Children's ambiguous understanding of weak *and* strong quantifiers

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Abstract

Despite suggestions in the literature that the semantics of *many* might be the key for understanding children's non-adult-like interpretations of quantified sentences (cf. Drozd 2001, Geurts 2003), experimental data on the acquisition of weak quantifiers like *many* is rare. This paper investigates children's comprehension of weak (*many*) versus strong (*many of, all*) quantifiers in English. In particular, by means of a truth-value judgment task, taking the semantic and syntactic characteristics of *many* into account, we tested whether 28 children aged between four and seven understand the ambiguous nature of *many* as described in the literature (Partee, 1988) and whether they transfer this ambiguity to *many of* and *all*. The results show that children have an ambiguous quantifier system for both strong and weak quantifiers. This runs counter the idea that the child always prefers a reading of *many* in which the arguments seem to 'switch' (as for adults in *Many French have won the Tour de France,* resulting in the interpretation Many Tour de France winners are French), as predicted by Drozd and Van Loosbroek's (1999) Weak Quantification Hypothesis. On the basis of our experimental results on children's understanding of both weak and strong quantifiers, we conclude that children's non-adult interpretations of quantified sentences are due to the ambiguous nature of (weak) quantifiers. This presents the language learner with the difficult, but necessary, task to distinguish between those different kinds of readings and understand their different semantic and syntactic representations in order to converge with the target language.

1. Introduction

Since Inhelder and Piaget's (1964) groundbreaking work, it has been known that children, regardless of their language, have difficulties in understanding quantified sentences, e.g. *Is every cowboy riding a horse?* in relation to figure 1 (cf. Freeman, Sinha, and Stedmon (1982), Roeper and de Villiers (1993), Philip (1995), Crain, Thornton, Boster, Conway, Lillo-Martin, and Woodams (1996), Brooks and Braine (1996), Drozd (2001), Geurts (2003), Hollebrandse and Smits (2006), Drozd and Van Loosbroek (2006)). Children aged between four and seven answer 'no' and point at the horse with no cowboy as if they take the sentence to mean "Is every horse being ridden by a cowboy?". This results in a 'no, not that one' answer. The difficulties that children have with quantified sentences disappear after the age of seven.

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Recently, Drozd and Van Loosbroek (1999) and Drozd (2001), claimed that the child's answer results from a reading of the strong quantifier *every* similar to the so-called 'switched' reading adults allow for the weak quantifier *many* in (1) (i.e. reading (1b), first observed by Westerståhl, 1985).

Figure 1: Is every cowboy riding a horse?

(1) Many French have won the Tour de France
  a. "Many French have won the Tour de France"
  b. "Many of the Tour de France winners are French"

In contradiction to the regular cardinal reading of (1) exemplified in (1a), for reading (1b), the first argument ('French') and second argument (Tour de France winners) of the quantifier *many*, seem to switch. This results in a reading according to which one might judge sentence (1) as true given the fact that, compared to the distribution of Tour de France participants per country, relatively many winners are French. In a similar way, children are argued to interpret *Is every cowboy riding a horse* as questioning the distribution of all horse-riders per animal. Children then answer in terms of their expectation, that, of all horse-riders, cowboys relatively most often ride a horse. Crucially, however, in this case, not all horses are being ridden by a cowboy. This runs counter the child's expectation and results in a 'no, not that one answer' (Drozd and Van Loosbroek, 1999 and Drozd , 2001).

In order to become adult-like, the child's task is then to only allow such a reading for weak quantifiers like *many*. To be more specific, Drozd and Van Loosbroek (1999) and Drozd (2001) imply that children have to disambiguate *every* from this switched reading to become adult-like. This suggests a developmental stage in the acquisition of quantification in which children allow switched readings for both *many* and *every*. However, while earlier experimental work regarding the acquisition of quantifiers focused on strong quantifiers like *every* and *all* (cf. the literature mentioned earlier),

experimental data on children's understanding of weak and strong quantifiers in experimental contexts similar to the situation described in (1) is rare (but with the exception of Krämer, 2005a, 2005b and Hollebrandse and Smits, 2006). This paper presents an experiment testing children's understanding of the ambiguous nature of *many,* and moreover, addresses the question whether children allow similar readings for the strong quantifiers *many of* and *all* to those that they allow for *many*. By analyzing children's interpretations of *many* in contexts similar to (1), we will identify an appropriate characterization of this quantifier for children and relate this to the acquisition of quantification.

2. The switched reading of many

Given the relevancy of the switched reading to the acquisition of quantification (as argued by Drozd and Van Loosbroek, 1999 and Drozd, 2001), the question arises what the actual nature is of this switched reading of *many*. We will now discuss three accounts of the switched reading that are given in the literature.

2.1 The switched reading as a focus affected reading

Herburger (1997, 2001) argues that the switched reading is an instance of a 'focus affected reading'. Given the fact that the switched reading is only possible with a weak quantifier (cf. the examples below containing the strong quantifiers *many of* and *all* and their infelicitous interpretations (2b) and (3b)), she takes the difference between weak and strong quantifiers as a starting point.

(2) a. Many of the French have won the Tour de France

b. *"Many of the winners of the Tour de France are French"

(3) a. All French have won the Tour de France

b. *"All winners of the Tour de France are French"

In Generalized Theory (Barwise and Cooper, 1981), weak quantifiers differ from strong quantifiers in the way they relate their arguments (the denotation of the NP and the VP). Weak quantifiers present an intersection relation between their first argument (the denotation of the NP) and second argument (the denotation of the VP), whereas strong quantifiers present a subset relation. In Keenan's (1987) words, weak quantifiers like *many* and *two* are symmetrical and strong quantifiers like *every* and *all* are not. This is exemplified below in which the NP 'men' is taken as the quantifier's first argument and the VP 'x are laughing' as its second argument.

(4) a. Many men are laughing <=> Many laughing x are men

b. Two men are laughing <=> Two laughing x are men

This difference between weak and strong quantifiers, Herburger argues, explains why only weak quantifiers allow a switched reading. This is illustrated in (5) and (6). While switching the arguments of a weak quantifier like *two* in (5) does not result in a difference in meaning, it does for a strong quantifier like *all* in (6).

(5) Two parrots are wearing a hat <=>Two hat-wearers are parrots

(6) All parrots are wearing a hat <=/=> All hat-wearers are parrots

Assuming a certain mapping from syntax to semantics, Herburger assumes that the semantic difference between weak and strong quantifiers is also reflected in the syntax. She suggests that weak quantifiers undergo Q-raising, a process of local raising of the quantifier determiner without its argument to a position that neutralizes the distinction between the first and the second argument set of the determiner (illustrated in (7a)).

(7) a. $[Q_i\ [[_{XP}\ t_i\ NP]\ YP]]$

b. $[Two_i\ [[_{DP}\ t_i$ parrots] are wearing a hat]]

In (7a), the quantifier (Q) moves out of the quantified noun phrase. As a result, there is no difference anymore between the relation of the quantifier with its first argument and the relation with its second argument (cf. (7b)). This is similar to the semantic characterization of weak quantifiers in terms of symmetry (cf. (5)). Strong quantifiers still move by means of QR (à la May, 1985), according to which the entire quantified noun phrase (quantifier and NP) moves to the beginning of the sentence.[1]

Now, recall that the switched reading is only possible with a weak quantifier. Since weak quantifiers are symmetrical and do not make a difference between its first and second argument set, the switched reading can not be explained in terms of the inherent characteristics of weak quantifiers. Therefore, Herburger claims that the switched reading results from "focal mapping". Focused material in the domain of the determiner (the quantifier's first argument) ends up as the second argument set and nonfocused material as the first argument set. In case of a strong quantifier,

[1] Despite the small notational difference between Q-raising and Quantifier Raising (or QR), note the important theoretical difference between these two raising operations. Following Herburger, we define Q-raising as raising of the quantifier determiner without its accompanying NP. This differs from the raising operation called Quantifier Raising (or QR) which involves raising of the entire DP, both quantifier and NP à la May, 1985)

focus on the first argument does not result in the switched reading since the syntax already dictates the order of the arguments (i.e. QR has been applied and the quantifier together with its first argument already moved to the beginning of the sentence).

2.2. The switched reading as a special cardinal reading

De Hoop and Sola (1995) argue against the view that (1b) is an instance of a switched reading of *many*'s arguments. They point at the role of a context set to explain the apparent inversion of *many*'s arguments. They crucially differ from Herburger (1997, 2001) in not predicting the switched reading to arise from focus on the NP. De Hoop and Sola (1995) argue that *many*'s first argument set intersects with some kind of context set of the expected or normal value of this set. This results in the switched reading in (8a) since surprisingly, as many as 14 Scandinavians had won the Nobel Prize in literature by 1984. This contradicts one's normal expectations, given the fact that out of each country in the world, only one person can win the Nobel Prize in literature per year.

(8) Many Scandinavians have won the Nobel Price in literature

  a. Many winners of the Nobel Price in literature are Scandinvians

2.3. The switched reading as a relative proportional reading

Cohen (2001) argues for a similar approach in terms of alternative sets. Defining the switched reading as a relative proportional reading, he distinguishes the switched reading from the regular cardinal (1a) and the abstract proportional reading of *many* (9).

(9) Many students got an A in my class

For (9), one only has to inspect whether there are more students that got an A than the ones that did not. This abstract proportional reading, Cohen argues, differs only slightly from the switched reading, which he calls a 'relative proportional reading'. For a relative proportional reading, however, one also has to inspect the alternative sets of the first and second argument set of the quantifier. Example (1), for example, involves, according to Cohen (2001), a comparison between various countries with respect to the proportion of the population who have won the Tour de France. The sentence is true only if the proportion of Tour de France winners is greater in France than it is in any other country. Hence the term 'relative proportional reading'.

2.4 Intermediate summery

In sum, all three accounts discussed above point at a different set that has to be taken into account to determine the truth-value of a switched reading. According to De Hoop and Sola it is the expected or normal frequency of a context set that the first arguments intersect with that explains the switched reading. Cohen points at the set of alternatives to the second argument set that has to be taken into account in order to get the switched reading. Herburger differs from both De Hoop and Sola and Cohen by arguing that the switched reading is an instance of a focus affected reading. She predicts to find more instances of switched reading if the NP is focused. As a result, all three accounts differ in the set comparison they assume that is necessary to interpret a switched reading.

If the acquisition of quantification is the topic at hand, as it is in the present paper, the question arises what kind of set comparison the child actually computes and whether her set comparison reflects an adult way of interpreting quantifiers. There is only sparse data on children's interpretation process of quantifiers, let alone on children's interpretation process of weak quantifiers. Questioning children's processing of quantification is a first step, we would like to argue, to a full understanding of children's mental representation of quantifiers.[2] In order to question children's processing of quantifiers from the perspective of the literature on the switched reading discussed above, our study focused on children's interpretation of the meaning of strong and weak quantified sentences in relation to focus *and* incorporates alternative sets of the argument of the quantifier in the design of the experiment and the ability to answer in terms of expectations of normal frequencies (cf. Hollebrandse, 2004 and the effect of focus on children's interpretation of quantified sentences). But before turning to the experiment that addresses the question whether children allow such a switched reading for weak and strong quantifiers in the first place and second, what kind of set-comparison the child computes, we will discuss how the switched reading and the difference between weak and strong quantifiers relates to the acquisition of quantification.

[2] Off course, we agree with an anonymous reviewer who pointed out that "performance data *supposedly* represent mental representations". Being outside the scope of the current paper, however, we leave the task to prove that performance data reveals children's actual mental representations for further research.

3. Set comparison, focus and the acquisition of quantification

Until now, research on the acquisition of quantification has mainly focused on strong quantifiers like *all*, *every* and *each*. However, two accounts make precise predictions for children's understanding of weak quantifiers.

Drozd & van Loosbroek (1999) suggest that children's non-adult interpretations of universally quantified sentences result from their expectations of normal quantities. Along the lines of De Hoop and Sola's (1995) explanations of the switched reading, Drozd and Van Loosbroek suggest that children also interpret strong quantifiers like *all* in terms of the expected or normal frequency of horse-riding cowboys. Put differently, they suggest that children interpret strong quantifier as weak existential ones. Furthermore, Drozd and Van Loosbroek predict that children, when the first argument set is salient or discourse active, apply an adult-like reading. When the first argument set is not in focus, children will switch the arguments of both a strong and a weak quantifier. Drozd and Van Loosbroek refer to this as the Weak Quantification Hypothesis.

Hollebrandse and Smits (2006) argue that children always try to fill in the two argument sets of a quantifier and randomly pick a set to do so. This explains their findings that Dutch children always prefer a strong reading of the Dutch quantifier *allemaal,* even when it appears in an existential there-sentence (which only allows a weak reading of *allemaal* for adults). Put differently, they found that children interpreted (10) as (11). We refer to Hollebrandse and Smits's hypothesis as the Rigid Mapping Hypothesis.

(10) Er vliegen allemaal papegaaien
There flying many parrots
There are flying many parrots

(11) De papegaaien vliegen allemaal
The parrots fly all
The parrots are all flying

How does this relate to Drozd and Van Loosbroek's (1999) Weak Quantification Hypothesis? Drozd and Van Loosbroek predict that focus on the second argument results in a switched reading. The Rigid Mapping Hypothesis, however, predicts that children prefer a strong reading of the quantifier anyway. Put differently, Hollebrandse and Smits predict that focus on either the first or second argument set does not affect the children's interpretation of a quantified sentence. In the next section, we discuss the experiment that tests these predictions.

4. Experiment: the acquisition of *many* and *all*

The main goal of the experiment is to compare children's interpretation of weak versus strong quantifiers, in particular *many* versus *all*. The starting point is that, while *all* is a strong, non-symmetrical quantifier and never can get a switched reading, *many* is a weak, symmetrical quantifier which can get the switched reading next to a cardinal (1a) and a proportional (9) reading. We want to find out, first, whether children master the ambiguity of *many* or only allow one of these three readings (in particular whether they only allow the switched reading as predicted by the Weak Quantification Hypothesis) and second, whether children interpret the strong quantifiers *many of* and *all* in a similar way as they interpret *many*.

As described in the previous section, the literature concerning the actual nature of the switched reading points at either the expected frequency of the first argument of the quantifier (De Hoop and Sola, 1995) or the set of alternatives of the first and second argument set (Cohen, 2001). In addition, Herburger (1997, 2001) points at the relation between focus and the switched readings. These three explanations of the switched reading are respectively accounted for in the design of the experiment by (i) enabling children to explain their answer in terms of the expected frequency of the first argument set by using the setup as described below (see 'procedure'), (ii) displaying the set of alternatives of the first and second argument set in the experimental test situation (see 'materials'), and (iii) introducing the test items in terms of making either the first or the second argument set more salient (see 'materials'). We also ran the experiment on adults, in order to confirm this latter effect experimentally.

4.1. Method

Subjects

We tested 28 children between the ages of 4;1 and 7;3 (mean age 6;0). Six children were excluded from further analysis because they didn't answer the control items correctly, suggesting that they did not pay attention or did not understand the task. All the children were recruited at preschools in the area of Amherst, Massachusetts (USA). We also tested a control group of 17 adult native speakers of English. They were all undergraduate students at the University of Massachusetts, Amherst (USA).

Procedure

The children were tested using a Truth Value Judgment Task that slightly differed from the classical Truth-value Judgment Task (Crain and

Thornton, 1998); instead of introducing a blindfolded puppet to the child, the experimenter told the child the following story:

> *At the university, I have built this computer and as you will see, there are a lot of pictures on it, but it is also able to play sentences via those speakers! But the problem is, I don't know whether I build this computer entirely the right way. So, I need your help to check whether the computer has been built the right way or the wrong way. Do you want to help me? OK, well, I show you the pictures I have got on this computer and when I will show you a picture, you will also hear something. Now, if you just want to tell me if this matches the picture or not. All right?*

A laptop was used to present the pictures and two separate speakers were used to play prerecorded test items. The test items were either presented in a context that forced a switched reading of the quantifier or a non-switched reading (see materials). Then the experimenter said "Let's hear what the computer says" and subsequently asked the child to press a button on the keyboard. As illustrated in the introduction story above, the child was instructed to check whether the pictures *matched* the sentences or not. This instruction was given to prevent children from answering in terms of world-knowledge (e.g. "parrots do not wear hats in the real world, so the picture is not right"). Next to this question, this setup crucially allowed us to also ask the child to explain her answer (being either 'yes' or 'no'), either in terms of her expectations, proportions or alternative sets of the first and second argument set.

Materials

Westerståhl's observation regarding the ambiguity of *many* was the starting point for the design of the pictures. In addition to this and following Cohen (2001), next to the set of individuals denoted by the noun phrase and the verb phrase, the alternative set of the first argument set and the alternative set of the second argument set was depicted. In the case of the test sentence *Many parrots are wearing hats*, this meant that, next to the set of parrots, also other animals (the alternative set of the quantifier's first argument) were depicted and, next to the set of parrots wearing hats, also other hat-wearers (the alternative set of the quantifier's second argument set).

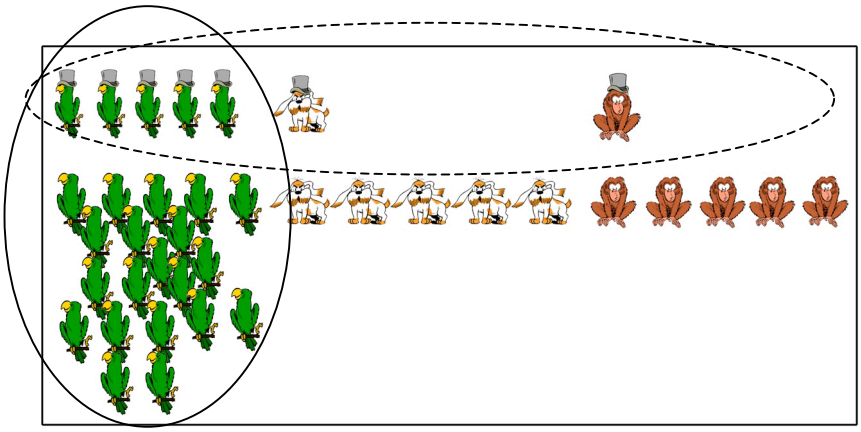

Figure 3: *Many/Many of the parrots are wearing hats*

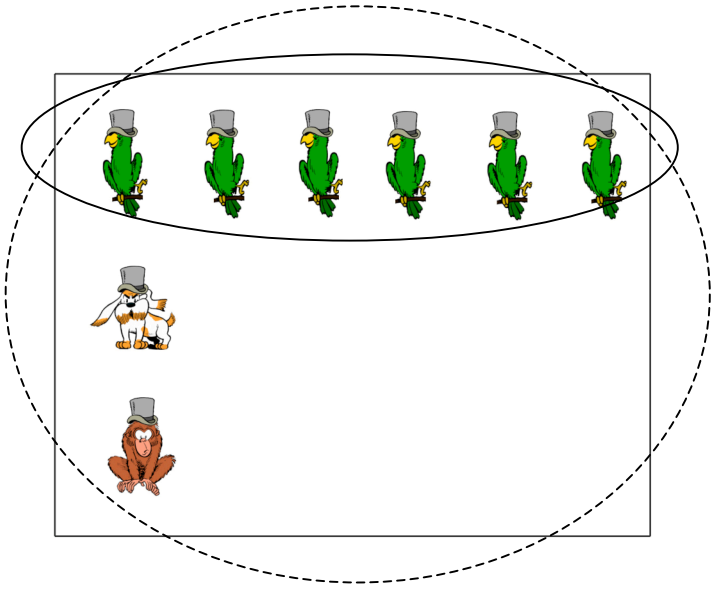

Figure 4: *All parrots are wearing hats*

The scenarios were used to test the children's comprehension of sentences containing the different types of quantifiers: *many*, *many of* or *all*. The setup of the picture that was used in the case of a sentence containing *all* (Figure 4) differed from the setup of the pictures that was used in the case of sentences containing *many* or *many of* (Figure 3). This was done so, because this enabled the child with a preference for a switched reading to say yes for Figure 3 (since many hat-wearers are parrots) and no for Figure 4 (since not all hat-wearers are parrots). The children were shown pictures along the lines of Figure 3 accompanied with a sentence containing *many* (six times) and *many of* (six times) and six times accompanied with a sentence containing *all*. See for an overview of all testitems the appendix.

In addition to the effect of Quantifier Type, the effect of Focus was tested by varying the introduction to each picture. The description either backgrounded the first argument set of the quantifier or the second argument set; the experimenter pointed at the set of individuals denoted by the verb phrase (indicated by the dashed oval in Figures 3 and 4 above, which resulted in focus on the first argument set) or at the set of individuals denoted by the noun phrase (indicated by the black oval in Figures 3 and 4 above, which resulted in focus on the second argument set). Following Herburger (1997, 2001), we take adults to answer 'no' in the case of a backgrounded NP (establishing focus on the VP) in Figure 3 for a sentence like *Many parrots are wearing hats* (due to a weak, symmetrical reading). Conversely, we hypothese adults to answer 'yes' in the case of a backgrounded VP (establising focus on the NP) in Figure 3 for a sentence like *Many parrots are wearing hats* (due to a switched reading).[3] For Figure 4, we hypothesize adults to answer 'yes' no matter which set is backgrounded.

Our experiment crucially involved gestural focus instead of intonational focus to achieve joint focus of attention. We take gestural focus to be a natural and important extension of intonational focus as a way of achieving joint focus of attention (cf. psychological work that shows that "pointing gestures circumscribe a referential domain by directing gaze to an approximate spatial region" (Bangerter, 2004:415; cf. references therein)). We takes this to be a natural extension of intonational focus because it extends the concept to pointing.[4]

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[3] As we agree with two anonymous reviewers, it might be hard to get a 'yes' answer for *Many parrots are wearing hats* in relation to picture 3 without gestural focus. Crucially, however, by pointing at the set of hat-wearers, only part of the figure is brought under the attention, and, as one reviewer admits, "the 'yes' answer gets very easily triggered".

[4] Moreover, it is known that children have problems understanding intonational focus but do understand the mechanism of pointing as a mean to establish joint attention between speaker and hearer. Children's understanding of pointing is confirmed in our experiment; all the children showed joint attention to the set the experimenter pointed out. Furthermore, all the children were able to point out the displayed objects when asked to do so. As a result, most children also explained their answers by either describing or pointing out the set relevant for their answer. This indicated that they master the mechanism of gestural focus to achieve joint attention. After the experimenter established this kind of joint attention on either the first or second argument set by means of gestural focus, we played the test sentence. As a result, the test sentence either contained a contrastive topic or not (i.e. the subject of the test sentence was either the set which we did or did not point out in the introduction story). We call this kind of contrastive focus simply 'focus' in the remainder of this paper.

Two control items using *many* and *all* were tested. In the control items, a sentence with *many* and *all* was used in combination with a picture in which respectively only e.g. one parrot was wearing a hat (triggering a 'no' answer) or e.g. four parrots were all wearing a hat (triggering a 'yes' answer).

4.2. Results

Set comparison and quantification

Do children process the meaning of quantified sentences, i.e. do they compute the set comparison that is necessary for understanding quantified sentences in an adult way? According to Drozd and Van Loosbroek's Weak Quantification Hypothesis, children prefer a switched reading. The Rigid Mapping Hypothesis (Hollebrandse and Smits, 2006) predicts that children analyze the quantifier as a strong, non-symmetrical quantifier. Recall that the children were asked to explain their judgments. These explanations allowed us to analyze the child's interpretation, i.e. processing of the meaning of *many*, *many of* and *all*; in terms of regular counting (cardinality), in terms of proportionality, or in terms of the switched reading. Or, to put it differently, the children's explanations enabled us to answer the question whether the different readings of *many* that have been proposed in the literature (Partee, 1988) are also given by children for strong quantifiers like *all* and *many of*.

The results show that this is indeed the case. Each child gave all three readings across Quantifier Type (no child consistently gave one of the three readings for either a weak or a strong quantifier). Example (12) illustrates a case of a child (shown a picture similar in setup to Figure 4, but also displaying two other birds with yellow wings) getting the switched reading (which is only possible with weak quantifiers for adults) for the strong quantifier *all*.

(12) child Ca. (age: 6;4.23)

Computer: All parrots have yellow wings

Child: No.

Experimenter: Why not?

Child: That's why: all of the characters have yellow wings

In (12), the child explains her answer in terms of the second argument set of the quantifier (all entities that have yellow wings). Put differently, the child quantifies over the intersection of the set of characters that have yellow wings and the set of parrots and then checks whether there are no

characters that have yellow wings outside this intersection. However, this is not the case; the picture also contains other characters that have yellow wings (cf. the child's description of the picture in the last line of (12)). Consequently, we take the child's reading of *all* as being an example of a switched reading of the arguments of the quantifier.

This switched reading of the arguments of the quantifier differs from non-switched answers. The example in (13) illustrates a case of a child (shown a picture similar in setup to Figure 3) giving a proportional reading of *many*.

(13) Child Si. (age: 5;8.15)

Computer: Many girls are holding balloons

Child: No! Many girls are NOT holding balloons

In (13), the child refers to the first argument set (i.e. the set of girls) to explain her answer. Moreover, the child points out that many girls are not holding balloons; she quantifies over the first argument set of the quantifier and checks whether this counts as *many*. She concludes that this is not the case; many girls are not holding balloons (i.e. 20 girls) which is more than the girls that are holding balloons (i.e. 5 girls).

In addition to switched and proportional readings, children gave cardinal answers. A case of a child (shown a picture similar in setup to Figure 3) giving a cardinal reading is illustrated in (14).

(14) Child Sh. (age: 7;2.20)

Computer: Many of the dogs have red tails

Child: Yes

Experimenter: That's true? OK. Why is that?

Child: Because there is more than one.

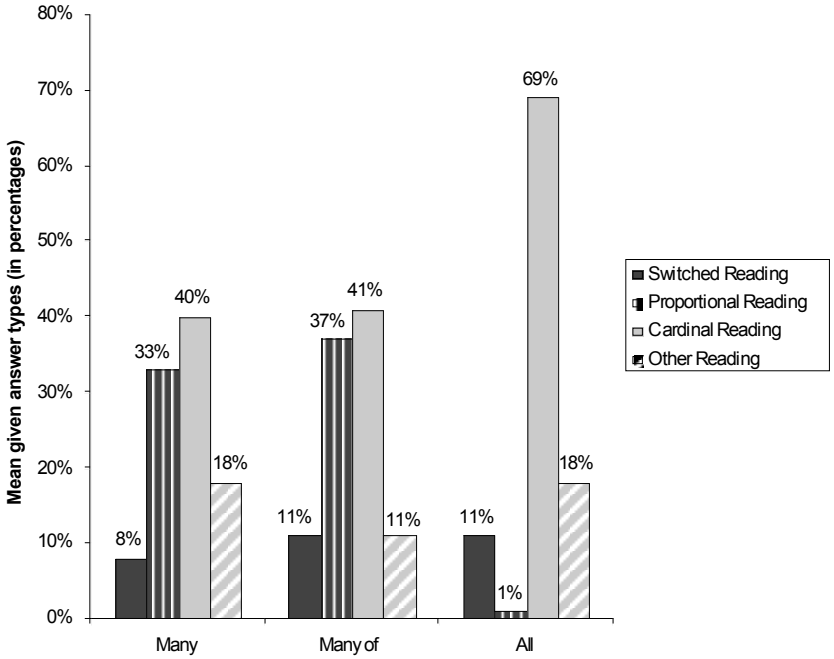
We called the answer of the child a cardinal reading (cf. (14)) if the child explained her answer by referring to a certain number (e.g. more than one of the dogs have red tails).[5]

If we look at the distribution of the different answers, we see that switched readings were given in 10% of all answers, 24% were proportional answers and 49% were cardinal answers. 16% of the answers were labeled as 'other' (answers in terms of world-knowledge). Only two times, a child answered in terms of the alternative set of the first arguments

5 We labeled an answer a 'cardinal answer' if the child answered either in terms of some kind of abstract cardinality (i.e. "because many is more than one") or in terms of pointing and an answer like "because there are five of them".

set (i.e. other animals) and pointed at the animals not wearing a hat. However, since this was not totally straightforward, we labeled these answers also 'other'. Figure 5 shows how these different types of readings were distributed over the three different quantifiers. The different quantifier types *many*, *many of* and *all* are mapped on the x-axis and the mean given answer types (in percentages) on the y-axis. The bars show the percentages of switched, proportional, cardinal and other readings.

Figure 5: children's explanations regarding their judgments for *many*, *many of* and *all*



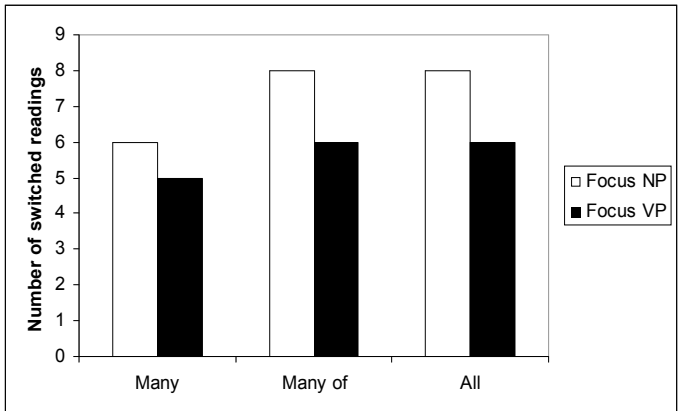
The children's explanations were analyzed in a repeated measures analysis of variance. Within-subjects factors were Quantifier Type (*many*, *many of* and *all*) and Answer Type (Switched reading, Proportional reading, Cardinal reading and other reading). This analysis shows a main effect of Quantifier Type ($F(3,63) = 9.697$, $p < .001$) within-subjects and an interaction effect between Quantifier Type and Answer Type ($F(6.126) = 6.62$, $p < .001$). T-tests show that this is mainly due to *all*; the children gave significantly more cardinal answers for *all* (69%) versus *many* (40%) and *all* versus *many of* (41%). (Significant differences exist between *all* and *many* ($t(16) = -2.33$, $p = .033$), on the one hand, and between *all* and *many of,* on the other ($t(16) = -2.33$, $p = .033$). There is no significant difference between *many* and *many-of*.)

Focus affected quantification

Focus was varied in the introductory description. Focus was either on the first argument set (NP) or the second argument set (VP) of the determiner. But are subjects sensitive to focus? The Rigid Mapping Hypothesis predicts that the children will not show an effect of focus. The Weak Quantification Hypothesis predicts that children will accept more switched readings if the VP is focused.

In order to test the effect of focus, we need to examine the proportional readings and the switched readings in detail, and check how children compared the sets. Leaving out now the cardinal and the proportional answers, figure 6 presents the number of switched answers per focus type. The different quantifiers are mapped on the x-axis. The number of switched readings is mapped on the y-axis. The bars show the frequency of switched readings for either focus on the NP or focus on the VP.

Figure 6: Number of switched readings per focus type

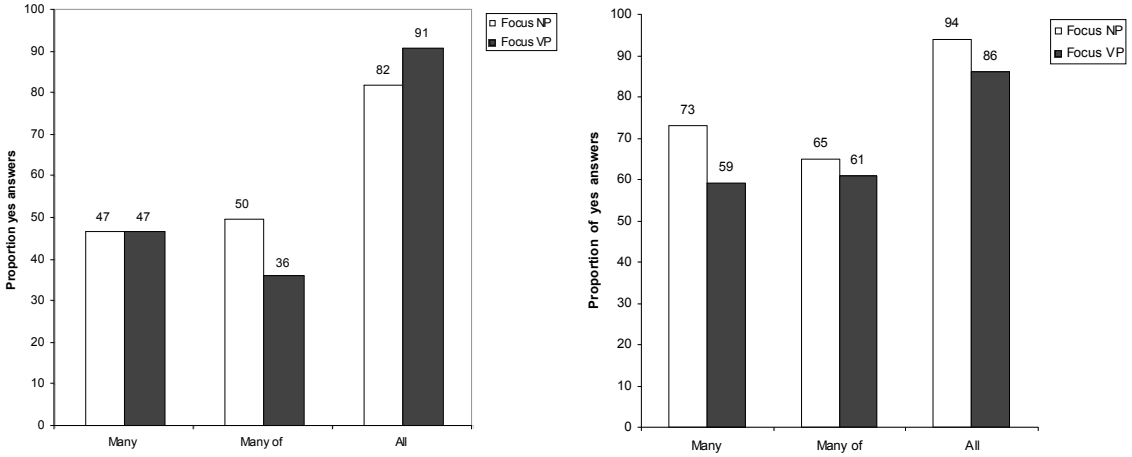


The switched answers were then compared with the proportional (non-switched) answers and analyzed in a 2 x 2 x 3 repeated measures analysis of variance. Within-subjects factors were Answer Type (Switched readings and Non-Switched readings), Focus Type (Focus NP and Focus VP) and Quantifier Type (*Many*, *many of* and *all*). There was no effect of focus.

As a second step, we tested the effect of focus by looking at the mean yes answer of both adults and children. Recall that, according to a switched reading of the arguments of the quantifier, one would answer "yes" with respect to the pictures that accompanied sentences containing *many* or *many of*, and "no" with respect to the pictures that accompanied *all*. The results contradict the prediction that children prefer a switched reading depending on focus type; for *many* and *many of*, the children's answers only consist of respectively 47% and 43% of yes-answers, for *all*, they answered 'yes' in 86% of the cases. This is visualized in figure 7 in which the conditions *many*, *many of* and *all* are mapped on the x-axis *versus* the

mean for *yes*-answers (in percentages) on the y-axis for children (left graph) and adults (right graph).

Figure 7: proportion of mean yes answers for Quantifier Type and Focus for children (left) and adults (right)



The adults seem to prefer a switched reading for *many* if the NP is focused; a 3 x 2 x 2 repeated measure of analysis (within-subjects factors were Quantifier type (*Many*, *Many of* and *All*) and Focus type (Focus NP and Focus VP), between-subjects factor was Group (adult and child)) reveals an interaction effect for Quantifier type * Focus type * Group ($F(2,74) = 3.489$, $p = .036$). Moreover, a t-test (two-sided) reveals a (nearly) significant difference between adults (73% yes answers) and children (47% yes answers) for *many* ($t(37) = -1.90$, $p < .065$) for focus on the NP.

Further analysis by means of two-sided t-tests (see Table 1) shows a significant difference between *many* and *all* and *many of* and *all* for both adults and children across focus type. No difference is found for both adults and children between *many* and *many of* (see table 1).

Table 1: significant differences for Quantifier Type (*many*, *many of* and *all*) for adults and children

		Std. Dev.	Std. Error Mean	t	df	Sig. (2 tailed)
Children	Many – Many of	10,20	2,17	1,74	21	,10
	Many - All	51,83	11,05	-3,56	21	,00*
	Many of - All	51,35	10,95	-3,94	21	,00*
Adults	Many – Many of	14,71	3,57	,82	16	,42
	Many - All	43,35	10,51	-2,33	16	,03*
	Many of – All	48,57	11,78	-2,33	16	,03*

* Significant at the $p < .05$ level

5. Discussion and conclusions

Despite current suggestions in the literature that the semantics of weak quantifiers, and the switched reading of *many* in particular, might be the key for understanding children's non-adult-like interpretations of quantified sentences, literature on the acquisition of quantification has failed to address the semantics and acquisition of weak quantifiers like *many*. This paper aimed to take into account the different semantic solutions that have been proposed to explain the switched reading of *many* and to identify its relevance for the acquisition of quantification. The experiment presented in the previous section and the analysis of the children's answers enable us to do so.

Our results show that children are capable of carrying out all three kinds of set comparisons, i.e. they allow weak, cardinal, proportional and switched readings. Although the design of the experiment opened up for it, the children gave no answers in terms of the set of alternatives of the first and second arguments set of the quantifiers (as predicted by Cohen, 2001). Nor did the children answer in terms of expected set sizes, which might be due to the instruction of the test (see the section entitled 'procedure'). But the children also allowed, next to the strong reading also a weak, cardinal reading even when the (adult) syntax does not allow such a reading (e.g. in the case of *many of* and *all*). This is in line with findings by Krämer (2005a and 2005b).

The results indicate that children do not prefer a reading of the quantifier but randomly pick a set as the first argument of a quantifier. Children do this even when the syntactic environment (i.e. focus) dictated them to pick a particular set. This supports the Rigid Mapping Hypothesis

(Hollebrandse and Smits, 2006). As such, an analysis in terms of the syntactic and semantic characteristics of weak and strong quantifiers provides an explanation which is more adequate than the pure reliance upon the Weak Quantifier Hypothesis proposed by Drozd and Van Loosebrook, which suggests that the object must be the basis of a proportional reading. Our hypothesis and evidence show children have all three possible forms: cardinal (weak), proportional (strong) and switched (strong) readings. [6]

The cardinal reading requires no comparison. Where a comparison is required, we argue that children assume the presence of two sets that are connected. What is left open is which set is primary and which designates a subset:

Q(A,B) => fill in both

If the subject set is primary, then the object-set is a subset. If the object set is primary, then the subject involves a subset. This comparison requires a syntax whereby both subject and object are within the scope of the quantifier. A Focus operation, raising just the quantifier, proposed by Herburger (1997, 2001), achieves this by putting both subject and object in the c-command domain of the quantifier. The focus-raising analysis fits the facts of both intonational and gestural focus. While it might require a period of time before children determine intonational focus, or even gestural focus, it is possible that the children have a default or arbitrary focus, sensitive to contextual salience (of any kind?), which allows them to focus either the subject or the object. Put differently, we argue, in line with Herburger (1997, 2001) that the weak, cardinal reading of *many* differs from the strong, switched reading in terms of the underlying movement operations. Weak quantifiers move by means of Q-raising (as defined by Herburger, i.e. the quantifier moves without its argument), strong quantifiers move by means of QR (as defined by among others May (1985), i.e. the quantifier moves together with its argument to the beginning of the sentence). Our results show that children, unlike adults, allow Q-raising for a strong quantifier (i.e. in the case of *many of* and *all).*

6 Drozd and Van Loosbroek (1999) called their account the 'Weak Quantification Hypothesis'. We take this label only to refer to the fact that the switched reading (which Drozd and Van Loosbroek hypothesize to be the children's preferred interpretation) is only possible with weak quantifiers like *many* and *few*. However, it does not make clear that the switched reading is a reading for which you have to do more than just look at the intersection of the first and second argument set. In that sense, we call the switched reading a strong reading.

This indicates that children initially have an ambiguous quantifier system. They allow both Q-raising and Quantifier Raising for weak and strong quantifiers.

In sum, this paper shows that the child has to learn to distinguish between quantifiers that make a distinction between the two arguments they quantify and those quantifiers that do not. Only by doing so will the child be able to compare sets in an adult-like manner. In this process, the child has to learn that weak quantifiers are unary and move by means of Quantifier Raising while strong quantifiers move by means of Q-raising. The child that allows these two movement operations for both weak and strong quantifiers permits an ambiguity in her grammar that is incompatible with the adult grammar. We suggest that, in the end (in the course of development?), the incompatibility with the target grammar will lead the child to restructure her grammar to ensure that *many of* and *all* can move by means of QR only.

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Appendix

Items with all

All boys are reading books
All doctors are carrying bags

All parrots are wearing hats
All girls are holding balloons
All parrots have yellow wings
All dogs have red tails

Items with many
Many monkeys are eating bananas
Many girls are holding balloons
Many parrots have yellow wings
Many parrots are wearing hats
Many boys are reading books
Many men are lifting boxes

Items with many of
Many of the dogs have red tails
Many of the dolphins are holding bones
Many of the donkeys are carrying girls
Many of the businessmen are carrying donkeys
Many of the doctors are carrying bags
Many of the dogs have green noses

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