The goal of this special issue on Interfaces is to explore the division of labor between pragmatics and grammar. In the introductory paper a system of different modules and interface mappings has been presented. Some suggestions were made where the job of the acquisition process is. It was posed that most, if not all, acquisition is in the mapping rules itself, rather than in the modules. This paper explores the possible interaction between topicality and the interpretation of universal quantifiers. The experimental finding is that children, interpreting quantifiers, take topicality into account only when the topic is realized in subject position. Topicality has no influence on the interpretation of quantifiers in object position. This means that these children do relate pragmatic information to specific syntactic positions.

1. Introduction

Three modules, Pragmatics, Syntax and Semantics and the mappings between them are involved in the interpretation of quantifiers. Based on the experimental findings, it will be concluded that the Pragmatics module maps topic information on the syntactic string and this syntactic string with its informational packaging (Vallduví 1994) is mapped onto a semantic structure (Heim’s tripartite structure). Topicality plays a role in the interpretation of subject quantifiers and not in the interpretation of object quantifiers.

In section 1.1 I will outline the adult interpretation of quantifiers. I will briefly address the semantic structure, following Heim (1982) and the mapping of the syntactic string onto that semantic structure, mostly following Diesing (1992). In section 1.2 I will propose how children deal with the interpretation of quantifiers, mainly discussing previous literature. In section 2.1 the experimental design is described. The results are given in section 2.2. The findings and their implications for the Interface system are discussed in section 3.

1.1 The adult interpretation of quantifiers

The pragmatic, the syntactic and the semantic module play a role in the adult interpretation of quantifiers. A possible organization of the semantic module might be as follows: adults interpret sentences with quantifiers by mapping the sentence onto a tripartite structure (Kamp, 1981; Heim, 1982). Such a tripartite structure exists out three positions. The noun in the quantifier NP is mapped onto the restrictive clause, which functions as a restrictor of the domain of quantification. The quantifier itself is mapped onto a quantifier position. The remaining predicate is mapped onto the nuclear scope. Indefinites are represented here as variables which are bound by an implicit existential operator, which functions to close off the nuclear scope, existentially. This is to prevent any unbounded variables. For the example in (1a) *every* is mapped onto the quantifier position. *Cowboy* is mapped onto the restrictive clause and the remainder is *riding a cow* is mapped onto the nuclear scope. This should read as universal quantification takes place over a domain restricted to
cowboys in the scope of riding a cow. The tripartite structure of this example (1a) is given in (1b).

(1) a. Every cowboy is riding a cow.
    b. 

\[
\begin{align*}
\forall x & \quad [x \text{ is a cowboy}] \\
\exists y & \quad [y \text{ is a cow} \land x \text{ is riding } y]
\end{align*}
\]

So far the relation between the two structures is not given yet. The structures relevant so far are the syntactic structure for a sentence, like (1a) and the tripartite structure for the same sentence. The process of mapping itself has not been outlined yet. This mapping determines the content of the restrictive clause and that of the nuclear scope. Or, as Diesing (1992:8) puts it: “one of the main questions that arises in applying restricted quantification to natural language is how to determine the restrictive clause. In other words, how is the syntactic structure divided into the “semantic partition” consisting of the restrictive clause and the nuclear scope?”. Diesing (1992) proposes a way of mapping, now known as the mapping hypothesis, which in essence cuts the tree syntactically in half and maps the higher syntactic IP-layer onto the restrictive clause and the syntactic VP-layer onto the nuclear scope (and the quantifier onto the quantifier-position).

In Diesing’s view object quantifiers are raised to a higher position, following May’s (1985) Quantifier Raising. Subjects are assumed to start out and stay VP-internal in this case. Quantifier Raising raises the object in (2a) to a position in the IP, resulting in the structure in (2b). This can then be mapped onto a tripartite structure, following Diesing’s mapping hypothesis (2c).

(2) a. A cowboy is wearing all hats.
    b. [IP all hats [VP a cowboy is wearing]]
    c. 

\[
\begin{align*}
\forall x & \quad [x \text{ is a hat}] \\
\exists y & \quad [y \text{ is a cowboy} \land y \text{ is wearing } x]
\end{align*}
\]

These tripartite structures are formed by a syntax – semantic interface mapping. Information from the pragmatic module plays a role as well. Information from the pragmatic module often plays a role in restricting the domain of quantification. Most of the information that plays a role is presuppositional in nature. For instance, the statement in (3) uttered at a party, is generally not understood as including everybody in the world, but the domain of quantification in this case is restricted to the people at the party.

(3) Everybody drinks beer.

It is even more complicated, as Geurts (to appear) shows with the example in (4). The domain of quantification is restricted in a curious way: the domain has to include the
people that were supposed to present, but not the people that are currently present. In the latter case, (4) would be a tautology and it would not be very informative.

(4)  Is everybody present?

So, an adult uses information from the pragmatic module to restrict the domain of quantification, as well as information from the syntactic structure.

1.2 The child’s interpretation of quantifiers

The following interesting observation of non-adult interpretation of universal quantifiers has been made: children being presented with a picture of four horses and three boys in such a way that each boy is riding horse and there was horse without a boy, will answer the question Is every boy riding a horse? negatively. These children justify this answer by pointing to the “empty” horse, saying Not, this one. This observation has been made under several different conditions by Inhelder and Piaget (1964), Freeman, Sinha and Stedmon (1982), Philip (1995), Takahashi (1991), Drozd and Van Loosbroek (1999). The general idea is that children assign a symmetric reading to the test sentence by exhausting both sets denoted by the NPs. De Villiers and Roeper (1993) and Philip (1995) refer to this as quantifier-spreading. In this paper I will take over the name and refer to the children just described as classical spreaders. The response will be referred to as the spreading or the symmetrical answer.

Philip (1995) is an extensive study into the child’s interpretation of presuppositional universal quantifiers. To explain the child’s non-adult behavior Philip proposes that the classical spreader quantifies over (parts of) the event and (parts of) its participants. This event quantification applied by the classical spreader is given in the tripartite structure (5), taken from Philip (1995:44).

(5)  

[quantifier]  
[PART (boy,e)]  
[PART (pony,e)]  

∀e [PART (boy,e)]  

’a boy is riding a pony’

or

The event quantification makes sure that both subject and object argument are mapped onto the restrictive clause, resulting in a symmetrical interpretation. De Villiers and Roeper (1993) propose that both NPs are in the scope to the quantifier. They argue that the quantifier in case such as (6a) is part of the clause structure, rather than the nominal structure. The reason for this is that the nominal structure has not been developed completely. The structure the child assigns to (6a) is as in (6b), instead of the adult structure in (6c).
(6) a. Every boy is riding a horse.
   b. [Every [boy] is riding a horse]
   c. [[Every boy] is riding a horse]

The advantage of this proposal is that both subject and object NP are in the scope of the quantifier. Therefore, the quantificational nature of these quantifiers demand exhaustion of both entities denoted by the subject as well as by the object. This might be a plausible approach for the younger children. However, it is not very likely that the 7 year-old spreaders are assigning clausal scope the quantifier *every* because of a lack of nominal structure, assuming that syntactic structure has been acquired by then. They might still assign such a scope to the quantifier on a parallel with adverbial quantification processes.

I will follow Philip’s proposal in the sense that I think that the spreading child has a different organization of the semantic module. They map more onto the restrictor than adults do.

I will now discuss four studies Crain, Thornton, Boster, Conway and Lillo-Martin and Woodams (1996), Freeman, Sinha and Stedmon (1982), Drozd and Van Loosbroek (1999) and Philip and Lynch (2000). These studies are relevant for this paper because they show the influence of the Pragmatics module on the interpretation of universal strong quantifiers. And although the first two of these studies claim that the spreading phenomenon is an essentially non-linguistic problem, I will use them to show that pragmatic factors play a role in the child’s quantificational system. Syntactic factors must play a role as well, as the results of the experiment below will show.

Crain et. al. (1996) argue that the phenomenon is not a linguistic one. They show that children can interpret sentences with prenominal universal quantifiers in an adult way when the test sentences are put in a sufficient context. They argue that the experimental design of *here are some boys and some horses* followed by the test question does not fulfill the condition of plausible dissent. In fact, “in our view, all symmetrical responses by children are errors due to flaws in experimental design” (Crain et. al.; 1996:109). In their experimental design the condition of plausible dissent is fulfilled by contrasting the entities in the test sentence with potential alternatives. The child is also provided with an alternative to the relevant event. In example (6) subjects are provided with an alternative to *boys*, say *girls*, an alternative to *horses*, say *donkeys* and an alternative to *horse-riding*, say *feeding*. Under this experimental design non-adult behavior decreases enormously, however, does not disappear completely. Adults suffer under the same flaws, but they are able to accommodate the lack of them.

Crain et. al. (1996) contribute both the unusual no-response and the high noise-level to the failing experimental task. When people are confused, or find the task difficult, they tend to answer positively. The lack of a yes-bias in the Philip-type design is, according to Crain et. al. (1996), due to failing expectations by the child. However, it could as well be the result of the fact that many different factors are involved in the interpretation of quantifiers. The pragmatic interface mapping onto syntax is involved, as well as the syntax-semantics interface. It could well be that the elaborate use of the different interfaces, pragmatic-syntax and syntax-semantics, is the cause of the high noise level. Of course, this would be in the line of this IRAL issue on Interfaces.

What remains puzzling is that this infelicitous situation resides to a symmetric answer. Again in the spirit of this special issue, when the pragmatic component is
doing its job in an adult way, why would the mapping between the syntax and semantic component result into both subject and object NP being mapped onto the restrictive clause. Although, it is not quite clear how the child comes to a symmetrical answer, when the condition of plausible condition is violated, it is clear that non-linguistic factors play a role in the child’s interpretation of quantifiers. After all, the child’s performance improves. The child shows a more adult-like behavior when the pragmatic information is sharpened enough.

It is clear from the Crain study that the pragmatic module is involved in the development of child’s interpretative process of quantifiers. More studies address issues which belong to the pragmatic module. I will briefly discuss the following: Drozd and Van Loosbroek (1999), Freeman, et. al. (1982), and Philip and Lynch (2000).

According to the Weak Quantifier Hypothesis first proposed in Drozd and Van Loosbroek (1999), the explanation of spreading behavior should be found in difficulties in the formation of presuppositions. The child finds “it difficult to distinguish the two sets they need to represent in order to proceed with a presuppositional interpretation of the universal quantifier” Drozd (2001:367). The child then resides to analyzing the quantifier as a weak cardinal one, which requires no presuppositional commitments.

Finally, Freeman, Sinha and Stedmon (1982) claim that children build up presuppositions on the basis of the presented picture. For the example in (1) the reasoning goes as following: horse-riding and boys and horses are introduced in a picture and so there is probably a missing boy for the empty horse. In fact they show similar behavior for adults in a one-trial experiment. They presented adults with three cups and four saucer. The cups are on the saucers. So, there is one empty saucer. Adults answer negatively, pointing to the empty saucer on the question: are all the cups on the saucers?.

All these examples are meant to show the effect of non-linguistic modules on the interpretation of quantifiers. In a reply to Crain et. al. (1996), Philip and Lynch (2000) varied the relevance of entities in the stories. They fore-grounded the subject and back-grounded the object in one trial and vice versa in another trial. They find that children make “the contrast between performance on the FORE and BACK conditions was marginally significant” (Philip and Lynch, 2000:595). The children gave non-adult answers 25% of the time in the case in which the quantifier phrase as back-grounded and only 10% non-adult answers in the case in which the quantifier phrase was fore-grounded.

2. The experiment

Philip and Lynch (2000) is taken as a starting point for the experiment below. This experiment tests the influence of topicality on the interpretation of quantifier constructions. It is this specific area which is chosen to explore the division of labor between the pragmatics, the syntax and the semantic component. Do children go along with the information in the pragmatics module or with information in the syntactic module? Are children following the route of pragmatic module, or are they following a route driven by the grammatical module?

2.1 The experimental design
Twenty-five children in the age range of 4 to 8 were tested most of them at De Boomhut. One child dropped out because of missing the NO condition.

A truth-value judgment task was used. The experimenter told stories accompanied by photographs. The story was interrupted by a blindfolded puppet, who commented on the pictures. The comments, most of which were the test items, then had to be judged by the children. Children were tested individually in a separate quiet spot of the building.

The experiment had a 2x2 design. The two conditions were sentence-type and discourse-topic type. For the condition sentence-type, two test sentences were used, which differed in position of quantifier: in one variant the prenominal quantifier was in subject position and in the other type it was in the object position, as in (7) and (8), respectively.

(7) Een cowboy draagt alle hoeden.
   A cowboy wears all hats
   “A cowboy is wearing all hats.”

(8) Alle hoeden hangen in een boom.
   all hats hang in a tree
   “All hats are hanging in a tree.”

The quantifier phrase was either a topic or a non-topic. The test sentences were introduced by short stories. The “topic” one was a story about X and was then combined with a question containing all X. The “non-topic” variant was a story about X and the quantifier occurred in all Y. The test sentence in (7) and (8) were paired with topic and non-topic types. So, sentence like (7) was combined with a story about cowboys in one trial and combined with a story on hats in another trial. This was similar for sentence (8). For the topics, each entity was only used once and for the non-topics an entity was never used in the story. Topics were only used once to avoid any effect of topic maintenance, as found in Karmiloff-Smith (1986).

In this way four types were tested: subject topic (ST), object topic (OT), subject non-topic (SNT) and object non-topic (ONT). Additionally, a NO-condition was added, in which, for instance, the following test sentence All Indians are sleeping on a bed had to be judged for a picture of two Indians on a bed and one on the floor.

The quantifier used in all cases was alle (“all”). This quantifier was chosen because the test sentences in which the quantifier is in object position comes out more natural, than with the quantifier iedere (“every”). Besides that the topic entities were referred in the story as a group and not referred individually. Philip (1995), as well as Drozd and Van Loosbroek (1999) show no significant differences in spreading between every and all in the classical design.

The experiment started off with the “classical” design in which the picture is presented without story and introduced by here are Xs and Ys and the test sentence was then of the form All Xs are Z-ing a Y. These items were added to determine the group of classical spreaders. The pictures used here were the classical ones: four horses, three cowboys. The quantifier used was alle (“all”).

Of each type three items were tested. This resulted in a total number of 18 test items per subject. Additional fillers were added to make sure the child understood that the puppet was able to make false statements, which did not fit the story and picture.
The story and test questions were accompanied by photographs of PlayMobil items. The photographs displayed the entity denoted by the quantifier phrase as a group and there were always two entities displayed that belong to the nuclear scope. For instance, a photograph depicted two tables, one with some tomatoes and one empty one. The test sentence was *All tomatoes are on a table.*

The story established the aboutness topic. Each non-topic was not introduced in the story, but only first occurred in the picture and in the statement made by the puppet. An example of the subject is given in (9), translated in English in (10).

(9) .. En een tijdje later komen de Indianen twee ridderkoningen tegen. De Indianen geven de kippen aan de ridders (*photograph: Indians give chicken to the knights*). De ridders nodigen de Indianen uit om bij in hun nieuwe huis kip te komen eten. De ridders zijn net aan het verhuizen en (*photograph: two knights and one is lifting two chairs*)

interruption by the puppet:

test sentence: Ooh kijk daar! Een ridder koning tilt alle stoelen op.

(10) .. 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 and (*photograph: two knights and one is lifting two chairs*)

interruption by the puppet:

test sentence: Wow, see there! A knight is lifting all chairs.

After a negative response the child was asked by the puppet for a reason. This was to elicit the classical *No, not this one* response.

### 2.2 The Results

The subjects were split in two groups by their spreading or non-spreading behavior. The children who gave 2 or 3 (out of 3) symmetric responses. The remaining children were labeled as non-spreaders. There were 12 spreaders and 12 non-spreaders. The averages for the classical spreading response in the four conditions are given in Table I in (11).
The difference between Subject as non topic (SNT) and Subject as topic (ST) is significant (t-test (two-tail): $p=.0000$). The difference between subject as topic (ST) and object as topic (OT) is significant ($p=.0137$) as well as the difference between subject as non topic and object as non topic ($p=.0004$). The difference between Object as topic (OT) and non topic (ONT) is not significant. A 2-way ANOVA was run, showing an effect for the condition TOPIC ($F=5.482,5.482$, $p=.020$) and an effect for SENTENCE * TOPIC ($F=11.439$, $p=.001$). There was no effect for the condition SENTENCE.

The difference between subject and object are not significant. The difference between Non Topic and Topic are significant (t-test(two-tail): $p=.0007$).

The remaining subjects, who were not labeled as classical spreaders, spread sometimes in the experiment, but there was no significant pattern in the data. Their results are given in table IV in (12).
3. Conclusions

The striking result is the huge difference in the interpretation of subject quantifier and object quantifiers. Subject quantifiers are interpreted far more adult-like when they are topics, than when they are not. Notice that these children are classical spreaders. They are willing to spread. Focussing on the result of subject quantifiers alone, a first conclusion is that spreading children are “helped” by topicality. The same result was found by Philip and Lynch (2000), for English and in a different experiment.

There is no effect of topicality on the interpretation of object quantifiers. In the Interface system, this means that topicality information is mapped onto subject position and not onto object position. So, topic mapping does not go directly onto the semantic module, but has to go through the syntactic module, first, at least for the subject tested in the experiment. This is schematically shown for (13) in (14). In the case of the object being topic (15), both subject and object are mapped onto the restrictor (16). An object case is given in (17).

(13) Alle **tomaten** liggen op een tafel.
all tomatoes lie on a table
“All tomatoes lie on a table.”

(14) Pragmatics: topic: TOMATOES

Syntax: all [TOMATOES TOP] are on a table

Semantics:
quantifier restrictive clause nuclear scope

all tomatoes are on a table

(15) Alle **hoeden** hangen in een **boom**.
all hats hang in a tree
“All hats are in a tree.”
(16) Pragmatics: topic: TREE

Syntax: all [HATS TOP] are hanging in a tree

Semantics:
  quantifier restrictive clause nuclear scope
  all hats, tree are hanging

(17) Een ridderkoning tilt alle stoelen op.  
a knight-king lifts all chairs up
“A knight is lifting all chairs.”

(18) Pragmatics: topic: KNIGHT

Syntax: a [KNIGHT TOP] is lifting all chairs

Semantics:
  quantifier restrictive clause nuclear scope
  all chairs, knights lifting chairs

Why would topics be more visible? A topic can be seen as a link to a file card in file change semantics (Heim, 1982). The idea is the following: to convey information from the speaker to the hearer, the latter keeps a system of file cards. New information provided by the speaker is added to the relevant file card. So, the hearer updates her file cards with the new information provided by the speaker. In this sense aboutness topics function as the pointers or links to the relevant file cards (see for uses of this, the work by Vallduví (1994), Avrutin (1999), a.o.).

The clear visibility of subject topics might still come from the file card being on top of the stack. The child tries to keep track of information. The essence of communication is adding new information to known (or old) information. Information packaging, in the sense of Vallduví (1994), is the way of linguistically linking new and old information. He states the following: “information packaging is the linguistic dimension that allows speakers to make structural choices in accordance with their assumptions about the hearer’s communicative state” (p574). The child in processing the story in the experiment keeps adding new information about the aboutness topic. The file card representing this topic stays on top of the stack. The syntactic module plays the following role: the subject position in the syntactic module is sensitive to topicality information. The object position is not.

There is a remaining puzzling fact. Given the proposal, we will predict that there is no difference in spreading subject quantifier as non-topic and object quantifiers, topic and non-topic. In these cases topicality does not get marked in the syntactic
string. All things being equal, the prediction is then that the child gives the “same” symmetrical response in these cases, because he or she will map both subject and object onto the restrictor. Looking at the results this is clearly not the case. Children are clearly more adult-like in the object cases, than in the non-topic subject quantifier case. A possible angle on this problem is that the interpretation of indefinite subjects and objects is not the same (see De Haan, 1979; Rullmann, 1989; Diesing, 1992). However, it is not clear to me at this moment how that would lead to less spreading in the quantifier object cases. I’ll leave this to future research.

Summarizing, this paper explores the division of labor between the Pragmatics, the Syntax and the Semantics module and their interactive mappings. It only explores this for the interpretation of universal quantifiers in L1 Dutch. There is a puzzling observation that many children quantify over both subject and object entities in case such as *Every boy is riding a horse*, whereas, of course adults only quantify over the entity in the quantifier phrase. This spreading phenomenon is taken as a starting point in the experiment. Children were singled out as spreader (or non-spreader). These spreaders behaved more adult-like (less spreading) in the cases in which pragmatic information (topichood) was added. However, the positive effect of topicality was only limited to subject quantifiers and not to object ones. This finding is taken as evidence that topicality is mapped indirectly onto the Semantics module. It is mapped from the Pragmatic module, through the Syntactic one.

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* The research for this paper was part of the NWO Interfaces between L1 and L2 Acquisition (dossier number: 360-70-010). I like to thank the members of that research program: Petra Bos, Peter Coopmans, Ger de Haan, Aafke Hulk, Roeland van Hout, Peter Jordens and Petra Sleeman for their useful comments. I also like to thank the audiences of the Groninger Language Acquisition Lab and the TaBu dag 2003. Finally, I want to thank Ken Drozd, Bart Geurts, Angeliek van Hout, Bill Philip and Tom Roeper. All errors, of course, remain mine.
1 There is a more elaborated tripartite structure given on page 69 in Philip (1995), which is irrelevant for the purpose here.
2 Thanks to Sita van Pelt, the teachers, the parents and most of all the children of De Boomhut.
In a study testing quantifier subject and object differences, Philip and Coopmans (1995) find that children give more symmetrical responses for object quantifiers, than for subject quantifiers, but they did not test differences of topicality.