Acquiring quantification
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Summary, Discussion and Conclusions

7.1 Introduction

In the past four decades, children’s non-adult-like understanding of quantified sentences has been explained in syntactic, semantic or pragmatic terms (see chapter 2). Recently, it has been suggested that quantification is a matter of taking into account syntax, semantics and pragmatics simultaneously rather than applying purely syntactic, semantic or pragmatic constraints on meaning. Explanations until now did not take such an integrated approach. Given the interaction of syntax, semantics and pragmatics, I explored children’s non-adult-like interpretations of quantifying expressions in terms of a developing balance of all these constraints on the meaning of quantified sentences. The starting point for this new approach to the acquisition of quantification is my Equilibrium Hypothesis presented in chapter 3 that the acquisition of quantification is a matter of establishing a target-like equilibrium between syntax, semantics and pragmatics and each of their contributions to meaning (repeated below as (1)).

(1) Equilibrium Hypothesis:
The acquisition of quantification is a matter of establishing a target-like equilibrium between syntax, semantics and pragmatics and their contribution to meaning

The Equilibrium Hypothesis was tested in chapters 4, 5 and 6, providing the basis for an empirical investigation of the interplay between these constraints of various nature in child language.

The experiments discussed in previous chapters aimed on the one hand to gain more insight into children’s understanding of quantified expressions and, on the other hand, to present experimental data on the interaction between syntax, semantics and pragmatics. The starting point for this investigation is the distinction made in chapter 3 between syntactic constraints concerning the scope of quantificational determiners, semantic constraints concerning the relation between the quantifier’s argument sets and pragmatic constraints concerning the effect of discourse context...
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and visual context on the scope of the quantificational determiner and the relation between the quantifier’s first and second argument set. The experiments presented in chapter 4, 5 and 6 each differ in their focus on the hypothesized interaction between syntax, semantics and pragmatics.

In this final chapter, I discuss the main experimental results and their implications for children’s understanding of quantified expressions. I argue that children use different clues than adults to interpret quantifying expressions. Whereas adults only restrict the quantifier domain by means of discourse or visual context in cases in which the syntax does not provide sufficient information to do so, children always use the (visual) context to restrict a quantifier domain. I conclude that these results are compatible with the Equilibrium Hypothesis.

This chapter is structured as follows. In section 7.2, I summarize the main findings of this thesis and discuss the results for each grammatical interface (syntax-semantics, semantic-pragmatics and syntax-pragmatics). After discussing the main implications of these findings in section 7.3 for the discussion concerning children’s understanding of quantifying expressions, I end this chapter with a short summary of the main conclusions.

7.2 Main findings

Each of the three sets of experiments addressed a different interface between syntax, semantics and pragmatics. Whereas the experiments presented in chapter 4 focused on children’s understanding of the interaction between syntax and semantics, the experiments in chapter 5 addressed the interaction between syntax and pragmatics and chapter 6 focused on the interaction between semantics and pragmatics. In chapter 4 (experiment 1 - 3), I focused on the interaction between the syntactic structure of a quantifying expression and the semantic difference between strong and weak quantifiers, in chapter 5 (experiment 4) I focused on the interaction between the syntactic difference between weak and strong quantifiers and pragmatics (discourse) and in chapter 6 (experiment 5 and 6) I focused on the interaction between the pragmatic discourse and the semantic notion of domain restriction. I will now summarize the results of these three sets of experiments.

7.2.1 Allemaal and the syntax-semantics interface

Testing the hypothesis of Roeper et al. (2006) that children do not restrict the quantifier domain to the noun phrase c-commanding the quantificational determiner, chapter 4 set out to explore children’s understanding of the interaction between syntax and semantics. I tested children’s interpretation of the Dutch quantifier allemaal which can be used as a floating quantifier or prenominally. The syntax plays a crucial role to determine which reading is at issue. Therefore, the Dutch quantifier allemaal provided an excellent tool to test children’s understanding of
the interaction between syntax and semantics. The central research question was formulated as follows:

(2) How do children use syntax to determine the meaning of *allemaal*?

Truth-value judgment tasks examined whether or not children use the syntactic structure of the sentence to determine the quantifier’s scope (i.e. the subject versus the object being in the quantifier’s scope, cf. the difference between (3-a) and and (3-b) and (4-a) and (4-b), tested in experiment 1 and experiment 2 respectively) and the relation the quantifier establishes between its first and second argument set (whereas *allemaal* gets an exhaustive reading in (5-a), it only allows a weak, existential reading (in the sense of Milsark, 1979) in (5-b), see experiment 3).

(3) a. De jongens hebben allemaal de koffers vast
   The boys have *allemaal* the suitcases fixed
   ‘The boys are all holding the suitcases’

   b. De jongens hebben de koffers allemaal vast
   The boys have the suitcases *allemaal* fixed
   ‘The boys are holding all the suitcases’

(4) a. De meisjes rijden allemaal op een paard
   The girls ride *allemaal* on a horse
   ‘The girls are all riding a horse’

   b. Een man draagt de ezels allemaal
   A man carries the donkeys *allemaal*
   ‘A man is carrying all the donkeys’

(5) a. De ezels huilen allemaal
   The donkeys cry *allemaal*
   ‘The donkeys are all crying’

   b. Er huilen allemaal ezels
   There cry *allemaal* donkeys
   ‘There are many donkeys crying’

Children were asked to judge sentences like in (3) - (5) for situations as depicted in respectively figure 7.1, 7.2 and 7.3.

The experimental data confirm the hypothesis that children do not restrict the quantifier domain by means of the syntactic notion of c-command. Children do not differentiate between sentences with subject and object quantification and show guessing behavior when the visual context contains both an extra object and an extra object as in figure 7.2. Moreover, the children overwhelmingly choose for an exhaustive interpretation of *allemaal* in an existential *there*-sentence in the case of a situation as depicted in figure 7.3, in contrast to adults’ interpretations of such sentences.

In sum, the research question whether children rely entirely on syntax to determine the meaning of a quantifying expression can be answered negatively; children
use syntax neither to restrict the quantifier domain, nor to determine the relation the quantifier establishes between its arguments. This presents the first evidence for the Equilibrium hypothesis that children rank syntactic information differently than adults to constrain the meaning of quantifying expressions.
7.2. Main findings

7.2.2  Many and the syntax-pragmatics interface

In chapter 5, I showed that, in the case of *many*, domain restriction is a pragmatic matter instead of a syntactic or semantic one; the surrounding discourse context of a quantified sentence plays an important role in determining the meaning. The interpretation of *many* depends on this discourse context. This becomes especially clear in the case of *many* versus *many of*; whether one considers something as *many*, depends on the discourse context of this sentence. In some cases, it suffices to understand *many* in terms of a certain cardinality; if there are five parrots, wearing a hat, this might be judged as *many* (given that they never wear a hat). In other cases, *many* should be understood as the partitive ‘*many of*’ as in *Many students got an A* (meaning ‘*many* of the students in my class got a A’). The interaction between pragmatics and the syntactic structure of a sentence containing *many* determines the domain of these quantifiers. To what extent do children master this interaction between pragmatics and the syntactic structure of a quantified sentence?

(6)  Research question: How do children use pragmatics to restrict a context-dependent quantifier domain?

The interaction between syntax and pragmatics was examined by investigating English learners’ usage of discourse context (introduction of a certain set as discourse topic) and visual context (a pointing gesture to that set) for the interpretation of *many* versus *many of*. The syntactic difference between *many* and the partitive *many of* was used to control for children’s usage of syntactic information to restrict a quantifier domain. In addition to a truth value judgment, I asked children to explain why they judged sentences like (7) true or false. The pictures shown to the children allowed both a cardinal reading (7-a), a proportional reading (7-b) and the so-called Westerståhl reading (7-c). The pragmatic context needed to be used to determine which reading was intended; the attention was pointed toward the denotation of the quantifier’s first or its second argument. For adults, this resulted in respectively a proportional or cardinal interpretation and a Westerståhl reading. For *many of*, no such effects were found for adults with the quantifier’s first argument set as discourse topic, but an effect was found with the quantifier’s second argument set as the discourse topic (i.e. a Westerståhl reading).

(7)  Many parrots are wearing hats
   a.  ‘5 parrots are wearing hats’ (cardinal reading)
   b.  ‘many of the parrots are wearing hats’ (proportional reading)
   c.  ‘Many parrots that are relevant to wearing a hat are parrots’ (Westerståhl reading)

(8)  Many of the parrots are wearing hats
   a.  ‘5 parrots are wearing hats’ (cardinal reading)
   b.  ‘many of the parrots are wearing hats’ (proportional reading)
c. ‘Many parrots that are relevant to wearing a hat are parrots’ (Westerståhl reading)

![Figure 7.4: EXPERIMENT 4 - THE MANY EXPERIMENT; Many/Many of the parrots are wearing hats]

The results of experiment 4 show that children are capable of carrying out all three kinds of set comparisons, i.e. they give cardinal readings, proportional readings and Westerståhl readings. Children sometimes allowed cardinal reading when such a reading is not allowed (e.g. in the case of many of and when the quantified sentence was preceded by a discourse in which the quantifier’s second argument set was already mentioned). Children’s answers were not affected by quantifier type (many vs. many of) or pragmatic context (a discourse about the quantifier’s first or second argument set).

The findings of experiment 4 add a new perspective to the discussion of the exact nature of children’s understanding of quantified sentences. The results show that it is not a more restricted set of readings that children allow - on the contrary, the children had the same three kinds of readings as adults - but rather how pragmatics limits (in a different way than for adults) when to accept these readings. This explains the finding that children allow the same readings for many and many of.

### 7.2.3 The universal quantifier and the pragmatics-semantics interface

Traditionally (see chapter 2), syntax is taken to prescribe the quantifier’s first argument set. However, in the case of (9-a), in addition to the syntax, the discourse context of (9-b) is needed to restrict the quantifier domain of all in (9-a) to the fish Mary has at home (whereas the syntax only restricts the domain of all to the set of fish).
7.2. Main findings

(9) a. Mary went to the pet shop. She bought a bag with new fish. On her way home, she thinks it is not nice for the fish to be in the bag. She throws them in a canal, so now they are free and can swim. At home, Mary has a fish bowl with fish in it. An orange and a blue one. Mary considers letting them free. But it might be too cold for the fish in a canal. The fish are hungry, look, Mary feeds them. And now, Mary is going to play outside.

b. All fish are swimming in a canal

This raises the following research question, subject of the experiments presented in chapter 6:

(10) Research question: How do children integrate the discourse context into the interpretation of a quantifying expression?

The experiments presented in chapter 6 aimed to answer the question when and under which conditions children allow a ‘discourse-based interpretation’ of quantified sentences. I discussed how various accounts in the literature point at a different characteristics of discourse to explain children’s improved performance with quantifiers in a discourse. Subsequently, I rephrased the discussion in the literature in terms of the interaction between pragmatic and syntactic constraints. From this perspective, I investigated the effect of discourse context on quantifier domains in adult and child language. Children were tested on their restriction of the domain of all in the extra object situation preceded by a discourse and the series of pictures depicted in figure 7.5 and for sentences like (9) accompanied by the series of pictures in figure 7.6.

(11) a. Here you see a bag of fries that John made himself. He is going to give the fries to his friends the elephants. Here you see the elephants. They really like fries! Oops! A bag of fries slips out of John’s hands. John gives the fries to the elephants! And now, there is no food left.

b. All elephants are eating chips

Figure 7.5: EXPERIMENT 5 - THE FRY CONTEXT EXPERIMENT; Alle olifanten eten een patatje ‘All elephants are eating chips’

The results of these two experiments showed that children’s understanding of quantified sentences interacts with the introduction of two discourse topics in the context preceding the quantified sentence. When children are asked to judge an
extra-object situation as true or false (see figure 7.5 and the test-sentence) when this situation is preceded by the introduction of two discourse topics, this results in chance behavior; when both argument sets are made salient in the previous discourse, children randomly use one of the two sets introduced in the discourse as the quantifier domain (whereas the discourse does not affect adults’ interpretations). Crucially, the results of experiment 6 show that, when no extra object is depicted (i.e. the picture is visually faithful to the syntactic structure), children show adult-like behavior and integrate the discourse in a target-like way. I account for these results by using Beaver’s (2004) Centering Optimality Theory, integrating the possible effects of the visual context into this framework (see chapter 6). These results present further evidence that children’s non-adult-like interpretations of quantified sentences do not stem from an incomplete grammatical system (i.e. not having acquired certain linguistics or pragmatic rules), but rather from ranking the relevant constraints on the meaning of quantified sentences in a non-adult way. This explains the findings of experiment 5 and 6.

7.3 Discussion and implications

Each of the experiments presented in this thesis focused on a different interplay between syntax, semantics and pragmatics. Whereas adults use information from the discourse context if there is not sufficient syntactic information to determine the meaning of a quantified sentence, the results show that children between four and six years of age rank the relevant syntactic, semantic and pragmatic constraints in a different way. How can we define this developmental stage in more detail? In chapter 3, I identified Optimality Theoretic (OT) semantics (Hendriks and De Hoop, 2001) as an ideal framework to do.

In OT semantics, interpretation is considered to be an optimization process with respect to a certain syntactic input. The constraints against which all possible interpretations are evaluated can be syntactic, semantic or pragmatic in nature. This means that it is possible to model how lexical material, syntactic structure and context play a role in the optimization process from form to meaning. Note that such an approach takes a completely different view on compositionality; it crucially
allows interaction between constraints of various nature. This differs from the classical view on compositionality, i.e. the view that the meaning of an expression is a function of the meaning of its parts and of the syntactic rule by which they are combined. In chapter 3, I concluded that the complex nature of quantifiers can only be accounted for if a constraint-based approach is taken. Moreover, my study of the acquisition of quantification points into a similar direction to account for the various effects of (visual and discourse) context on children’s interpretations of quantified sentences (cf. chapter 2).

In sum, the results showed that adults rank these constraints differently than children. Whereas adults only use visual information when there are no other clues to restrict a quantifier domain or when this visual clue is very prominent, children between four and six always use this visual information to interpret a quantified sentence. This explains the results in chapter 4 that children’s understanding of quantified sentences interacts with the presence of an extra object or extra subject item in the picture and also the results in chapter 6 that a child’s interpretation interacts with the introduction of two discourse topics in the context preceding the quantified sentence. Moreover, these latter results show that children use the discourse context, and not syntax, to restrict a quantifier domain (and even start guessing when the discourse provides two possible quantifier domains). This leads to the following conclusions (‘»’ should be understood as ‘is preferred above’):

(12) Adult ranking:
    Syntax » Discourse Context » Visual Context

(13) Child ranking:
    Visual Context » Discourse Context » Syntax

The present thesis adds a new perspective to the current body of literature on the acquisition of quantification. In particular, whereas previous work always focused on one particular aspect of quantification (the syntactic structure of the quantified sentences, the discourse or visual context), this thesis aimed to take all these aspects into account simultaneously. In this respect, the main conclusions of this thesis are not opposite to those that were drawn earlier by various other people. Rather, this thesis tries to reconcile the various conclusions made in the literature and encourages to explore the Equilibrium Hypothesis in more detail.

7.4 Conclusions

The results presented in this thesis underline that more insight can be gained into the course of language development when multiple factors that are relevant to assigning meaning to linguistic structures are taken into account. For quantified sentences,  

1With respect to the effect of visual context on children’s interpretations of quantified sentences, Rahklin (2004) points into a similar direction and argues that children indeed use the visual context differently than adults do.
this means that both syntax, semantics and pragmatics have to be taken into account. Instead of focusing on either the syntactic, semantic or pragmatic constraints that are at play when one (adult or child) is asked to interpret a sentence, a more dynamic approach is needed that incorporates all factors that determine interpretation. In this thesis, I took such an approach by using the framework of (Centering) Optimality Theory, following recent work by Hendriks and De Hoop (2001) and Beaver (2004). Moreover, by taking the alternative view on compositionality of De Hoop et al. (2007) as a starting point, the present thesis explored an alternative approach to the acquisition of quantification. I showed that acquiring quantification is neither a case of ‘lacking’ certain grammatical rules nor a case of just the ‘wrong’ experimental setup that elicits a non-target-like answer. Instead, I presented experimental data showing that the acquisition of quantification is a matter of establishing a target-like equilibrium between syntax, semantics and pragmatics.