6
Quantifying in Context

6.1 Introduction

In this chapter, I discuss children’s understanding of quantified expressions in a discourse. Various studies have shown that children interpret quantifiers adult-like if the quantified sentence is appropriately embedded in a discourse (Freeman, Sinha, and Stedmon, 1982; Crain, Thornton, Boster, Conway, Lillo-Martin, and Woodams, 1996; Drozd and Van Loosbroek, 2006; Hollebrandse, 2004). Given children’s non-adult like interpretations of quantified sentences when these are not embedded in a discourse, the question arises why and under which discourse conditions children show adult-like behavior if such a discourse is provided. What are the characteristics of a discourse that enable a child to understand quantified expressions adult-like? In this chapter, I test children’s understanding of quantified expressions in two discourse manipulations.

Section two summarizes the acquisition literature on the acquisition of quantification and discourse. Section three is devoted to context-dependent domain restriction in adult language. Taking an optimization approach to interpretation and discourse coherence along the lines of (Centering) Optimality Theoretic Semantics (Hendriks and De Hoop (2001) and Beaver (2004)), I analyze context-dependent quantifier domain restriction in terms of the constraints ALIGN-Q and FORWARD DIRECTIONALITY. I rephrase the results from the acquisition literature on quantification using these two characteristics. I present two experiments in section five which both address the question how children use the discourse to determine the quantifier domain. Can we decipher to what extent children are able to determine the role that syntax and semantics allow pragmatics to play in different, well-controlled and manipulated discourse conditions? This chapter thus aims to contribute to a better understanding of the interaction between syntax, semantics and pragmatics and its role in first language acquisition. I conclude that establishing an equilibrium between pragmatics, semantics and syntax is the necessary step for the child toward an adult understanding of quantifiers. An approach along these lines to first language acquisition in general and to the acquisition of quantification in particular allows us
to formulate new, precise predictions for further research and reveals a new horizon in both child language acquisition research and theoretical syntax, semantics and pragmatics.

6.2 The acquisition of quantification in relation to discourse

Since the work of Inhelder and Piaget (1958), it is well-known that children between four and six years of age assign non-adult interpretations to universally quantified expressions (see chapter 2). When children are asked to judge a sentence like *Is every cowboy riding a horse*, some children will answer (one more often than the other) “no, not that one” in a situation in which three cowboys are each riding a horse and one fourth horse is not being ridden (the so-called extra-object situation). Conversely, if an extra-subject item is displayed (e.g. three horses are displayed and three cowboys are each riding a horse, leaving one cowboy doing nothing), some children answer *yes* to the question *Is every cowboy riding a horse?*. In the literature, both answers, which are not given simultaneously by the same child, are known as symmetrical responses (see Philip (1995) and chapter 2). Starting with the work of Freeman, Sinha, and Stedmon (1982), various people have pointed at the notion of discourse to explain these two kinds of responses.

Freeman et al. argue that children in previous research were confronted with test situations (i.e. the extra object pictures) in which they had to choose between a grammatical analysis or a pragmatic (discourse-based) analysis to determine whether the test item correctly described the displayed picture or not. Since the test items in the experiments were presented without any kind of discourse, the child might conclude that the speaker could not be talking about the actual topic of the sentence (i.e. cowboys for the sentence *Is every cowboys riding a horse?*), and so she inferred a discourse topic she assumed the speaker intended. In this sense, the child had the option to choose between a grammatical analysis and a pragmatic analysis. Freeman et al. argue that children go for the pragmatic analysis and understood test items as being about the violation of a one-to-one relation between horses and cowboys in the extra-object situation. The child guesses what the speakers means (instead of figuring out what the words mean). As Freeman et al. put it, the child tries to understand “the speaker’s purpose and intended frame of reference” (1982:54). Children resort to such a strategy because the actual topic of the sentence is not in line with the child’s assumption about the topic of the sentence. The child’s exhaustive pairing answer is thus explained as a context-driven interpretation; the child guesses a topic instead of relying on the topic of the sentence itself.

Subsequent work on the acquisition of quantification also points at the relation between the (lack of a) discourse context and children’s non-adult like interpretations of quantified sentences. Drozd and Van Loosbroek (2006) suggest that children “lack or do not invoke the pragmatic principles adults use to constrain the interpretation of universal quantifiers at the discourse level” (2006:135). This is reminiscent of Meroni, Gualmini, and Crain’s (2006:101) conclusions that “young children are
subject to the same discourse constraints as adults and older children; younger children are just less successful in making the necessary accommodations when discourse principles are flouted”. Hollebrandse (2004) also concluded that children use pragmatic information to restrict a quantifier domain. The question arises exactly what kind of pragmatic principles or discourse constraints affect children’s understanding of quantifiers. I will review these three theories (Crain et al., 1996; Drozd and Van Loosbroek, 2006; Hollebrandse, 2004)) to discuss in more detail the effect of discourse on children’s understanding of quantified sentences.

6.2.1 Satisfying the Condition of Plausible Dissent

Crain et al. (1996) show that children are able to interpret a quantified sentence adult-like if the test item is embedded in a discourse context that provides both a yes and a no-answer as a possible answer to the test item (cf. later work by the same authors, e.g. Meroni et al. (2006)). Compare the following discourse context for the quantified sentence *Every skier drank a cup of hot apple cider* (from Crain et al., 1996:126).

(1) **Characters and crucial props:**
Three skiers (a mom and her two girls)
Five bottles of soda and five cups of apple cider
A styrofoam mountain, with an arch to ski through

**Protocol:**
Exper.: In this story, this mom and her two girls go skiing. They’re going to ski down this mountain here and try to ski through this arch. Over here are the drinks at the ski lodge for when they’ve finished skiing. First, they all go on the ski lift to the top of the mountain. Then, this girl skis down the mountain.

Girl 1: This looks a bit scary. Here I go! Whee! Oops, here comes the arch . . . Yeah I made it! <first girl skis down the mountain, and safely through the arch>.

Girl 2: Now it’s my turn. Whee!Oops, I nearly fell. But I made it. Yeah! <second girl skis down the mountain and safely through the arch>.

Mom: OK girls, watch me. Whee! Oh wow, I didn’t realize this arch was so low, I’ll have to really bend down to make it through <mom skis down mountain, but barely makes it through the arch>, Oh girls, that gave me a real fight. I almost banged into the arch. Let’s go in now and get a drink <mom and girls go over to drinks set out on a table>. I’ll have a cup of this nice hot apple cider. This will help calm me down <mom takes a cup of cider>.

Girl 1: Oh, look at these sodas. I want this bottle of orange soda.
Girl 2: I want this bottle of cola.
Mom: Girls, don’t take a bottle of soda. You should have a cup of hot apple cider so you get nice and warm. You can have soda another time.

Girl 1: OK. I’ll take this cup, it’s full to the top.

Girl 2: I want a full cup too. Are any of these other cups of cider full?

Kermit: That was a hard story, but I think I know something that happened. Every skier drank a cup of hot apple cider.

Child: Yes.

or

No, not these cups of apple cider. (symmetrical interpretation).

In this discourse, the so-called Condition of Plausible Dissent is satisfied which states that “it is felicitous to ask whether a sentence S is false on a reading only if the discourse context is such that S has been under consideration on that reading” (Crain and Thornton, 1998:237). This is the case in (1): because the children considered drinking a soda instead of the apple cider, it is felicitous to ask whether Every skier drank a cup of hot apple cider. This would explain why 88% of the answers is in line with the target reading of Every skier drank a cup of hot apple cider. In this respect, Crain et al. differ from Freeman et al. since they do not attribute children’s adult-like interpretations to a spelled-out discourse topic in the discourse preceding the quantified statement.

These are two missing elements in their explanation. Crain et al. do not answer the question why children cannot derive a target-like semantic representation when the test item is not embedded in a proper discourse. Specifically, why do they resort to an exhaustive pairing answer when the Condition of Plausible Dissent is not satisfied? Adults do not need a discourse to restrict the quantifier domain and so the question arises how Crain et al. can explain how a child will become an adult language user (for similar and other criticism against Crain et al.’s explanation, see among others Drozd (2004a,b); Philip (2004); Geurts (2000, 2003).

6.2.2 Presupposed sets

Drozd and Van Loosbroek (2006) (cf. Drozd and Van Loosbroek, 1999; Drozd, 2001) argue for an alternative approach and claim there is a similarity between the child’s exhaustive answer and, what they call the adult non-conservative reading (2-a) of (2).¹,²

(2) Many French have won the Tour de France

¹The notion of conservativity states that one only has to inspect the quantifier’s first argument set and the intersection of the first and the second argument set to interpret a quantified sentence. As a result, only the part of the second argument set that intersect with the first argument set plays a role if one is asked to interpret a quantified sentence. However, since the entire second argument set of many in (2) needs to be considered for an interpretation in (2-a), conservativity seems to be violated here (but for an alternative explanation, see chapter 5 and references therein.)

²In chapter 5, I have labeled this the Westerståhl reading.
a. “Many Tour de France winners are French”

For reading (2-a) of (2), the hearer interprets the sentence in terms of the set of French Tour de France winners (and finds that their number exceeds some expected number). When children are faced with a sentence like *Every cowboy is riding a horse*, Drozd & Van Loosbroek argue, they apply just such a non-conservative reading, for which they compare the number of horse-riding cowboys against an expected number of horse-riding cowboys (i.e. a one-to-one relation between cowboys and horses).

Drozd and Van Loosbroek raise the hypothesis that children need the domain of quantification to be properly introduced in the preceding discourse. Referring to Szabolcsi (1997), they point at adults’ use of a so-called witness set. The witness set is the set in the real world to which the quantifier’s domain needs to be linked in order to determine the truth value of the quantified expression.³ Consider (3), describing a situation in which a man loves all the jaguars in his garage (and the jaguars in his garage is the witness set that the linguistic expression refers to).

(3) The man loves all the jaguars in his garage

Children interpret a quantified sentence adult-like when such a witness set is introduced (“presupposed” in Drozd and Van Loosbroek’s terms) and its members are properly identified in the previous discourse, which is the case in the Crain et al. (1996) paradigm, Drozd and Van Loosbroek argue:

“children’s performance improves on conditions like Crain et al.’s Skiers Condition because the set the children need to represent as the domain of quantification for the quantifier *every* is presented as presupposed before Kermit presents the test sentence for judgment. This makes it possible for children to establish the restriction and nuclear scope arguments for the quantifier as independent sets and to proceed with the presuppositional interpretation of the quantifier.” (Drozd and Van Loosbroek, 2006:119)

Drozd and Van Loosbroek (2006) set out to confirm this hypothesis by asking Dutch children, before asking the test item with a quantifier, to point out a set (the witness set) in a pictured context (the Show Me Condition, exemplified in (4)) or to answer a question irrelevant to the quantified sentence (the Irrelevant Property Condition, exemplified in (5) below). After the child answered this question, the child was asked to judge the test item.⁴

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³Formally, a witness set for a quantifier $D(A)$ living on $A$ is any subset $w$ of $A$ such that $w \in D(A)$ (Barwise and Cooper, 1981) and, as Barwise and Cooper point out, the mechanism behind this is “... not totally unlike some computational models for the verification of quantified sentences which have been suggested in the psychological literature...” (Barwise and Cooper, 1981:104).

⁴There was a third condition in Drozd & Van Loosbroek’s (2006) experiment, which was argued to satisfy the Condition of Plausible Dissent and in which children did not answer significantly different
The Show Me Condition

Experimenter:
Dit lijkt wel een woestijn. (‘This looks like a desert.’)
Allemaal zand en bergen. (‘All sand and mountains’)  
En dit zijn jongens? (‘And these are boys?’)  
Hier zie je? (olifanten) (‘Here you see?’ (elephants))

Cookie Monster:
Wijs de jongens eens aan. (‘Point to the boys.’)

Experimenter:
Rijden alle jongens op een olifant (“Are all boys riding an elephant”)

The Irrelevant Property Condition

Experimenter:
Dit lijkt wel een woestijn. (‘This looks like a desert.’)  
Allemaal zand en bergen. (‘All sand and mountains’)  
En dit zijn jongens? (‘And these are boys?’)  
Hier zie je? (olifanten) (‘Here you see?’ (elephants))

Cookie Monster:
Heeft iedere jongen schoenen? (‘Does every boy have shoes?’)

Experimenter:
Rijden alle jongens op een olifant (“Are all boys riding an elephant”)

Since the child’s attention is drawn to the intended domain of quantification in both conditions (the set of boys), Drozd and Van Loosbroek argue that “each condition provided contextual support for the presuppositional interpretation of the universal quantifier” (2006:127). Their results show that this is indeed the case; children’s interpretation of quantified sentences improves in both conditions, which Drozd and Van Loosbroek argue to be due to the introduction of the set in the discourse before the quantified question was asked. On the basis of children’s improved behavior on (4) and (5) in contrast with a classical extra-object task with no discourse, Drozd and Van Loosbroek then suggest that children do not update their discourse model in contexts which are incompatible with the “presuppositional requirements” (2006:138) of a universal quantifier. Providing a context which is compatible with the “presuppositional requirements” (like in (4) and (5) above, they argue), would result in adult-like interpretations.

The question arises whether children are able to use such pragmatic information to restrict the quantifier domain also in other discourse manipulations. A clue that children are indeed able to comes from the work by Hollebrandse (2004).

than in the other conditions. However, Crain, Meroni, and Gualmini (2000) (commenting on an earlier presentation of Drozd and Van Loosbroek’s (2006) results) argues that this third condition in Drozd & Van Loosbroek (2006) does not satisfy the Condition of Plausible Dissent at all. For this reason, Crain et al. rejects Drozd & Van Loosbroek’s conclusion that satisfying the Condition of Plausible Dissent does not result in significantly different improved performance.
6.2.3 Providing a discourse topic

Hollebrandse (2004) shows that topicality plays a role in children’s interpretations of quantified sentences. Hollebrandse compared the behavior of Dutch children who consistently gave exhaustive pairing answers in a classical paradigm, i.e. without a discourse, to their behavior in conditions with a discourse. In the discourse preceding the quantified sentence, either the subject or the object was the discourse topic. An example of a translated test item can be found in (6) in which the set of knights is the topic.

(6) And after a while the Indians run into two knights, who are kings. The Indians give the chickens to the knights <photograph: Indians give chicken to the knights>. The knights invite the Indians for dinner at their new home. The knights have just moved <photograph: two knights, one is lifting two chairs>

Puppet interrupts: Wow, look there! A knight is lifting all chairs

In this situation, the set of knights is the topic and the quantifier domain is restricted to the set of chairs. The results show that children who initially gave a symmetrical answer, interpret a sentence containing a quantified subject adult-like if the subject was the discourse topic (cf. Philip and Lynch (2000) for similar results). Conversely, if the subject was not topicalized or the object was quantified over, significantly fewer adult-like answers were found. Hollebrandse concludes that children use pragmatic information to restrict a quantifier domain: “These spreaders behaved more adult-like (less spreading) in the cases in which pragmatic information (topichood) was added” (2004:213).5

Hollebrandse (2004) does not discuss why children now suddenly choose a discourse-based interpretation of the quantified sentence. Why would it be easier to interpret a quantified subject topic than an object topic? Is it the status as discourse topic that helps the child to quantify over a particular set, and if so how exactly, or is it because of some other effect?

6.2.4 Putting discourse into context

In sum, various people explained the child’s exhaustive-pairing answer in terms of a lack of a proper discourse context. ‘Discourse context’ can either be understood as an ‘intended frame of reference’ (Freeman et al., 1982) or satisfaction of certain pragmatic felicity conditions (Crain et al., 1996). Drozd and Van Loosbroek (2006) argue that children give an adult-like interpretation of a quantifier when the domain of the quantifier is presupposed in the preceding discourse. Hollebrandse (2004) argues that it is a discourse topic that enables the child to interpret a quantified sentence adult-like when a discourse is provided.

5Hollebrandse follows Roeper and De Villiers (1991) and calls children who give an exhaustive pairing answer spreaders.
The controversy about the correct explanation of children’s improved performance in a discourse, is a first reason to take up the question what the actual characteristics of a discourse are that turn the child into an adult language user. Is it satisfying the Condition of Plausible Dissent, help with presupposing the quantifier domain or providing a discourse topic that leads the child to an adult interpretation of a quantified sentence?

A second reason to look in more detail at children’s understanding of quantified sentences in a discourse is that all accounts discussed above fail to address the question why children differ from adults in the classical condition and apparently cannot interpret a quantified expression adult-like without a discourse. Why and under which conditions do children differ from adults?

A third reason to take up this matter is formulated by Meroni et al. (2006), who argue that the current debate in the acquisition of quantification is in fact a debate about the learnability of linguistic principles. The view that linguistic principles need to be acquired implies, according to Meroni et al., that children’s grammars have to change over time. In the case of the acquisition of quantification, children have to acquire how to obey compositionality and apply universal properties of determiner meanings like conservativity. Meroni et al. point out that Drozd and Van Loosbroek’s approach implies that children’s grammar violates conservativity. Children have to unlearn this non-conservative reading for every. This leads to a serious learnability problem, they argue, since it implies that the child’s grammar has to change enormously in order to reach an adult state. But how can that be, they point out, if children, next to the symmetrical answer, also give adult-like answers at least in certain conditions? For this reason, Meroni et al. argue that Drozd and Van Loosbroek’s analysis should be rejected (and for the same reason, Crain et al. reject the work of Philip and Lynch (2000) and Geurts (2003) which they take raises similar learnability problems) and conclude that children have adult knowledge of quantified expressions.

On the one hand, children are argued to apply non-adult like interpretations to quantifiers. On the other hand, children are argued to have adult-like readings of quantified expressions but the experiments testing this knowledge blurs this picture; the test situation is infelicitous and confuses the children. A key argument for Crain and colleagues is that other, linguistic accounts all pose a learnability problem and so they to maintain the latter view and argue for a non-linguistic account. However, Meroni et al.’s account also raises a learnability question: given that adults do not need a discourse to interpret quantified sentences, how do children learn to interpret a quantified expression adult-like without a discourse? A solution to the learnability problem is to take an alternative view on quantification and discourse along the lines of Hendriks and De Hoop (2001) and Beaver (2004).
6.3 Context dependent domain restriction

In this section, I present an optimization approach to interpretation along the lines of Hendriks and De Hoop (2001) and Beaver (2004). I will argue that this enables us to avoid both the “pitfalls” of a linguistic account and a non-linguistic account. Hendriks and De Hoop’s Optimality Theoretic semantics is specifically developed to account for the role of context on e.g. quantifier domains. Moreover, it takes a totally different perspective on compositionality and constraints on determiner meanings. My explanation of children’s understanding of quantified sentences in terms of Optimality Theoretic semantics circumvents all problems Meroni et al. argue a linguistic account runs into by taking a new perspective on the learnability issue and, even more importantly, enables us to formulate a new hypothesis reconciling earlier psychological, syntactic and pragmatics work on children’s understanding of quantified sentences. Beaver’s (2004) reformulation of Centering Theory (Grosz, Joshi, and Weinstein, 1983, 1995) in OT enables us to narrow down the constraint DOAP introduced in chapter 3 and to formulate precise predictions how discourse coherence and topicality interact with quantifier domain restriction in child language.

I will now discuss how (context dependent) domain restriction works in Optimality Theoretic semantics and how quantifier domain restriction is related to discourse coherence and topicality in adult language.

In adult language, the context can restrict a quantifier domain. Compare the following example (a modified example from Recanati (1986)):

(7) Back from my holidays, I found that my house had been broken into. And yes, the burglar took everything.

Without any further kind of information, one will take the burglar took everything in (7) to mean that the burglar took all objects from the house he broke into (and world-knowledge might even lead you to conclude that the burglar took everything of value or everything he could reasonably take, e.g. everything that he could carry). The discourse context leads you to this interpretation and rules out a reading according to which the burglar took all objects in the world. By taking a new perspective on interpretation, Hendriks and De Hoop (2001) account for the role of discourse context in interpretation by using Optimality Theory semantics (for an introduction to OT semantics, see chapter 3.)

6.3.1 Optimality Theoretic Semantics; Hendriks and De Hoop, 2001

Hendriks and De Hoop formalize the effect of context and syntax on the possible meanings of a quantified expression with the following two soft constraints (from Hendriks and De Hoop, 2001:22,15; cf. chapter 3): Syntactic Structure and Don’t Overlook Anaphoric Possibilities.
(8) **Syntactic Structure**
If there is an N’ that constitutes an NP together with a determiner, use this N’ to restrict the domain of quantification of that determiner.

(9) **Don’t Overlook Anaphoric Possibilities (DOAP)** (Williams, 1997)
Make sure that anaphoric elements are related to the previous discourse.

The constraint Syntactic Structure makes sure that each quantifier domain is restricted to the N’ the quantifier accompanies. This constraint is argued to be never violated. This approach to quantifier domain restriction is not different from either the functional or relation perspective on quantified sentences (see chapter 2). To illustrate the role of DOAP, consider (10).

(10) Some like to fly, others do not.

In (10), the determiner is not followed by an N’. To interpret this sentence in which the domain of quantification is not spelled out by the speaker, one has to fill it in oneself by means of the discourse context. The hearer has to select a set available in the (discourse) context which appears to be the most relevant one. For (10), this might be e.g. a set of particular birds. Starting out from the assumption that e.g. pronominally used determiners as in (10) establish an anaphoric relation with an antecedent in the preceding discourse, the constraint DOAP makes sure this set is actually selected in the preceding discourse.

Now consider example (11) (cited in Hendriks and De Hoop, 2001:6).

(11) The buildings are all two and three stories running half a block deep with brick and glass fronts. Most were built together, a few have narrow alleys between them. Many are still boarded up, a couple were burned out years ago.

In (11), we take the discourse topic to be buildings. The constraint **Topicality** in (12) states that the antecedent is the topic of an anaphoric expression, if no other constraints apply. ‘Topic’ should be understood, as Hendriks & De Hoop point out, in terms of e.g. Vallduvi (1990).

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6 But cf. for an alternative account e.g. Herburger (1997, 2000).

7 Note that such an approach on context dependent quantifier domain restriction differs from the one taken by Westerståhl (1985) and Von Fintel (1994). Crucially, these accounts differ from Hendriks & De Hoop (2001) in assuming that each quantificational determiner is accompanied by a covert context variable. Although Hendriks and De Hoop point in a similar way at the anaphoric relation between the quantifier’s arguments and certain sets in the discourse, they do not assume that this anaphoric relation is a lexical characteristic of quantificational determiners. Hendriks and De Hoop rather assume that it is a general pragmatic preference to interpret anaphora as related to the previous discourse.

8 Topics (grounds in Vallduvi, 1990) are also known as backgrounds or presuppositions, as Vallduvi points out (cf. Vallduvi and Engdahl (1996) and references therein). Vallduvi identifies topicalisation as one of the clues that enables the hearer to understand the speaker’s sentence as optimal as possible. As such, topicalisation is a pragmatic factor that affects the sentential form. Moreover, Vallduvi argues that topicalisation is a particular form of information packaging (or information structure). The idea behind
6.3. Context dependent domain restriction

(12)  
**Topicality**
As the antecedent of an anaphoric expression, choose a topic.

However, it is not always the topic that restricts the quantifier domain. Consider example (13).

(13)  Ten students attended the meeting. Three spoke.

In (13), the domain of the second quantifier, *three*, is not restricted to just the topic of the first sentence (*students*), but to the set of students who attended the meeting. This is, as Hendriks & De Hoop point out, in line with the notion of conservativity. Conservativity states that, for the interpretation of a quantified sentence, one only has to inspect the denotation of the first argument set and the denotation of the intersection of the first and the second argument set. It is the intersection of the first and second argument set that is the first argument of the quantifier *three* in (13). This is captured by the constraint **Forward Directionality** (Kuppevelt, 1996).

(14)  
**Forward Directionality**: The topic range induced by the domain of quantification of a determiner (set A) is reduced to the topic range induced by the intersection of the two argument sets of this determiner (A ∩ B).

DOAP is satisfied whenever **Forward Directionality** or **Topicality** is obeyed.

In sum, Hendriks’s & De Hoop optimization approach to interpretation states that a quantifier domain is restricted by the syntactic structure of the quantified expression and by the discourse context. They account for this by assuming that soft, i.e. violable constraints on the possible meanings of a quantified sentence (i.e. **Topicality** and **Forward Directionality**) interact with the constraint **Syntactic Structure**. The advantage of Hendriks’s & De Hoop’s optimization approach is that they incorporate syntactic, semantic and discourse constraints in one model, thereby modeling the interaction between these different modules.

While Hendriks and De Hoop (2001) explain how topichood plays a role in quantifier domain restriction, they do not incorporate how sets introduced in the discourse context are marked as topic/non-topic and function with respect to restricting the quantifier domain. Beaver’s (2004) reformulation of Centering Theory (Grosz et al., 1983, 1995) in Optimality Theoretic semantics (COT) allows us to do so and to refine DOAP in even more detail.

Information packaging is that a speaker structures information in a precise and well-defined way and by doing so, offers the hearer all kind of clues how to integrate this information to understand the speaker’s message as optimal as possible. Topicalisation is one of such clues.

But see for example Herburger (1997, 2000) who argues that focus can overrule the syntactic structure of a sentence.
6.3.2 Centering Optimality Theory; Beaver, 2004

Beaver (2004) reformulates the Centering theoretic model of anaphora resolution and discourse coherence (Grosz et al., 1983, 1995) in Optimality Theory. In a Centering Theory (CT) analysis all the referents referred to in a sentence are ordered in a so-called “forward-looking center list” according to their argument role or grammatical obliqueness, with subjects being less oblique than direct objects, direct objects less oblique than indirect objects, etcetera. The least oblique element (the entity ranked highest in the forward-looking center list, i.e. the subject) is termed the “preferred center” (Cp). Further, the discourse entity referred to in the current sentence that was also the least oblique or the most prominent discourse entity under discussion in the previous sentence (i.e. the entity ranked highest on the previous sentence’s forward-looking center list) is identified as the topic of the current sentence, or “backward looking center” (Cb). A continuing discourse is a discourse in which the backward-looking center is unchanged and is also the preferred center of the new sentence. Consider example (15):

(15) a. Jane\textsubscript{i} likes Mary\textsubscript{j}
b. She\textsubscript{k} often gives her\textsubscript{l} flowers

In (15-a), the forward-looking center list contains Jane and Mary with Jane being the preferred center (Cp). According to the definition of ‘topic’ or ‘backward looking center’ as the entity most prominent under discussion in both the current and the previous sentence, Jane in (15-b) is identified as the topic or backward looking center (Cb). Additionally, Rule-I in CT says that “If there are pronouns in the current sentence, then one of them refers to the backward looking center of the current sentence” (cited in Beaver, 2004:8). This means that she in (15-b) can only refer to Jane. Since continuations from (15-a) to (15-b) (the backward-looking center is unchanged and is also the preferred center of the new sentence) are preferred over retentions (the backward-looking center is unchanged but is no longer in preferred position), she should be identified with Jane and her with Mary in (15-b). Note that the backward-looking center of (15-a) is empty; there is no previous sentence and, as a result, no backward-looking center can be mapped onto the entity in the current sentence which is also the most significant entity under discussion in the previous sentence.

Centering Theory provides an elegant way of accounting for discourse coherence. However, as Beaver (2004) points out, despite the fact that Centering Theory has been central in natural language processing and psycholinguistic studies, far less attention has been attributed to the framework in formal semantics and pragmatics which “have tended to concentrate on absolute semantic constraints on what can be anaphoric to what, rather than to build up detailed pictures of which discourse entities are salient, and hence likely to be referred to, at which times.” (Beaver, 2004:3). Beaver (2004) tries to bridge the gap between these different disciplines by
reformulating CT in Optimality Theory.¹⁰

First, Beaver replaces the term *backward-looking center* with *topic* to link the notion to a large body of linguistic research on the very same matter. I will adopt Beaver’s terminological change and define *topic* as in (16) (from Beaver, 2004:14).

(16) The *topic* of a sentence is the entity referred to in both the current and the previous sentence, such that the relevant referring expression in the previous sentence was minimally oblique. If there is no such entity, the topic is undefined.

Second, Beaver introduces six violable, soft constraints. Two of them are relevant for our current purposes (since his other constraints are only relevant for resolving pronouns): COHERE (motivated, as Beaver points out, by among others Givón, 1983) and ALIGN. These constraints are defined as follows (from Beaver, 2004:15):

(17) COHERE: The topic of the current sentence is the topic of the previous one.
ALIGN: The topic is in subject position.

When we apply these constraints to the sentences (15-a) and (15-b), we can construct an OT tableau. Note that for (15-a), the topic is by definition undefined since there is no preceding sentence (in a similar way as there was no backward-looking center in CT for discourse-initial sentences). This means that, next to COHERE, ALIGN is also not relevant (indicated by the gray cells in (18)). This means that (15-a) is interpreted by means of other constraints, e.g. stating that for a transitive verb, the subject is the actor and the object is the patients (represented by the constraint Subject in (18)). This results in the reading according to which Jane likes Mary (indicated by the little hand in the tableau in (18)) and not the other way around.

(18) Example (15-a)

<table>
<thead>
<tr>
<th>Subject</th>
<th>COHERE</th>
<th>ALIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Like(j,m)</td>
<td>![GrayCell]</td>
<td>!</td>
</tr>
<tr>
<td>Like(m,j)</td>
<td>![GrayCell]</td>
<td>![GrayCell]</td>
</tr>
</tbody>
</table>

When we now consider (15-b), notice that COHERE and ALIGN make a difference between two possible interpretations (‘Jane often gives Mary flowers’ and ‘Mary often gives Jane flowers’). First, COHERE is violated in both cases since the topic of the first sentence is undefined. Second, the interpretation that Mary gives flowers to Jane is ruled out since this interpretation violates ALIGN. The topic of (15-b) must be the subject of (15-a) since that is the entity referred to in both sentences and moreover occupies the minimally oblique position in (15-a). Since ALIGN states that the topic should be a subject, *she* needs to be identified with *Jane*. This means that,

---

¹⁰It is not my purpose to motivate Centering Optimality Theory here. I refer to Beaver (2004) for more motivation for a reformulation of Centering Theory in Optimality Theory.
for the reading in which Mary gives flowers to Jane, ALIGN is violated. Since this is not the case for the reading in which Jane gives flowers, this interpretation turns out to be the most optimal interpretation of *She often gives her flowers*.

\[
\begin{array}{|c|c|c|}
\hline
\text{Example (15-b)} & \text{COHERE} & \text{ALIGN} \\
\hline
k = i, l = j & * & * \\
\hline
k = j, l = i & * & *!
\end{array}
\]

I will now use Beaver’s Centering Optimality Theory to account for the effect of discourse on quantifier domain restriction. However, only using Beaver’s constraints to model (context dependent) domain restriction is not sufficient. It is not always the case that the discourse topic needs to be related to the sentence’s subject. As example (11) illustrated, repeated here as (20), in the case of a quantified sentence in a discourse, the topic (buildings in this case) relates to the quantifier’s first argument set rather than to the sentence’s subject. This results e.g. in the interpretation of *most* as *most of the buildings*.

\[(20)\quad \text{The buildings are all two and three stories running half a block deep with brick and glass fronts. Most were built together, a few have narrow alleys between them. Many are still boarded up, a couple were burned out years ago.}\]

Partee (1991) also pointed in a similar way at the relation between the (discourse) topic and the quantifier’s first argument set. Moreover, as she points out, topic-hood might affect the quantified structure, but not to the extent that the syntax is overruled (Partee, 1991). This is in line with Hendriks and De Hoop’s (2001) approach discussed above that next to Syntactic Structure (paraphrased as ‘use the N’ to restrict the quantifier domain’) other factors play a role in domain restriction (see the previous section). If we now combine these approaches and take ALIGN-Q to be a more fine-grained version of Beaver’s ALIGN stating that one has to use the topic to determine the quantifier’s first argument set, the following constraints are relevant to our current endeavor to account for the effect of discourse on quantifier domain restriction (in rank order, with the top constraint the highest ranked):

\[
\begin{align*}
\text{(21) Syntactic Structure: Use the N’ bar to restrict a quantifier’s domain} \\
\text{COHERE: The topic of the current sentence is the topic of the previous one} \\
\text{ALIGN-Q: Use the topic to restrict a quantifier’s domain} \\
\text{Forward Directionality: The topic range induced by the domain of quantification of a determiner (set A) is reduced to the topic range induced by the intersection of the two argument sets of this determiner (A \cap B).}
\end{align*}
\]
6.3. Context dependent domain restriction

By means of these constraints, we can explain why the set of cows is understood as the restriction of *many* in (22-c) (Forward Directionality is not relevant here for this case and is left out from the tableau).

(22) a. In The Netherlands, there are cows\textsubscript{h} everywhere.
   b. Cows\textsubscript{i} are great animals\textsubscript{j}.
   c. Many\textsubscript{k} are black and white, and some\textsubscript{l} are brown.
   d. But I love them all.

In (22-c), COHERE is satisfied since the entity of cows is referred to in both the current and the previous sentence and moreover occupies the first position on the forward-looking center list in (22-b) (i.e. *cows* are the subject). ALIGN-Q is only violated if something else than *cows* is the domain of quantification. As a result, the most optimal candidate is the one that does not violate either COHERE or ALIGN-Q. This leads one to interpret the speaker of (22-c) as being talking about *many cows* instead of *many animals*. This is represented in the tableau in (23).

(23)

<table>
<thead>
<tr>
<th>Example (22-c)</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>( k = i )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( k = j )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Syntactic Structure only applies if there is an N'. If not, Align-Q takes over and supplies a set (i.e. the discourse topic) to restrict the domain of the quantifier. Take for example sentence (24) with the discourse topic *pigeons* and (25) with the discourse topic *parrots*.

(24) a. There are pigeons everywhere in Amsterdam.
   b. Pigeons are great.
   c. Many are gray.

   b. Parrots are great.
   c. Many pigeons are gray.

Syntactic Structure does not apply in (24) since there is no N' and Align-Q supplies the quantifier domain (i.e. the set of pigeons). In (25) Syntactic Structure applies (since there is an overt quantifier argument) and provides the set of pigeons as the domain of *many*. Due to the ranking of Syntactic Structure and Align-Q, this is also the most optimal interpretation, despite of the fact that this violates Align-Q and Cohere because of the discourse topic of the set of parrots. This is illustrated in (26) and (27).
Turning to quantified sentences with an overt argument like (28), SYNTACTIC STRUCTURE ensures that, for adults, an exhaustive pairing answer is impossible. If such an answer is possible in the target-language, this would mean that something else than the N’ is used to restrict the quantifier domain and that such a constraint overrules Syntactic Structure or, to put it differently, is ranked higher than Syntactic Structure. This is clearly not the case in the adult language; if there is an overt argument, one has to use the N’ to restrict the domain. (Cohere and Align-Q are violated since the topic is undefined.)

(28) Every cowboy is riding a horse

<table>
<thead>
<tr>
<th>(29) Example (29)</th>
<th>SYNT. STR.</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Every(A,B)</code></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><code>Every(A,B) ∧ Every(B,A)</code></td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
So discourse does not make a difference for adults in the interpretation of (28); a reading for which something else than the N’ is used to restrict the quantifier domain is ruled out by Syntactic Structure. This is illustrated in (30) in which the quantified sentence is embedded in a discourse, but the exhaustive pairing answer is still not possible (as shown in (31)).

(30)

a. Horses are great. Wow, a lot of horses are out there!
b. Every cowboy is riding a horse.

(31)

<table>
<thead>
<tr>
<th></th>
<th>SYNT. STR.</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every(A,B)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every(A,B) &amp; Every(B,A)</td>
<td></td>
<td></td>
<td>!</td>
</tr>
</tbody>
</table>

Recall that there is also the constraint Forward Directionality (FD). This constraint, ranked below ALIGN-Q, makes sure that the quantifier’s first argument set intersects with the discourse topic (cf. the definition of FD in (21)). This results in the reading of (32-b) that three of the students who attended the seminar passed the exam. Cohere is violated because the topic of (32-a) is undefined (since there is no previous sentence, see (16)), ALIGN-Q and SYNTACTIC STRUCTURE are both satisfied since respectively the topic students is the domain of the quantifier three for both interpretations and the N’ is used to restrict the domain.

(32)

a. Ten students attended the seminar
b. Three students passed the exam

(33)

<table>
<thead>
<tr>
<th></th>
<th>SYNT. STR.</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
<th>FD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>three students who attended the seminar</td>
<td></td>
<td></td>
<td>!</td>
<td></td>
</tr>
<tr>
<td>three arbitrary students</td>
<td></td>
<td></td>
<td>!</td>
<td>!</td>
</tr>
</tbody>
</table>

In sum, combining the work of Hendriks and De Hoop (2001) and Beaver (2004), the effect of discourse on quantifier domain restriction can be accounted for by taking an optimization approach to interpretation, i.e. all possible interpretations of a sentence need to be evaluated against the constraint SYNTACTIC STRUCTURE on the one hand and the constraints that I take all to be related to DOAP on the other hand (COHERE, ALIGN-Q and FORWARD DIRECTIONALITY). In the next section, I will use the constraints to account for children’s non-adult interpretations of quantified sentences and formulate the predictions about the role of context in children’s interpretations that follow from this.
6.4 Optimal acquisition; hypotheses and predictions

As outlined in section 6.2, different approaches point at the importance to take into account the notion of discourse to account for children’s understanding of quantified sentences. This is the starting point for the two experiments that will be discussed in the next section. The null-hypothesis is that acquisition is a matter of re(ranking) constraints (Smolensky, to appear) and, more particular, that acquiring quantification is a matter of reranking the syntactic, semantic and pragmatic constraints identified in the previous section. I hypothesize that, in line with the Equilibrium Hypothesis and the literature discussed in chapter 3 and the conclusions drawn in chapter 4 and 5 that, for children between four and six years of age, the constraint Syntactic Structure is ranked lower than Align-Q and Forward Directionality.

Recall from chapter 4 that the child’s non-target-like interpretation of (34) can be illustrated as in (35) (in which the child’s non-target-like interpretation is represented as \( \text{Every}(A,B) \land \text{Every}(B,A) \)). Cohere and Align-Q are violated since there is no discourse topic. For the same reason, Forward Directionality is violated. Since these constraints do not make a distinction between the first or second interpretation, they are left out from the tableau in (35).

(34) Every cowboy is riding a horse

\[
\begin{array}{|c|c|c|}
\hline
 & \text{FAITH-VIS} & \text{SYNT. STR.} \\
\hline
\text{Every}(A,B) & \ast & \ast \\
\text{Every}(A,B) \land \text{Every}(B,A) & \ast & \ast \\
\hline
\end{array}
\]

Crucially, the ranking of the constraints in (35) differs from the adult ranking. Whereas adults rank Syntactic Structure above Cohere, children are hypothesized to rank Syntactic Structure below Cohere and even below Faith-Vis, the constraint introduced in chapter 3 that makes sure visually prominent items are incorporated into the interpretation of a quantified sentence.

(36) FAITH-VIS:
Make sure that anaphoric elements are related to the theme of a picture (i.e. visually prominent items)

In (36), ‘visually prominent’ has to be understood as, for example, exceptions to a rule/generalization which stand out more than non-exceptions (see chapter 3). In the case of the classical extra object picture with one horse without a cowboy

\[\text{Every}(A,B) \land \text{Every}(B,A)\]

\[\text{Every}(A,B) \land \text{Every}(B,A)\]

11 Different views can be found in the literature what triggers such a reranking of constraints. This question, however, lies outside the scope of this thesis.
sitting on it, this horse clearly stands out as an exception and therefore is a visually prominent item. It explains the findings of Meroni et al. (2001) that adults’ eye fixation patterns reveal that adults also look at the horse without a cowboy on top of it in an extra-object figure; adults check whether there is a visually prominent item, possibly to check whether Faith-Vis is violated or not.

Turning back to the role of discourse in the interpretation of quantifiers, we can now formulate precise prediction regarding children’s understanding of the identified discourse constraints. When the child is asked to interpret a quantified sentence preceded by a discourse as in (37), the current (C)OT framework and the proposed child ranking predicts that children will interpret the sentence like adults. Forward Directionality applies and is satisfied for both the target and non-target-like interpretation; the quantifier domain *cowboys* is restricted to the set of cowboys that are identified in (37-a). COHERE and ALIGN-Q also apply. The latter is violated by the non-target-like interpretation because the quantifier domain for this interpretation (*cowboys and horses*) is not in line with the topic *cowboys* in the preceding discourse. Syntactic Structure is violated by the second interpretation because its domain contains more than the N’. The adult interpretation (*Every(A,B)* in the tableau in (38)) thus turns out to be the optimal one despite its violation of FAITH-Vis. This is in line with the results of Hollebrandse (2004) (and Drozd and Van Loosbroek, 2006).

\[
(37) \quad \text{a. Cowboys are great. Wow, a lot of cowboys are out there!} \\
\text{b. Every cowboy is riding a horse.}
\]

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Example (37)} & \text{COHERE} & \text{ALIGN-Q} & \text{FD} & \text{FAITH-Vis} & \text{SYNT. STR.} \\
\hline
\text{Every}(A,B) & \checkmark & & & & \\
\text{Every}(A,B) \land \text{Every}(B,A) & & & \checkmark & & \\
\hline
\end{array}
\]

In contrast, when the discourse is about the set denoted by the object, e.g. horses, the child is predicted to give an exhaustive pairing answer; the first interpretation in (40) violates ALIGN-Q, while the other violations remain the same. Because this constraint is higher ranked than SYNTATIC STRUCTURE, the second reading becomes the optimal one. The experimental data of Hollebrandse (2004) confirm that, for (39), children indeed give more exhaustive pairing answers than for (37).\footnote{Note that also Krämer (2000) predicts that children’s interpretation of quantified sentences improves if discourse clues are provided.}

\[
(39) \quad \text{a. Horses are great. Wow, a lot of horses are out there!} \\
\text{b. Every cowboy is riding a horse}
\]
In sum, children’s understanding of quantified sentences and the helpful or confusing role of context can be explained in terms of (C)OT semantics. Moreover, with the framework and the proposed child ranking discussed in the previous section, we can account for children’s improved performance in a discourse and answer the question why they differ from adults. The hypothesized child ranking in (41) is the subject of the experiments discussed in the next section.

(41) HYPOTHESIZED CHILD RANKING:
    Cohere » Align-Q » Forward Directionality » Faith-Vis » Syntactic Structure

6.5 Experiments

Two experiments test children’s use of discourse to restrict the quantifier domain. Both experiments aim to answer the question whether children’s interpretations are affected by discourse prominent items versus visually prominent items (as in the classic paradigm). To put it differently, these experiments explore the possibility to rephrase children’s non-adult understanding of quantified sentences in terms of ranking the pragmatic constraints Align-Q and Forward Directionality higher than Syntactic Structure. Do children differ from adults in their understanding of quantified sentences due to a non-adult ranking of these constraints?

6.5.1 Experiment 1: Align-Q and the Discourse Context

Experiment 1 addresses the hypothesis in (42).

(42) Hypothesis:
    Children rank Align-Q higher than Syntactic Structure

The underlying assumption of (42) is that children use the constraint Align-Q to restrict the quantifier domain (cf. Hollebrandse, 2004). Starting out from Hollebrandse’s (2004) (cf. Philip and Lynch, 2000) findings that children prefer to use topichood to restrict the quantifier domain instead of the syntactic structure, the research question is what happens if both the quantifier’s first and second argument set are topicalized in the discourse preceding the quantified sentence. With such an ambiguous context (which Hollebrandse and Philip crucially did not have in their experiments), children can interpret either the subject or the object as the discourse topic. In the first case target-like behavior is predicted, in the latter non-target-like
behavior. This is exemplified for (43) in tableau (44-a) when the subject is selected as the discourse topic (DT in (43)) and in (44-b) when the object is selected as the discourse topic (DT in (43)). With a picture accompanying (43) displaying an extra object, the constraint Faith-Vis is violated by the first interpretation since the picture displays an exception to a rule (i.e., one fry is not being eaten is not being eaten). Syntactic Structure is violated for the second interpretation since the non-target-like answer takes another set than the one denoted by the N’ as the quantifier’s first argument. Crucially, children are predicted to randomly interpret (43) as (43-a) or (43-b).

(43) All elephants$_{DT}$ are eating fries$_{DT}$
   a. ‘All elephants$_{DT}$ are eating fries’
   b. ‘All elephants are eating fries$_{DT}$’

Note that for adults (with a ranking according to which Syntactic Structure is ranked above Cohere and the other discourse constraints), having introduced two discourse topics does not result in chance behavior; for both options (either choosing the subject or the object as the discourse topic), the exhaustive interpretation (Every(A,B) ∧ Every(B,A)) is ruled out:

(45) a. Interpretation (43-a)
Experiment I thus looks for further support, although from a different perspective, for the findings of Hollebrandse that children prefer pragmatic cues like discourse context to syntactic structure. In addition, it would also present further evidence for the hypothesis that the acquisition of quantification is a matter of establishing a target-like equilibrium between syntax, semantics and pragmatics.

### 6.5.1.1 Method

**Participants** Twenty-six Dutch speaking children were tested at a local elementary school in Groningen, The Netherlands. From this group three children were excluded from further analysis because they incorrectly answered more than four of six control items, strongly suggesting they were not paying attention during the task. The twenty-three children remaining (12 boys and 11 girls) ranged in age from 4;2 to 6;7 (mean age 5;9). As a control group, twenty-five adult native speakers of Dutch were tested. They were all undergraduate students at the University of Groningen, The Netherlands.

**Materials** The test had a 2x2 design plus six control items (three control yes-items and three control no-items). The Discourse Condition consisted of six extra-object stories with a discourse and the Single Sentence Condition consisted of six extra-object items without a discourse (and only one picture). The Single Sentence condition was used to identify children that give exhaustive pairing answers. The items with a discourse were accompanied by five pictures. Each story was about two sets of entities, rather than one as in Drozd and Van Loosbroek (2006) and Hollebrandse (2004). The introduction did not mention one set more often than another. It also did not consider an alternative outcome to the test item as in Crain et al.’s (1996) experiment (i.e. the Condition of Plausible Dissent was not satisfied).

1. Picture 1 shows one set. The experimenter introduces this set with a bare plural and introduces a second set in a similar way, e.g. *Here you see some fries that John made himself. He is going to give the fries to his friends the elephants.*
2. Picture 2 displays the second set. The experimenter introduces this set with “the N” and the first set is mentioned again, e.g. *Here you see the elephants. They really like fries!*
3. Picture 3 displays an event, marking one of the members of the first set as an outlier, e.g. *Oeps! One bag of fries slips out of John’s hands.*

<table>
<thead>
<tr>
<th>Interpretation (43-b)</th>
<th>SYNT. STR.</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
<th>FD</th>
<th>FAITH-Vis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every(A,B)</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Every(A,B) ∧ Every(B,A)</td>
<td></td>
<td></td>
<td></td>
<td>*†</td>
<td></td>
</tr>
</tbody>
</table>
4. Picture 4 shows an extra-object situation, similar to the extra-object items without a discourse. The experimenter tells what happens, e.g. *John gives the fries to the elephants!*

5. Picture 5 shows a neutral picture; the experimenter points out that this is the end of the story and without mentioning one of the two sets or using the predicate of the test item, e.g. *And now, there is no food left.*

All test sentences were similar in syntactic structure and contained a transitive sentence and quantification over the subject as in (46). An example of a set of pictures that accompanied the test items (in this case (46)) is displayed in figure 6.1.

(46) Alle olifanten eten een patatje

All elephants eat a fry

‘All elephants are eating french fries’

![Figure 6.1: Example test item for Alle olifanten eten een patatje 'All elephants are eating chips'](image)

**Procedure** In the Discourse Condition, the pictures appeared one after another on a row in the middle of the screen. After the fifth picture, the puppet commented on what he thought had happened (the test sentence) while all pictures remained visible. In a similar way, the puppet described the extra-object picture while the picture remained visible in the Single Sentence Condition. The experimenter then asked the child whether the puppet was right or not and to explain her answer. All pictures were displayed on a laptop screen by means of Microsoft Powerpoint 2003.

Children were brought individually from their class to a room by the main experimenter and the child sat in front of the test screen next to the main experimenter. The child was told by a puppet that the computer had been built by the experimenter, but that the puppet believed that the computer was built the wrong way. The puppet then commented on each picture displayed on the screen. For each item, the experimenter asked the child whether the puppet was right or not and to explain her answer. The experimenter noted down the child’s answer and, additionally, the child’s response was audio recorded.
6.5.1.2 Results

Children A t-test comparing the distribution of yes-answers for the Single Sentence and the Discourse Condition reveals a significant difference between the Single Sentence Condition (mean 47.83%, S.D. = 40.30%) and the Discourse Condition (mean 73.91%, S.D. = 28.35%) (t(22) = 3.896, p < .001). However, the large standard deviations indicate that there is a lot of variance in the mean given yes-answers between children. In figure 1, a boxplot shows the variance of the yes-answers in percentages for both the Single Sentence Condition and the Discourse Condition. Taking a closer look at individual answer patterns, the results show that, in the Single Sentence Condition, ten out of the twenty-three children answered in more than four out of six cases “no, not that one” or gave an answer similar to that. I label these children as spreaders and distinguish them from the remaining 13 non-spreaders; children who gave in three or less than three out of six cases an exhaustive answer. But do these spreaders restrict the quantifier domain at chance in the Discourse Condition?

![Boxplot mean given yes-answers for the Single Sentence Condition and the Discourse Condition](image)

Figure 6.2: Boxplot mean given yes-answers for the Single Sentence Condition and the Discourse Condition

A comparison between the spreader mean given yes-answers in the Single Sentence Condition and the mean given yes-answers in the Discourse Condition turns out to be significant (see table 6.1 and figure 6.3; 8.33% in the Single Sentence Condition versus 55% in the Discourse Condition; t(9) = -5.056, p = .001). To put it differently, the spreaders have a guessing strategy in the Discourse Condition (analysis by means of a t-test shows a non-significant difference with at chance per-
formance; \( t(9) = 0.502, p = 0.627 \). The non-spreaders do not answer differently in the Single Sentence Condition than in the Discourse Condition (78.33\% versus 88.46\%; \( t(12) = -1.477, p = 0.165 \)). No significant differences were found between the mean ages of spreaders and non-spreaders.

![Figure 6.3: Mean yes-answers for spreaders, non-spreaders and adults on the Single Sentence and the Discourse Condition.](image)

**Adults**  As predicted, the adults do not answer differently in the Single Sentence Condition (mean yes-percentage 93.33\%, S.D. = 14.43) than in the Discourse Condition (mean yes-percentage 84.67\%; \( t(24) = 1.915, p = 0.067 \)). The table below show the mean yes percentage and standard deviations for children and adults.

**Adults versus Children**  Two one-way ANOVAs were used to determine, per condition, whether children differ from adults. The one-way ANOVAs with group as independent variable (spreaders, non-spreaders and adults), for the Single Sentence Condition and the Discourse Condition an effect of group was found in both the Single Sentence Condition \( (F(2,47) = 89.80, p < .001) \) and the Discourse Condition.

\[ \text{13} \] The large standard deviations in the Discourse Condition for the spreaders, however, indicate again that there is a lot of variance in the answers of the children. This is partly due to two children, who continue giving exhaustive pairing answers in the Discourse Condition. However, leaving these to children out of the analysis, a \( t \)-test still shows a non-significant difference from chance performance for the remaining children in the Discourse Condition (mean yes percentage 66.67\%, S.D. 21.82\%; \( t(7) = 2.160, p = 0.068 \)).
Table 6.1: Mean yes-answer for spreaders, non-spreaders and adults in the Single Sentence Condition and the Discourse Condition

<table>
<thead>
<tr>
<th>group</th>
<th>Condition</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-spreaders (n = 13)</td>
<td>Single Sentence</td>
<td>78.21</td>
<td>24.89</td>
</tr>
<tr>
<td></td>
<td>Discourse</td>
<td>88.46</td>
<td>14.25</td>
</tr>
<tr>
<td>spreaders (n = 10)</td>
<td>Single Sentence</td>
<td>8.33</td>
<td>8.78</td>
</tr>
<tr>
<td></td>
<td>Discourse</td>
<td>55.00</td>
<td>31.48</td>
</tr>
<tr>
<td>adults (n = 25)</td>
<td>Single Sentence</td>
<td>93.33</td>
<td>14.43</td>
</tr>
<tr>
<td></td>
<td>Discourse</td>
<td>84.67</td>
<td>18.58</td>
</tr>
</tbody>
</table>

\((F(2,47) = 8.84, p = .001)\). Posthoc analyses (t-tests with Bonferroni adjustments) shows that the difference lies between adults and spreaders and adults and non-adults in the Single Sentence Condition \((p < .001 \text{ and } p = .039)\), but only between adults and spreaders in the Discourse Condition \((p = .001)\).

In sum, the children who gave a non-target-like answer in the Single Sentence Condition showed a guessing strategy to determine the quantifier’s domain in the Discourse Condition. This contrasts with children who gave a target-like answer in the Single Condition, since these children also answer target-like in the Discourse Condition.

\subsection*{6.5.1.3 Discussion}

Experiment 1 tested the hypothesis that for children, \textsc{Syntactic Structure} is ranked below \textsc{Align-Q}. This hypothesis was tested by providing a discourse which preceded the quantified sentence, which contained two discourse topics. For children who behave non-target-like at the classical Single Sentence Condition, at chance behavior was predicted in such a Discourse condition with two topics.

The results from the Single Sentence Condition confirm earlier findings that children violate \textsc{Syntactic Structure}. Second, the results show that these children answered at chance in a Discourse Condition in which the quantifier’s first and second argument set were discourse topics. This confirms the hypothesis that children indeed consider two interpretations of a quantified sentence; an adult reading and a non-adult-like, exhaustive pairing reading. Since they take satisfaction of \textsc{Align-Q} to be more important than \textsc{Syntactic Structure}, this then results in either the adult answer yes or no, not that one, depending on the discourse topic they take to be the one intended by the speaker. In the experiment, I take this to mean that, for the child, this specific discourse turns the quantifier into an ambiguous one; the child assigns either an adult interpretation to it or a non-adult-like, exhaustive interpretation. This is exactly what follows from the hypothesis that children rank \textsc{Syntactic Structure} below \textsc{Align-Q}, disambiguate the test item by means of...
Align-Q and randomly select the quantifier’s first or second argument set as the discourse topic.

### 6.5.2 Experiment II: Forward Directionality and the Discourse Context

The second experiment tests whether children use **Forward Directionality**. Are children able to restrict a quantifier domain by means of this constraint when the syntax does not provide sufficient information? Drozd and Van Loosbroek (2006) account for children’s adult-like interpretations of quantified sentences in a discourse by pointing at the explicit activation of the quantifier’s domain in the preceding discourse. This presupposes that children are able to distill this information from the discourse. This second experiment continues along these lines and addresses the question whether children are also able to restrict the quantifier domain to a certain subset introduced previously in the discourse, given the hypothesized child ranking:

(47) **Hypothesis 2:**
Children rank **Forward Directionality** higher than **Syntactic Structure**

What does the ranking in (47) predict for children’s interpretation of (48)? Consider its possible interpretations in (48-a) and (48-b).

(48) Mary bought ten fish and went home. All the fish are now swimming in a fishbowl.
   a. ‘All fish that Mary has at home are swimming in a fishbowl’
   b. ‘All fish that Mary bought are swimming in a fishbowl’

In (48-b), the set of fish is restricted to the fish Mary bought. Syntactic Structure is violated since the quantifier domain is more than the N’. Forward Directionality is however satisfied, since the quantifier domain intersects with the discourse topic. Note that the first interpretation (48-a) violates Forward Directionality. This constraint thus turns out to be a crucial one to interpret (48) correctly and despite of the non-adult ranking of Forward Directionality above Syntactic Structure children are predicted to interpret (48) target-like as (48-b). This is illustrated in (49) (child ranking) and (50) (adult ranking):

(49) **Child ranking:**

<table>
<thead>
<tr>
<th>Example (48)</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
<th>FD</th>
<th>FAITH-VIS</th>
<th>SYNT. STR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(48-a)</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(48-b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>
(50) Adult ranking:

<table>
<thead>
<tr>
<th>Example (48)</th>
<th>SYNT-STR</th>
<th>COHERE</th>
<th>ALIGN-Q</th>
<th>FD</th>
<th>FAITH-VIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(48-a)</td>
<td>*</td>
<td></td>
<td></td>
<td>*1</td>
<td></td>
</tr>
<tr>
<td>(48-b)</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To test whether this prediction is born out, the present experiment is set up in such a way that, for example in the case of (48), the different interpretations result in different truth values. By doing so, we will be able to know whether children indeed are able to restrict a quantifier by means of context despite their non-adult ranking of the relevant constraints (Forward Directionality versus Syntactic Structure).

Note that children’s target-like use of Forward Directionality becomes especially relevant when the so-called over-exhaustive answers are taken into account. In the literature (among others Philip, 1995), it has been reported that children answer affirmative to the question *Are all cowboys riding a horse*. From the perspective of the OT account proposed above, these children do not seem to grasp the notion of Forward Directionality and restrict the quantifier domain to a set the speaker has not in mind (i.e. the set that makes the sentence true). To control for these answers in the next experiment, children are also tested on such Extra Subjects items to check whether they not only violate Forward Directionality in these particular cases but also for discourse context as (48).

6.5.2.1 Method

Participants  Twenty Dutch speaking children from a local elementary school in Groningen, The Netherlands, were tested. From this group four children answered two or more control items incorrectly. Taking this again (similarly as in Experiment I) to suggest that these children were not paying attention or did not understand the task, I excluded these four children from further analysis. The sixteen children remaining (10 boys and 6 girls) ranged in age from 4;1 to 5;11 (mean age 5;2). As a control group, the same 25 adults that were tested in the first experiment were tested.

Materials  The participants were asked to interpret 12 stories, plus 6 Extra Subject items and 6 control items (3 control yes-items and 3 control no-items). An example of an Extra Subject item and a control item can be found in respectively (51-a) and (51-b). All test sentences in the stories were intransitive and had a quantified subject as in (52).
6.5. Experiments

(51) a. Alle cowboys rijden op een paard
    All cowboys are riding a horse
    ‘All cowboys are riding a horse’

b. Alle apen slapen
    All monkeys sleep
    ‘All monkeys are sleeping’

The Extra Subject items displayed a situation in which three cowboys are riding a horse and a fourth cowboy is not. The stories were accompanied by five pictures. At the third picture, the experimenter always wondered whether the same thing would happen to the set he just introduced than had happened to the first set (i.e. the Condition of Plausible Dissent was satisfied). The experimenter then continued that something else happened to this second set and explained why. The stories present two subsets of similar entities (e.g. fish) and an action that happens to one of the subsets. We varied when in the story the targeted subset is mentioned as the first or last subset. In the Subset-First condition, the experimenter referred to the first mentioned subset which happens with the second picture in a series of five pictures that accompanied the story. An example of such a (translated) story and the pictures shown to the child can be found in (52) and figure 6.4.

(52) 1. The introduction of a set; *Mary went to the pet shop. She bought a bag with new fish.*
2. Something happens to the set just introduced; *On her way home, she thinks sitting in bag is not nice for the fish. She throws them in a canal, so now they are free and can swim.*
3. The introduction of another set; *At home, Mary has a fish bowl with fish in it. An orange and a blue one. Mary considers setting them free.*
4. Something that happened to the second set just introduced; *But it might be too cold for the fish in a canal. The fish are hungry, look, Mary is feeding them.*
5. A neutral picture; *And now, Mary is going to play outside.*
6. Experimenter: *All fish are swimming in a canal*

Figure 6.4: Example subset-first Condition; *Alle vissen zwemmen in een sloot* ‘All fish are swimming in a canal’ - targeting a no-answer for adults according to the interpretation *All fish that Maria has at home are swimming in a canal*
In the Subset-Last condition (six items), the experimenter referred to the action mentioned with the fourth picture in the series of five pictures:

(53) 1. The introduction of a set; John went to the flower shop. He holds a yellow and a red flower.
2. Something happens to the set just introduced; On his way home, he sees his girlfriend. He gives Mary the flowers.
3. The introduction of another set; At home, John has a bunch of red flowers. Will he give these to Mary as well?
4. Something that happened to the second set just introduced; No, John puts these flowers into a vase. That looks beautiful.
5. A neutral picture; John loves flowers.
6. Experimenter: All flowers are in a vase

Figure 6.5: Example subset-last condition; Alle bloemen staan in een vaas ‘All flowers are in a vase’ - targeting a yes-answer for adults according to the interpretation All flowers that John has in a vase at home are in a vase.

For adults, satisfying Forward Directionality in the Subset-First condition results in a no-answer and satisfying Forward Directionality in the Subset-Last condition results in a yes-answer. For example, for (52) and 6.4 (a subset-first item in which the experimenter referred to the action mentioned in the second picture in figure 6.4), the interpretation arises that all fish that Mary has at home are swimming in a fish bowl and not in a canal. This is not true in the story, hence a no-answer. In the Subset-Last condition, satisfying Forward Directionality results in a yes-answer. For (52) and figure 6.5, for example, the Dutch testitem Alle bloemen staan in een vaas ‘All flowers are in a vase’ targets a yes-answer for adults since indeed All flowers that John has in a vase at home are in a vase.

Procedure  In a similar way as in experiment I, all pictures were displayed on a laptop screen by means of Powerpoint. Children were brought individually from their class to a room and sat in front of the screen next to the main experimenter. The child was told by a puppet that the computer had been built by the experimenter, but that the puppet believed that the computer was built wrong. The pictures appeared one after another on a row in the middle of the screen. After the fifth picture, the puppet commented on what he thought had happened (the test sentence) while all pictures remained visible. For each item, the experimenter asked the child whether
the puppet was right or not and to explain her answer. The experimenter noted down the child’s answer and, additionally, the child’s response was audio recorded.

For the Extra Subject items and the control items, only one picture was shown to the child. In the same manner as with the Subset-First items and the Subset-Last items, the puppet commented on what he thought happened at the picture and the experimenter asked the child whether the puppet was right or not and to explain her answer.

To control for an effect of the order in which the items were displayed, half of the children were first presented all six Subset-First stories and then all six Subset-Last stories and the other half of the children were first presented 6 Subset-Last stories and then 6 Subset-First stories. In both lists, the Extra Subject items and control items were mixed in with the Subset-First and the Subset-Last items.

6.5.2 Results

Children  The children give a yes-answer for the Extra Subject trials in 15.62% of the cases. This percentage is mainly due to two children who accepted 6 out of 6 times and two children who accepted one out of six possible times a quantified sentence like All cowboys are riding a horse. Maintaining a similar criterion as in Experiment I, I label the two children who gave such an answer in more than 5 out of 6 times under-exhaustive children. However, these two children did not answer significantly different from the other children in the Subset-First and Subset-Last condition (a chi-square analysis shows that there is no significant difference between the answers of these two children and the other children; $\chi^2(1) = 2.636, p = 0.104$). Therefore, in the analysis, the results of the children giving non-exhaustive answers and the other children are collapsed. This results in a mean yes answer of 30.21% in the Subset-First condition and 58.33% in the Subset-Last condition. This difference turns out to be significant ($t(15) = -3.878, p = .001$).

An additional effect was found of the order in which the items were presented. If the child is first asked to look at the Subset-First items and then to the Subset-Last items, the child accepts the quantified sentence in respectively 70.83% versus 25% of the cases ($t(7) = -5.60, p = .001$). The difference disappears if the child is asked to first look at the Subset-Last items and then to the Subset-First items ($t(7) = -1.26, p = .25$).

Adults  The adults answer significantly more often yes on the Subset-Last condition (25.33%) compared to the Subset-First task (2%; $t(24) = -3.055, p = 0.005$). Table 6.2 summarizes the main findings for adults and children.

Adults versus Children  Comparing adults with children, a one-way ANOVA shows that there is a significant effect of group for both the Subset-First condition ($F(1,40) = 16.249, p < 0.001$) and the Subset-Last Condition ($F(1,40) = 8.185, p = 0.007$).
### 6.5.2.3 Discussion

The current experiment aimed to answer the question whether children rank Forward Directionality above Syntactic Structure and whether they, despite of this ranking, show target-like behavior. Children were predicted to answer adult-like despite of this different ranking since no other constraints interfered. To answer this question, a subtle experiment was set up targeting children's domain restriction by means of Forward Directionality. Crucially, the sets Forward Directionality applied to were either introduced at the beginning of the story or towards the end, eliciting respectively a quantifier domain that was restricted by the first introduced set (the Subset-First Condition) and a quantifier domain that was restricted by the last introduced set (the Subset-Last Condition).

The results show that children make a distinction between the Subset-First and the Subset-Last condition, like adults do. This means that they are sensitive to the order in which the sets are presented, and that they use this information to restrict the quantifier domain. When the targeted subset is mentioned first, it is not taken to restrict the quantifier domain whereas when the subset is mentioned last, this latter set is taken to restrict the quantifier domain. This confirms the prediction that children, despite of their ranking of Syntactic Structure below Forward Directionality, restrict their domain adult-like to the topic range of the determiner. In a typical OT tableau, this is shown in (54) and (55) for the Subset-First condition (respectively adult and child ranking) and in (56) and (57) for the Subset-Last condition (respectively adult and child ranking). In both cases, either the first or last subset restricts the quantifier domain. This explains why children, similarly as adults, distinguish the Subset-First from the Subset-Last items.

\begin{center}
<table>
<thead>
<tr>
<th>group</th>
<th>Condition</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>children (n = 16)</td>
<td>Subset-First</td>
<td>30.21</td>
<td>34.54</td>
</tr>
<tr>
<td></td>
<td>Subset-Last</td>
<td>58.33</td>
<td>33.33</td>
</tr>
<tr>
<td>adults (n = 25)</td>
<td>Subset-First</td>
<td>2.00</td>
<td>5.53</td>
</tr>
<tr>
<td></td>
<td>Subset-Last</td>
<td>25.33</td>
<td>37.61</td>
</tr>
</tbody>
</table>
\end{center}

Table 6.2: Mean percentages yes-answers for children and adults for the Subset-First Condition and the Subset-Last condition.

\((54)\)  All fish are swimming in a canal
a. ‘All fish that Mary has at home are swimming in a canal’: NO
b. ‘All fish that Mary bought are swimming in a canal’: YES
6.5. Experiments

(55)  a. 
      | Example (54) | FD | SYNT. STR. |
      | (48-a)       |   |           |
      | (48-b)       | *!|           |

      b. 
      | Example (54) | FD | SYNT. STR. |
      | (48-a)       |   |           |
      | (48-b)       | *!|           |

(56) All roses are in a vase

  a. ‘All roses that John has at home are in a vase’: YES
  b. ‘All roses that John bought are in a vase’: NO

(57)  a. 
      | Example (56) | FD | SYNT. STR. |
      | (56-a)       |   |           |
      | (56-b)       | *!|           |

      b. 
      | Example (56) | FD | SYNT. STR. |
      | (56-a)       |   |           |
      | (56-b)       | *!|           |

There is also a difference between children and adults; in general, adults answer more often no. This might be due to the fact that adults consider, next to (58-a) and (58-b), a third reading of a test item like (58), i.e. the interpretation represented in (58-c).

(58)  All fish are swimming in a canal

  a. “All fish that Mary has at home are swimming in a canal”
  b. “All fish that Mary bought are swimming in a canal”
  c. “All fish in the story are swimming in a canal”

Whereas (58-a) and (58-b) resulted in respectively a no and yes-answer in the experi-
ment (cf. figure 6.4), (58-c) results in a no-answer too. Apparently children do not consider a no-answer as often as adults.  

6.6 General discussion and conclusions

The experiments presented in this chapter aimed to answer the question of when and under which conditions children resort to a discourse-based interpretation of quantified sentences. I discussed how various acquisition accounts make use of different discourse characteristics to explain children’s improved performance in a discourse. Subsequently, I addressed the relation between a quantifier domain and discourse from the perspective of (Centering) Optimality Theory and identified Align-Q and Forward Directionality as the crucial constraints in addition to Syntactic Structure to interpret a quantified sentence in a discourse. I hypothesized that children allow discourse constraints to play a more important role in interpreting a quantified sentence than the syntactic constraint (i.e. children rank Align-Q and Forward Directionality higher than Syntactic Structure). From this perspective, I then investigated the effect of discourse context on children’s interpretation of quantified sentences in two experiments.

Experiment I zoomed in on children’s understanding of the constraint Align-Q and children were asked to interpret a quantified sentence preceded by a discourse containing two discourse topics (DT in (59) below) as represented in (59).

(59) All elephants<sub>_DT</sub> are eating a fry<sub>_DT</sub>

For children who behave non-target-like for the classical extra-object items (i.e. condition labelled the Single Sentence Condition in Experiment I to distinguish these items from the discourse items), chance behavior was predicted (these children were labeled as ‘spreaders’); children randomly pick the quantifier’s first or second argument set as the quantifier’s domain. This prediction was born out.

Experiment II zoomed in on children’s understanding of Forward Directionality as in (60) (preceded by a story which either yielded interpretation (60-a) or (60-b)):

(60) All fish are swimming in a canal
   a. ‘All fish that Mary has at home are swimming in a canal’
   b. ‘All fish that Mary bought are swimming in a canal’

Despite of the hypothesized non-adult-like ranking of this constraint above Syntactic Structure, target-like behavior was predicted in this experiment because Syntactic Structure was satisfied for all interpretations. This meant that children were predicted to distinguish (60-b) from (60-b) and restrict the quantifier domain respectively.

14I leave it for further research whether adults’ interpretations are rather like (58-c) than like (58-a). Crucially, the domain of quantification in (58-a) is a result of applying Forward Directionality, whereas (58-c) clearly is not (since it does not concern the last mentioned set, but rather the superset that functions as the domain of interpretation in general).
to the set mentioned in the discourse. The results of the second experiment showed that children, similarly as adults, distinguish these two discourse contexts and restrict the quantifier domain target-like.

The results of the two experiments present further evidence for the idea proposed in the literature that children use discourse information to restrict a quantifier domain (Drozd and Van Loosbroek, 2006; Hollebrandse, 2004). Crucially, the present findings present experimental evidence for the proposed relation between quantifier domain restriction and discourse context. I conclude that, in line with the Equilibrium Hypothesis introduced in chapter 3 that the acquisition of quantification crucially concerns fine-tuning the interaction between syntax, semantics and syntax. It is this process of fine-tuning which explains children’s non-target-like answers, rather than the hypothesis that children have not acquired yet certain linguistic rules. Moreover, the results in this chapter show that the acquisition step to an adult way of understanding language lies in restricting the role of pragmatics to such an extent that the syntactic structure overrules any discourse based constraints on quantifier domains.