1, the presence of an explicit standard of comparison (e.g. *than*) does not improve children's performance when they poorly perform on truncated comparatives (Arii (2010, 2011), Ehri (1976), Sinclair de Zwart (1967), Townsend (1974), etc.). Considering these previous findings, it is not so surprising if it takes long for children to acquire the adult-like syntactic/semantic representations of differential comparatives, and we cannot abandon Hudson's (1983) linguistic hypothesis.

However, we do not have any evidence against Nunes and Bryant's (1996) cognitive hypothesis. It is technically difficult to investigate only children's cognitive resources which are required to solve a comparison problem because such a comparison problem is always given through verbal instruction. So, this paper does not argue that the source of children's difficulty in solving a comparison problem is either linguistic or cognitive. Instead, in order to pin down the source of the difficulty, it introduces new experimental data. After showing the data, this paper will present a possible way to tease apart these two hypotheses in section 6.

4. Equalizing Problems

As we have seen in section 3.1, Hudson (1983) reported that when problems that involve comparing sets are expressed without using a comparative, English-speaking children aged six-to-seven years can solve them. At the same time, he showed that they displayed an ability to establish correspondences between two sets, which is necessary to solve a comparison problem. Using a similar experimental design to Hudson's (1983), this section will confirm Japanese-speaking children aged four-to-six years (younger than the participants in Hudson's (1983) experiment) are able to determine a differential between two sets either by doing subtraction or using one-to-one correspondence strategies, both of which are necessary to solve a comparison problem. When we solve a comparison problem like "How many more apples does John have than Tom?" we have to determine the differential between cardinal values of the two sets (i.e., John's apples and Tom's apples.). At that time, we are considered to use either subtraction operation or one-to-one correspondence strategies.

4.1 Participants and Design

Twenty Japanese-speaking children (4;1-6;1, mean age: 5;0) participated in this experiment. Data from two additional children were excluded due to excessive failure on control tasks. The child participants were individually investigated.

[12] Clark (1970), Donaldson and Balfour (1968) and Donaldson and Wales (1970) argue that children acquire the positive polar adjective earlier than the negative one and that they misinterpret *less* as *more*. On the other hand, Carey (1978) argues that there is no such "*less* is *more* stage" and that children just exhibit a response bias towards increasing in the property.

Each child was presented 4 TVJTs, 4 Act-out tasks and 3 control tasks in pseudorandom order. Sentence order was counterbalanced across participants. The TVJTs examine children's interpretation of NCP comparatives. In the task, first an experimenter gave candies to two animals. At that time, she insisted that she should give them the same number of candies in order to avoid inequality. However, she gave them a different number of candies eventually. (17) shows the following interaction between the experimenter, a child and a puppet (Pikachu).

(17) Situation: A dog gets three candies and a cat gets two candies from the experimenter.
Experimenter: "Do they have the same number of candies?" [translated into English]
Child: "No"
Experimenter: "Which has more?"
Child: "The dog."
Experimenter: "That's right. Then, let's ask Pikachu how many more candies the dog has. Pikachu, how many more candies does the dog have?"
Pikachu: "one (comparative condition)/ two (neutral condition)/ three (absolute condition)"

At the end of the story, the puppet is asked the question in (18), which is a stimulus sentence. (18) corresponds to the underlined sentence in (17).

(18) Inu-no-wa nan-ko ooi-kana?
dog-Gen-Top how-many-Cl more-Q
'How many more candies does the dog have?'

In the same way as the experiments of Arii (2012a), three kinds of conditions were used: a comparative condition, an absolute condition and a neutral condition. The TVJTs consisted of 1 trial in a comparative condition, 1 trial in an absolute condition and 2 trials in a neutral condition. When children rejected the puppet's statement, they were invited to supply justification for their rejection. For instance, if they reject the puppet's statement in the neutral condition, saying "because the dog has not two but one more candies" (comparative reason), we can tell they interpret (18) as comparative. On the other hand, if they reject it, saying "because the dog has not two but three candies" (absolute reason), we can know they interpret (18) as absolute.

Next, the Act-out tasks examine children's ability to use one-to-one correspondence strategies or do subtraction operation in order to determine a differential between two sets. The same story as the TVJT tasks was used in these tasks. In contrast to the TVJT, the experimenter gave not the puppet but children an instruction. After confirming which animal has more candies, the experimenter asked a child to make the number of the two animals' candies the same, saying (19).

(19) Jaa onaji-ni shite.
then the same-at make
'Make the same (the number of their candies).'

Importantly, at that time, the experimenter did not use a comparative in her instruction. There were a box of candies beside children. They were expected to give the cat a candy or to remove a candy from the dog.

Lastly, the control tasks examine children's simple arithmetic ability such as '3-1' and '3-2,' using a change problem. In the tasks, an animal is given some cakes and eats some of them. Children were not able to see him eating. After that, they were shown the remaining cakes and asked to guess how many cakes the animal has eaten. As we have seen in section 3.2, according to Nunes and Bryant (1996), it is easy for children to do simple arithmetic when things are added or taken away. Our targets are only children who are able to do simple arithmetic in such situation. So, data from children who failed the control tasks more than twice were excluded.

4.2 Results and Discussion

All of the 20 children correctly responded to the three control tasks. This finding replicates that of Nunes and Bryant's (1996) that children appropriately use addition and subtraction operations in order to solve a change problem. Data from additional two children (5;1, 5;5) were excluded because of excessive failure in the control tasks. Moreover, to the Act-out tasks, they correctly responded 100% of the time. They appropriately gave an animal extra candies or removed some candies from an animal. This leads to the conclusion that when they try to figure out a difference between two sets, children aged 4-to-6 years are able to use one-to-one correspondence strategies or do subtraction operation. Only with these data, we cannot conclude which operation they use. However, although we do not know whether they are sufficient operations to solve a comparison problem, both operations are certainly necessary to solve a comparison problem.[13]

On the other hand, they did not do well on the TVJTs, which replicated the previous findings. They responded correctly 68% (54/80) of the time. The rates of their correct responses in each condition is presented in Figure 3: they correctly responded 40 % (8/20) of the time in the comparative condition, 25% (5/20) of the time in the absolute condition and 98% of the time (39/40) in the neutral condition.

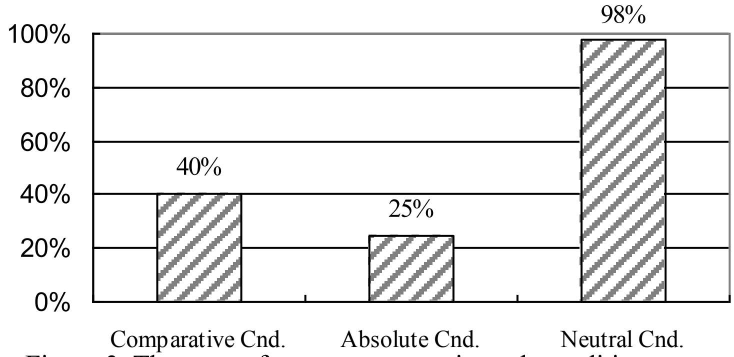


Figure 3. The rates of correct answers in each condition

Based on their responses and justification, their interpretation of the stimulus sentence is scored as comparative (C) or absolute (A). The rates of their absolute and the comparative readings in each condition is represented in Figure 4: they interpreted the stimulus sentence as comparative 40% (8/20) of the time in the comparative condition, 25% (5/20) of the time in the absolute condition and 30% (12/40) of the time in the neutral condition. Only one child did not make clear justification in one task in the neutral condition. His/her data is not included in the figures in Table 4.

[13] Both one-to-one correspondence strategies and subtraction operation are necessary to solve a comparison problem, but it is possible that we also use other cognitive resources in order to solve a comparison problem. In order to solve a comparison problem like "How many more apples does John have?," we have to judge which set is larger. Based on the judgment, we have to set the smaller set as the standard of comparison. Then, we calculate how many more objects the larger set contains than the standard of comparison. In order to solve a comparison problem, rather complicated computation is required. Therefore, we cannot abandon the Cognitive Hypothesis only with the finding that children can use one-to-one correspondence strategies or subtraction operation in order to determine a differential between two sets.

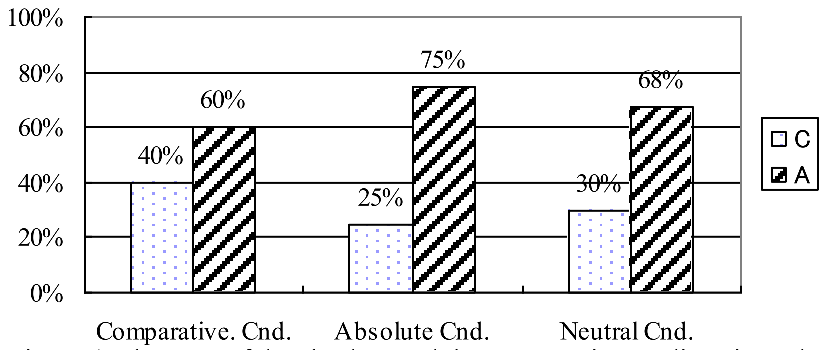


Figure 4. The rates of the absolute and the comparative readings in each condition

Moreover, children are classified into three groups based on their interpretation of the stimulus sentence. When their responses and justification in all conditions are scored as C, such children are classified into Group (C). On the other hand, when their responses and justification in all conditions are scored as A, such children are classified into Group (A). Lastly, when their scores include both C and A, such children are classified into Group (Mixed). As shown in Figure 5, 5 children (mean age: 5;7) are classified into Group (C), 12 children (mean age: 4;11) are classified into Group (A) and 3 children (mean age: 4;7) are classified into Group (Mixed). Given that only a few children are classified into Group (Mixed), most of children's interpretation of the stimulus sentence is consistent.

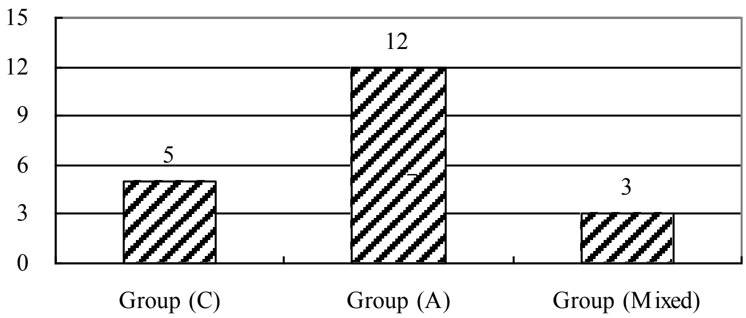


Figure 5. Classification of children based on their interpretation of the stimulus sentence

The present experiment has revealed that when problems that involve comparing sets are expressed without using a comparative, Japanese-speaking children can solve them, using either one-to-one correspondence strategies or subtraction operation. This confirms Hudson's (1983) finding in the sense that children are able to determine a differential between two sets when the problem is given without using a comparative. However, unlike Hudson's (1983) conclusion, we cannot conclude which operation children use at that time, one-to-one correspondence strategies or subtraction operation. Moreover, this experiment has revealed that even 4-year-olds can use either operation to determine a differential between two sets.

5. Differential Verbal Expressions

This section examines Japanese-speaking children's interpretation of a differential verbal expression like (20).

(20) Onnnanoko-no keiki-wa ni-ko fue-ta-yo.
girl-Gen cake-Top two-Cl increase-Past-Excl
'The number of a girl's cakes has increased by two.'

(20) is structurally similar to the differential comparative in (21). However, on the basis of the following two

reasons, we expect that children are able to appropriately interpret a differential verbal expression more easily than a differential comparative.

(21)	Onnanoko-no	keiki-wa	ni-ko	ooi-yo.
	girl-Gen	*cake-Top*	*two-Cl*	*more-Excl*

Literal meaning: 'The number of a girl's cakes is two more.'
Intended meaning: 'The girl has two more cakes.'

First, a situation expressed with a differential verbal expression like (20) involves comparing sets and it also involves a change unlike the one expressed with a differential comparative. As we have seen in section 3.2, Nunes and Bryant (1996) claim that children's initial conceptions of addition and subtraction are based on increasing or decreasing a quantity. So, in change problems, they can easily understand what actions they need to carry out to solve a problem with the support of blocks or their fingers. On the other hand, in a comparison problem the connection between the situation and an operation on symbolic objects that would lead to problem solution is not clear because nothing is added or taken away from either of two sets unlike change problems. They argue that this is the reason why children have difficulty in solving a comparison problem. Given Nunes and Bryant's (1996) argument, children should be able to solve a problem accompanying a differential verbal expression more easily than a comparison problem.

Second, children use a comparative expression to describe within-object changes before they use it to talk about between-object comparisons (Bloom et al. (1975) and Gitterman and Johnson (1983)). According to Bloom et al. (1975), children are more likely to tune into events involving changes of states than pay attention to and comment on states of unchanging objects. For example, regarding comparative adjectives, a young child watches a balloon being blown up and says *bigger*, before he comments that one already inflated balloon was bigger than another. So, children are more sensitive to within-object changes than between-object comparison. On the basis of these reasons, a differential verbal expression should be easier for children to interpret than a differential comparative.

5.1 Participants and Design

Fifteen Japanese-speaking children (5;4-6;3, mean age: 6;0) who were able to do simple arithmetic participated in this experiment. They were individually investigated. Two kinds of experiments were conducted: Experiment I examined children's interpretation of a differential verbal expression and Experiment II examined that of a differential comparative. A within-subject design was adopted and the same children's interpretation of these constructions was investigated at intervals of more than a week.

The experiment employed a TVJT in a 'prediction mode' (cf. Chierchia et al. (1998)). The Prediction Mode differs from a standard TVJT in that a stimulus sentence (a puppet's statement) is presented to a child before the completion of a story as a prediction about what will happen in the remainder of the story. This ensures that child participants listen to a whole stimulus sentence and that they make judgment based on it. If they are presented with target objects before listening to a stimulus sentence, it is possible that their attention might be stuck to the number of the objects and children judge a stimulus sentence on the basis of it. In order to avoid this possibility, the TVJT in a prediction mode was adopted.

Three kinds of conditions were used: a comparative condition, an absolute condition and a neutral condition. A representative story of each condition in Experiment I is presented below. An experimenter told a story, using Power Point presentation on a computer screen.

(22) Comparative Condition

Experimenter: “These are mysterious boxes. If we put something into these boxes, their size or number will change. A girl and a boy each have the box.” [translated into English]

Situation: The girl and the boy each have a pineapple. Then, they put it into their own box. [the picture (i) in Figure 6]

Experimenter: “Let’s see what has happened to the girl’s pineapple. Oh, nothing has changed. She has one pineapple. Then, Pikachu, could you make a prediction about the boy’s pineapple?” [the picture (ii) in Figure 6]

Pikachu: “I think the number of the boy’s pineapple has increased by two.” [(23)]

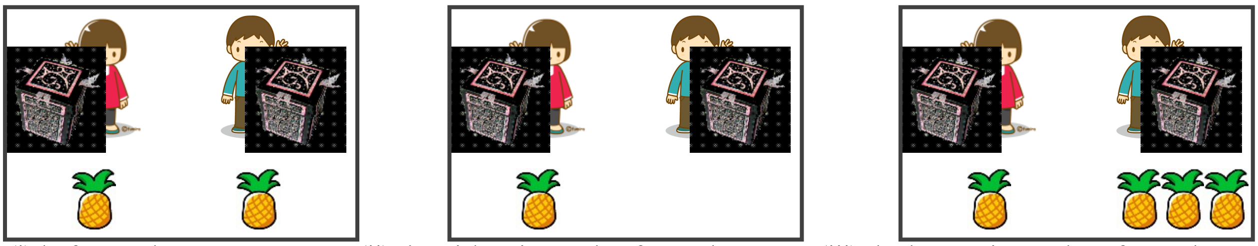
Experimenter: “In order to check whether what Pikachu has said is true or false, let’s see.”

Situation: The boy has three pineapples. [the picture (iii) in Figure 6]

Pikachu: “I said the number of the boy’s pineapple has increased by two. Was I right?” (right)

(23) A stimulus sentence in the comparative condition (Experiment I)

Otokonoko-no painappuru-wa ni-ko fue-ta-to-omou-yo.
boy-Gen pineapple-Top two-Cl increase-Past-Comp-think-Excl
‘I think the number of the boy’s pineapple has increased by two.’



(i) before a change (ii) the girl’s pineapple after a change (iii) the boy’s pineapples after a change

Figure 6. The pictures used in the comparative condition

(24) Absolute Condition

Situation: The girl and the boy each have an ice cream. Then, they put it into their box. [the picture (i) in Figure 7]

Experimenter: “Let’s see what has happened to the boy’s ice cream. Oh, nothing has changed. He has one ice cream. Then, Pikachu, could you make a prediction about the girl’s ice cream? [the picture (ii) in Figure 7]

Pikachu: “I think the number of the girl’s ice cream has increased by two.” [(25)]

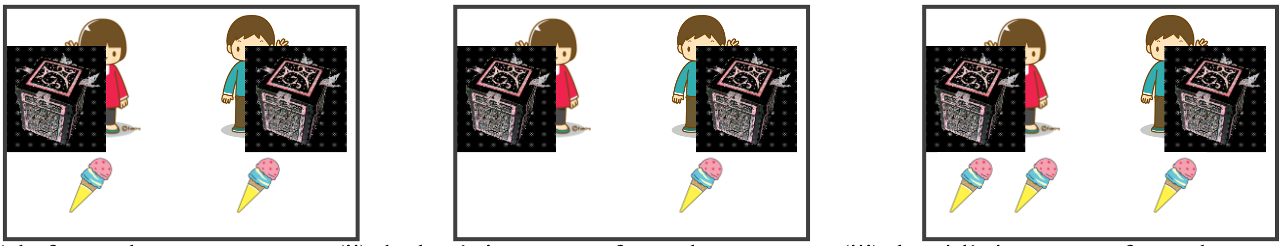
Experimenter: “In order to check whether what Pikachu has said is true or false, let’s see.”

Situation: The girl has two ice creams. [the picture (iii) in Figure 7]

Pikachu: “I said the number of the girl’s ice cream has increased by two. Was I right?” (wrong)

(25) A stimulus sentence in the absolute condition (Experiment I)

Onnanoko-no aisu-wa ni-ko fue-ta-to-omou-yo.
girl-Gen ice cream-Top two-Cl increase-Past-Comp-think-Excl
‘I think the number of the girl’s ice cream has increased by two.’



(i) before a change (ii) the boy's ice cream after a change (iii) the girl's ice cream after a change

Figure 7. The pictures used in the absolute condition

(26) <u>Neutral Condition</u>

Situation: The girl and the boy each have a cake. Then, they put it into their box. [the picture (i) in Figure 8]

Experimenter: "Let's see what has happened to the girl's cake. Oh, nothing has changed. She has one cake. Then, Pikachu, could you tell me about the boy's cake? [the picture (ii) in Figure 8]

Pikachu: "I think <u>the number of the boy's cake has increased by one.</u>" [(27)]

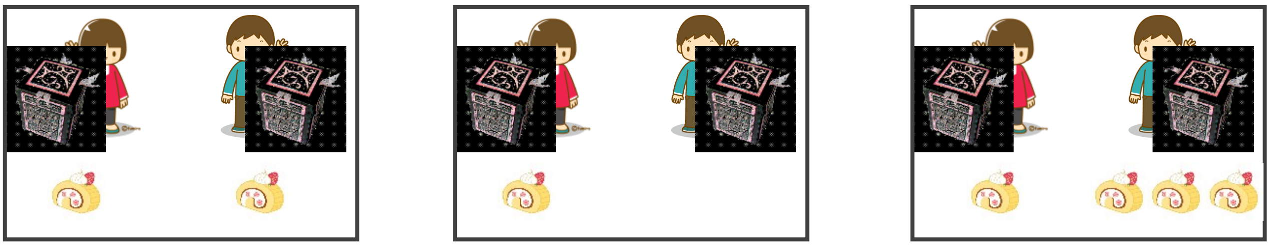
Experimenter: "In order to check whether what Pikachu has said is true or false, let's see."

Situation: The boy has three cakes. [the picture (iii) in Figure 8]

Pikachu: "I said the number of the boy's cake has increased by one. Was I right?" (wrong)

(27) <u>A stimulus sentence in the neutral condition (in Experiment I)</u>

Otokonoko-no keiki-wa ik-ko fue-ta-to-omou-yo.
boy-Gen cake-Top one-Cl increase-Past-Comp-think-Excl
'I think the number of the boy's cake has increased by one.'



(i) before a change (ii) the girl's cake after a change (iii) the boy's cakes after a change

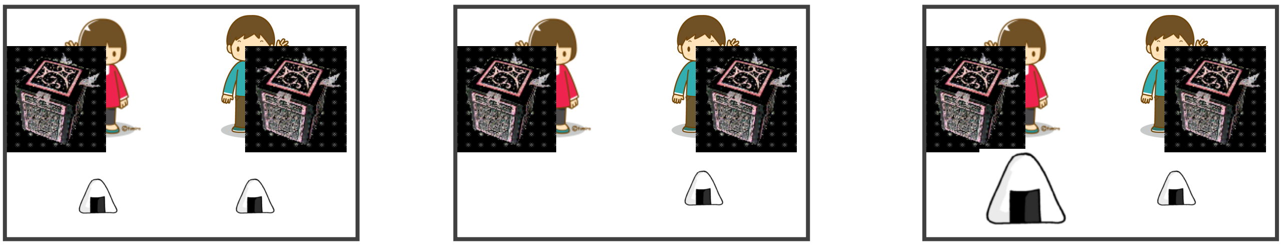
Figure 8. The pictures used in the neutral condition

In the comparative condition, Japanese-speaking adults accept the puppet's statement because the number of the boy's pineapple has changed from one to three and it increased by two. In the absolute condition, they reject it because the number of the girl's ice cream has increased not by two but by one. Lastly, in the neutral condition, they also reject it because the number of the boy's cake has increased not by one but by two. When children rejected the puppet's statement, they were invited to supply justification for their rejection.

In a filler task, the size of an item changes as shown below.

(28) <u>Stimulus sentences in the filler tasks</u>

Onnanoko-no onigiri-no-hou-ga ookii/chiisai-to-omou-yo.
girl-Gen rice ball-Gen-which-Nom bigger/smaller-Comp-think-Excl
'I think the girl's rice ball is bigger/smaller.' (right/wrong)



(i) before a change (ii) the boy's rice ball after a change (iii) the girl's rice ball after a change

Figure 9. The pictures used in the filler task

Each filler sentence had both true and false versions in order to allow the experimenter to elicit variable responses (*right* or *wrong*) based on how children responded to preceding stimulus sentences. For example, if a child answered *right* to a given stimulus sentence, the puppet made a wrong prediction, that is, 'I think the girl's rice ball is smaller' in (28) in order to elicit *wrong*, and vice versa. I excluded data from children who wrongly answered more than onece in the filler tasks. Each child was given 12 trials: 3 filler tasks, 3 tasks in the comparative condition, 3 tasks in the absolute condition and 3 tasks in the comparative condition. Sentence order was counterbalanced across children.

Experiment II had the same design as Experiment I. It differs from Experiment I only in its stimulus sentence. As a stimulus sentence, in Experiment II a differential comparative was used, as shown below.

(29) A stimulus sentence in the comparative condition (Experiment II) (the story in (22) was used)
Otokonoko-no painappuru-wa ni-ko ooi-to-omou-yo.
boy-Gen pineapple-Top two-Cl more-Comp-think-Excl
'I think the boy has two more pineapples.'

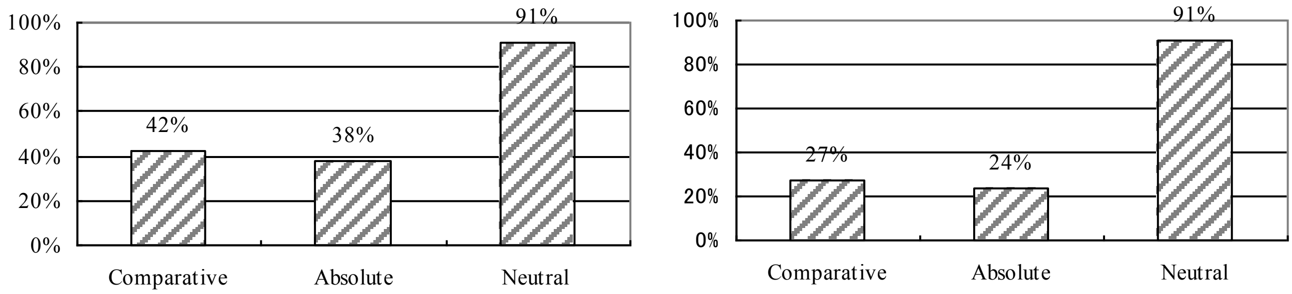
(30) A stimulus sentence in the absolute condition (Experiment II) (the story in (24) was used)
Onnanoko-no aisu-wa ni-ko ooi-to-omou-yo.
girl-Gen ice cream-Top two-Cl more-Comp-think-Excl
'I think the girl has two more ice creams.'

(31) A stimulus sentence in the neutral condition (Experiment II) (the story in (26) was used)
Otokonoko-no keiki-wa ik-ko ooi-to-omou-yo.
boy-Gen cake-Top one-Cl more-Comp-think-Excl
'I think the boy has one more cakes.'

In the same way as Experiment I, Experiment II consists of 12 trials: 3 filler tasks represented in (28), 3 tasks in the comparative condition, 3 tasks in the absolute condition and 3 tasks in the neutral condition. Sentence order was counterbalanced across children.

5.2 Results and Discussion

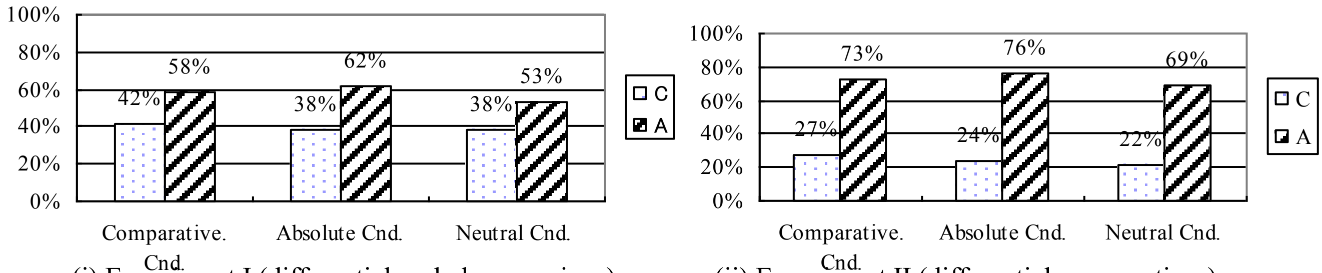
Both in Experiment I and II, all of the children correctly responded to filler tasks 100 % of the time. On the other hand, they responded correctly 57% (77/135) of the time in the target conditions in Experiment I and 47% (64/135) in Experiment II. The rates of their correct response in each condition are presented in Figure 10. In Experiment I, they correctly responded 42% (19/45) of the time in the comparative condition, 38% (17/45) of the time in the absolute condition, 91% (41/45) of the time in the neutral condition. In Experiment II, they correctly responded 27% (12/45) of the time in the comparative condition, 24% (11/45) of the time in the absolute condition and 91% (41/45) of the time in the neutral condition.



(i) Experiment I (differential verbal expressions) (ii) Experiment II (differential comparatives)

Figure 10. The rates of correct answers in each condition

Based on their responses and justification, their interpretation of the stimulus sentence is scored as comparative (C) or absolute (A).[14] The rates of their absolute and the comparative readings in each condition are represented in Figure 11. In experiment I, they interpreted the stimulus sentence as comparative 42% (19/45) of the time in the comparative condition, 38% (17/45) of the time in the absolute condition and 38% (17/45) of the time in the neutral condition. In Experiment II, they interpreted the stimulus sentence as comparative 27% (12/45) of the time in the comparative condition, 24% (11/45) of the time in the absolute condition, and 22% (10/45) of the time in the neutral condition.



(i) Experiment I (differential verbal expressions) (ii) Experiment II (differential comparatives)

Figure 11. The rates of the absolute and the comparative readings in each condition

The rates of the absolute responses in the three conditions altogether are as shown in Figure 12. Children interpreted a differential verbal expression as absolute 57.8% (78/135) of the time and interpreted a differential comparative as absolute 72.5% (98/135) of the time. Analyzing the data with a Wilcoxon Signed Rank test, we find that there is no significant difference between the rate of children's absolute responses to them (p= .156 > .05).

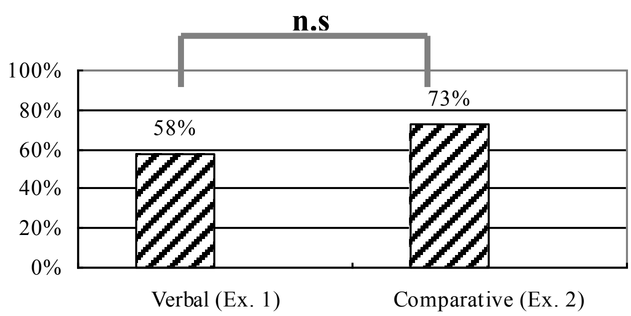
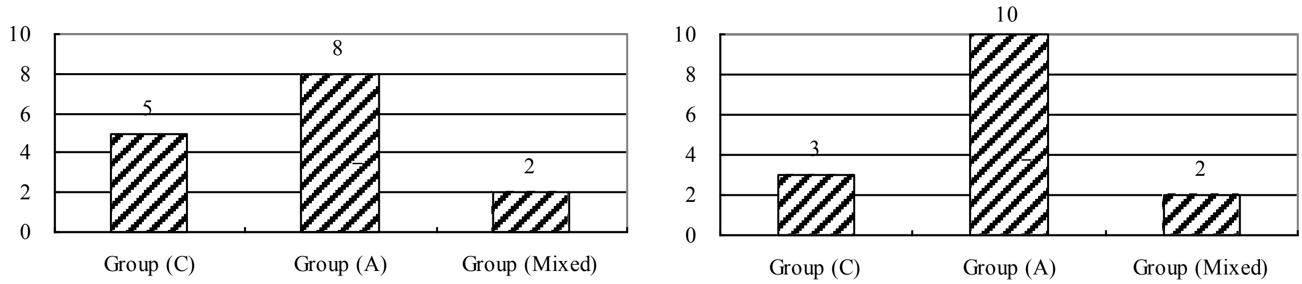


Figure 12. The rates of the absolute responses in the three conditions altogether

Moreover, children are classified into three groups based on their interpretation of the stimulus sentence. When

[14] Although it is not appropriate that we score children's interpretation of a differential verbal expression as comparative or absolute, for convenience, following the scoring on their interpretation of a differential comparative, we adopt the classification to that of a differential verbal expression.

their responses and justification in all conditions are scored as C, such children are classified into Group (C). On the other hand, when their responses and justification in all conditions are scored as A, such children are classified into Group (A). Lastly, when their scores include both C and A, such children are classified into Group (Mixed). As shown in Figure 13, in Experiment I, 5 children (mean age: 6;1) are classified into Group (C), 8 children (mean age: 5;7) are classified into Group (A) and 2 children (mean age: 6;1) are classified into Group (Mixed). In Experiment II, 3 children (mean age: 6;0) are classified into Group (C), 10 children (mean age: 5;10) are classified into Group (A) and 2 children (mean age: 6;0) are classified into Group (Mixed). Given that only a few children are classified into Group (Mixed), most of children's interpretation of the stimulus sentence is consistent.



(i) Experiment I (differential verbal expressions) (ii) Experiment II (differential comparatives)

Figure 13. Classification of children based on their interpretation of the stimulus sentence

The number of absolute responses of an individual child is represented in Table 5. Analyzing the data with Spearman's rank correlation, children's absolute responses to the two constructions are correlated (r= .739). That is, children who interpret a differential verbal expression as absolute always interpret a differential comparative as absolute.

subject	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
age	6;3	6;3	6;2	6;2	6;1	6;1	6;1	5;11	5;11	5;10	5;10	5;8	5;4	5;4	5;4
Experiment 1	8/9	9/9	0/9	9/9	8/9	4/9	0/9	0/9	9/9	7/9	9/9	9/9	9/9	9/9	8/9
Experiment 2	1/9	9/9	0/9	0/9	8/9	0/9	0/9	0/9	9/9	8/9	7/9	9/9	9/9	9/9	9/9

Table 5. The number of absolute responses from an individual child

The experiments have revealed that children interpret a differential verbal expression as absolute on the same degree as a differential comparative. The expectation that children should be able to interpret a differential verbal expression more easily than a differential comparative has been disconfirmed. Moreover, children's absolute responses to the two constructions are correlated. So, it is reasonable to consider that the source of their difficulty in interpreting them is the same. Therefore, whatever properties of the two constructions cause their absolute interpretation, we can conclude that their absolute interpretation is not specific to static comparison expressed with a differential comparative and that children have difficulty in mapping a numeral phrase to a differential between two sets.

6. General Discussion

The previous experiments have shown that children as young as four years old are able to use either one-to-one correspondence strategies or subtraction operation in order to determine a differential between two sets. Moreover, they have also revealed that children interpret a differential verbal expression as absolute on the same degree as a differential comparative and that they have difficulty in mapping a numeral phrase to a differential between two sets.

However, we cannot conclude whether the source of children's difficulty in solving a comparison problem is linguistic or cognitive only with the data. There is a possible way to tease apart these two hypothesis. We can investigate this issue by examining children's interpretation of differential comparatives which include a non-numeral phase like *a little*. By examining children's interpretation of these sentences in (32), we can know whether their absolute interpretation is specific to a differential comparative including a numeral phrase or not.

(32) a. The girl has *two* more apples.
b. The girl has *a little* more juice.

For example, both in Figures 14 and 15, the girl has a lot of juice. While she has a lot more juice than the boy in Figure 14, she has a little more juice in Figure 15. If children correctly interpret a differential comparative including *a little* as comparative, they reject (32b) regarding Figure 14 and accept it regarding Figure 15. On the other hand, if they interpret it as absolute, they reject (32b) both in Figures 14 and 15 because the girl has a lot of juice. Children who interpret it as absolute accept the statement "The boy has a little more juice." regarding Figure 14 and reject it regarding Figure 15 because the boy has a lot of juice.

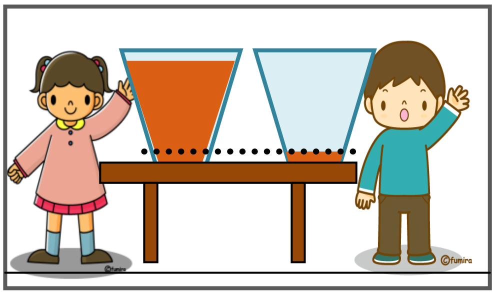


Figure 14. 'a lot more'

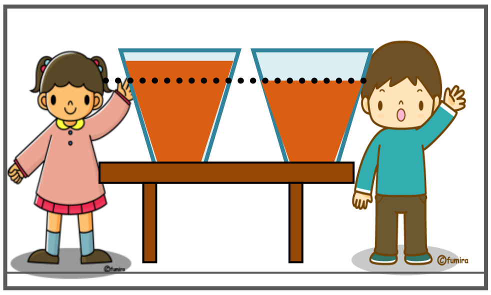
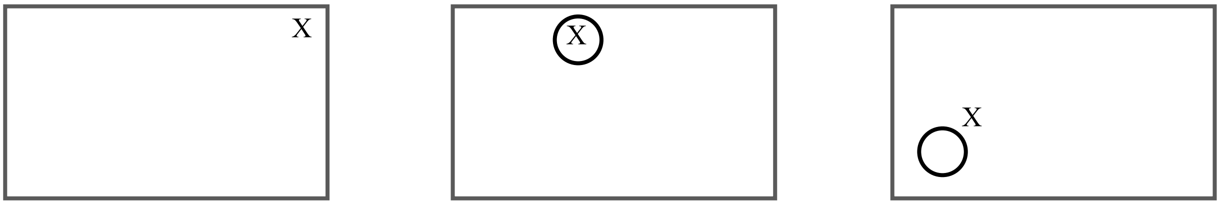


Figure 15. 'a little more'

If children can appropriately interpret a differential comparative including a non-numeral phrase, we can conclude that their absolute interpretation is specific to a differential comparative including a numeral phrase and that children have cognitive resources to grasp the concept of a differential between two sets. Moreover, as we have seen that they can use either one-to-one correspondence strategies or subtraction operation to determine a numeral differential between two sets. So, in this case, the reason why children have difficulty in solving a comparison problem is that their grammatical knowledge of a differential comparative including a numeral phrase is different from adult grammar. Considering that children justified their absolute responses, not only saying a numeral phrase but saying a differential comparative itself (see (15)), we cannot say that their absolute interpretation is caused by paying their attention only to a numeral phrase. They might interpret a differential comparative including a numeral phrase in a conjunctive way: They might interpret "X has two more apples." as "X has two (apples) and the number of them is more."

Alternatively, if children also interpret a differential comparative including a non-numeral phrase as absolute, it is possible that they have difficulties in grasping the concept of a differential between two sets in the first place. However, the problem is not so straightforward because the grammatical knowledge of a differential comparative can be the basis on which children can grasp the concept. That is, it is possible that we have to have grammatical knowledge of a differential comparative (or an expression to indicate a differential between two sets) in order to solve a comparison problem. In this case, we cannot tease apart two possibilities concerning the source of children's difficulty in solving a comparison problem: Linguistic Hypothesis or Cognitive Hypothesis.

According to Spelke (2003), combining capacities, each of which is shared by non-human animals, is made possible by natural language, which is unique to humans. Non-human animals and young children shared many kinds of cognitive capacities with human adults but they sometimes show interesting limits. For example, although non-human animals are endowed with rich and exquisitely precise mechanisms for navigating through the spatial layout, the navigation of non-human animals shows limits. In experiments conducted by Biegler and Morris (1993, 1996), rats learned readily to locate food by searching in a particular geocentric position (e.g. the northeastern corner of the test chamber) or by searching near a particular landmark (e.g. in the vicinity of a white cylinder), but they had more difficulty in learning to search in a particular geocentric relationship to a particular landmark (e.g. at the northeast of the while cylinder), as illustrated in Figure 16.



(i) 'At the northeast corner' (ii) 'In the vicinity of the cylinder' (iii) 'At the northeast of the cylinder'

Figure 16. Schematic and simplified depiction of three tasks presented to rats in the experiments by Biegler and Morris (1993, 1996): the square represents the test chamber, X represents food and the circle represents the cylinder

Although rats could represent that food was located 'at the northeast corner' or 'in the vicinity of the cylinder,' they could not readily combine these representations in order to represent that food was located 'at the northeast of the cylinder.' Moreover, Hermer and Spelke (1994, 1996) found that the same limit exits in children. To sum up, both children and rats can learn to search to the left or right of a geometrically defined landmark (i.e., the left or right of the test chamber), and they can learn to search directly at a non-geometrically defined landmark (i.e., the cylinder), but they do not readily combine these two sources of information in order to search left or right of a non-geometrically defined landmark (i.e., at the northeast of the cylinder). In contrast, human adults tested under similar circumstances exhibited this ability. Hermer et al. (2001) suggest that the transition to adult-like navigation is closely related to the emergence of spatial language like *left* and *right*. In their experiments, the transition was found to occur at about six years of age, around the time that children's language production shows mastery of spatial expressions involving *left* and *right*. Hermer et al. (2001) conclude that spatial language and flexible navigation are correlated.[15] On the basis of these previous findings, Spelke (2003) argues that natural language allows humans to combine flexibly the representations which they share with other animals.

Following Spelke's (2003) argument, it is possible that although children have adult-like abilities which are required to solve a comparison problem (e.g. one-to-one correspondence strategies, subtraction operation, etc.), they cannot combine them to grasp the concept of a differential between two sets because they do not have adult-like representations of a differential comparative (or an expression to indicate a numeral differential between two sets) in their grammar. As an example, let us consider a comparison problem with the support of visual objects (e.g. pictures or plastic toy objects): "Given that John has three apples and Tom has two apples, how many more apples does John have than Tom?" In order to determine the differential between John's and Tom's apples, first we compare the quantities of their apples and confirm that John has more apples than Tom. Next, we establish correspondences across John's and Tom's apples and count the number of John's apples left without a pair in Tom's apples (one-to-one correspondence strategies) or determine the cardinal value of John's and Tom's apples and subtract the number of Tom's apples from that of John's (subtraction operation). So, in order to solve a comparison problem, we have to combine our cognitive abilities: the ability to compare the quantities of two sets, the ability to count and the ability to use one-to-one correspondence strategies or subtraction operation. Children as young as five (even some four-year-olds) have each ability like adults. However, they are likely not to be able to combine these abilities because they do not have adult-like representations of a differential comparative, and they fail to solve a comparison problem. In brief, children might have to acquire a differential comparative to grasp the

[15] Spelke (2003) further suggests a possibility that the compositionality of natural language makes humans more flexible navigators.

concept of a differential between two sets and to solve a comparison problem. Therefore, even though children cannot interpret a differential comparative including a non-numeral phrase appropriately, there still remains a possibility that their grammatical knowledge has some consequences on their concept of comparison. This issue is left for further research in this paper.

7. Conclusion

This paper has presented new experimental data to pin down the source of children's difficulty in interpreting differential comparatives. Children as young as 4 years old are able to use either one-to-one correspondence strategies or subtraction operation in order to determine a differential between two sets. Moreover, children interpret a differential verbal expression as absolute on the same degree as a differential comparative and they have difficulty in mapping a numeral phrase to a differential between two sets. We cannot conclude whether the source of children's difficulty in solving a comparison problem is linguistic or cognitive only with the data. Moreover, we still do not know how they finally come to respond to a comparison problem in an adult-like way. There is ample room for inquiry in children' acquisition of a differential comparative. Further research remains to be done.

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