

# Temporal quantification and events in Dutch child language\*

Bart Hollebrandse and Sylvia Visser  
University of Groningen

## 1. Introduction

Young children interpret variables differently from adults. This is most clearly seen in their interpretation of universal quantifiers that quantify over individuals. We tested cases in which adult quantification takes place over times. We compare the results of the temporal cases with those of nominal cases. We find that children who have difficulty with nominal quantification ignore the temporal information in temporal quantification and have a strong preference for quantifying over events instead of times. We conclude that the conceptually abstract nature of times makes them hard to recognize as variables.

## 2. One quantifier — different variables?

Quantifiers may quantify over different kinds of entities, including individuals, events, and times (De Swart, 1991). However, a Fregian–Carnapian approach to logic for natural language treats those different entities in the same way. Nominal variables denote sets of individuals, for instance, the set of *witches* in (1).

- (1) a. Every witch is smiling.
- b.  $\forall x (\text{witch}(x) \rightarrow \text{smile}(x))$

Event variables denote sets of events, for example *conjuring* events in (2) (Davidson, 1967).

- (2) a. A witch always conjures an apple for breakfast.
- b.  $\forall e (\text{have-breakfast}(\text{witch}, e) \rightarrow \text{conjure}(\text{witch}, \text{apple}))^1$

Temporal variables denote sets of times (including time-intervals). In (3) the temporal variable denotes sets of *nights*.

- (3) a. Every night a witch is laughing.  
 b.  $\forall t (\text{night}(t) \rightarrow \text{laugh}(\text{witch}, t))$

All variables are treated equally by the logical system: the universal quantifier is not influenced by the set denoted by the variable. Universal (and also existential) quantifiers apply similarly to variables (1), event variables (2) and temporal variables (3).

The difference between the variables lies in the nature of the sets they quantify over. Nominal variables are conceptually easier to grasp than temporal ones, because nominal variables denote sets of individuals. Temporal variables denote times, which are far more abstract than nominal variables. Event variables, which denote sets of situations or actions, are like nominal variables.

### 3. Quantification in Child language

The interpretation of nominal variables by children is well-studied. It is a well-known fact that many children in the age range of 4–6 judge a sentence such as *Every witch is conjuring an apple* as an unsuitable description for the picture in (4). In the explanation for their answer, they refer to the apple “without a witch”.

- (4) Every witch is conjuring an apple.



This phenomenon, first noted by Inhelder and Piaget (1964) (in a different experimental setting), was found repeatedly by Donaldson and Lloyd (1974), Freeman, Sinha and Stedmon (1982), Brooks and Braine (1996), Crain, Thornton, Boster, Conway, Lillo-Martin, Woodams (1996), among others.

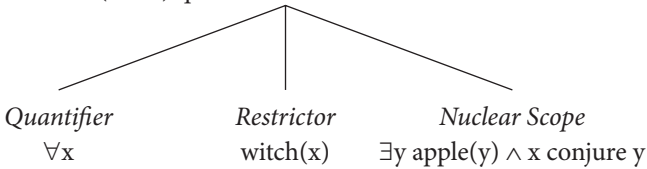
The first linguistic explanation was given by Roeper and De Villiers (1993). They proposed that the quantifier had scope over the entire clause instead of only the noun immediately following the quantifier. Roeper and De Villiers assumed that the quantifier was attached to the sentence rather than to the subject noun, as illustrated in (5a) vs. (5b). By scoping over the entire clause both subject and object nouns could be quantified over.

- (5) a. [<sub>CP</sub>[Every witch] is conjuring [an apple].]  
b. [<sub>CP</sub>Every [witch] is conjuring [an apple].]

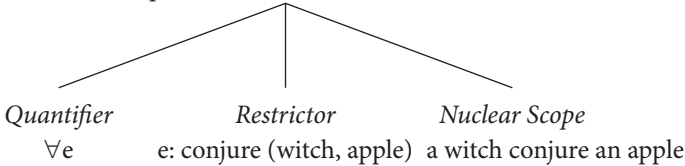
Roeper and De Villiers (1993) coined the term quantifier spreading for the children's behavior. The quantifier's effect spreads over subject and object.

Philip (1995) proposed that spreading children do not interpret the quantifier as directly quantifying over nominal variables, but rather over event variables. He argued that *every* in the case of (4) quantifies directly over the event *conjure* and all of its participants. In his view the subject and object noun phrase are as event-participants part of the event and therefore are indirectly quantified over. The adult nominal and child event quantification analyses for (4) are given in the tripartite structures<sup>2</sup> in (6) and (7).

(6) Nominal (adult) quantification



(7) Event (child) quantification



Although most thoroughly studied for English, spreading is certainly not a phenomenon restricted to English. Children learning other languages show the same behavior, including learners of Dutch (Drozd and Van Loosbroek 1999; to appear, Philip and Coopmans 1995; Hollebrandse, 2004).

Spreading has only been studied for nominal variables denoting sets of individuals. Spreading of temporal or event variables has not, to our knowledge, been studied. They are subject of study in this paper.

#### 4. Research Question

The logical representation of natural language contains different kinds of variables which bind different sorts of entities: temporal variables target times, event variables events and nominal variables individuals. Although they denote different kinds of entities, they may be bound in the same way by the same quantifiers, for example universal and existential quantifiers. Classical

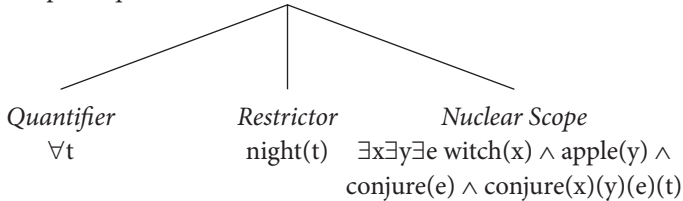
logic does not make a distinction between quantifiers and the variables they bind; there is no quantifier that only applies to a certain type of variable and not others. As far as the logical system is concerned, a quantifier binds whatever variable is available.

Children might not be that “logical”, however. Children might make distinctions between the different variables. We may expect them to have a harder time with temporal variables, because times are conceptually more abstract than individuals and events. Most individuals and events are visible in the “real” world, but temporal entities are not.

In this paper the focus is on variables denoting sets of times for sentences such as (8). The adult interpretation of (8) is given in a tripartite structure in (9).

(8) Every night a witch is conjuring an apple.

(9) Temporal quantification



The research question of this paper is: do children make distinctions between nominal, temporal and event variables? From the point of view of classical logic, children should not distinguish between sorts of variables and let their universal quantifier bind whatever variable it sees. From the point of view of cognition, children may make distinctions between variables, because the nature of the sets denoted by the different variables is very different. Temporal variables are conceptually much harder to grasp, since they are less visible in the real world than nominal and event variables.

## 5. Method and Design

Twenty-two Dutch children between the ages of 4;1 and 6;1 (mean age: 5;0) participated in the experiment, using a truth-value judgment task.<sup>3</sup> Twenty-six Dutch adults were tested as a control group. The children were told short stories accompanied by pictures which were followed by test sentences containing temporal adverbial phrases. The test sentences were of the form in (10). In the stories nights were alternated with afternoons. Other predicates we used included *zitten op* ('to sit on'), *vallen over* ('to fall over'), *liggen op* ('lie on'), *lezen* ('read'), *rennen naar* ('run to'), *slaan* ('hit'), *eten* ('eat'), *vliegen op* ('fly on').

- (10) Elke nacht tovert een heks een appel.  
 every night conjures a witch an apple  
 “Every night a witch conjures an apple.”

All children’s answers were followed up by questions of clarification, not only after rejections of test sentences, but also after confirmations.

The design contains four different conditions. Temporal information and event information are varied in these conditions. In condition A the event occurs at night in every situation. In condition B the event always occurs, but once it is during the day. In conditions C the event only occurs at night and not during the day. And in condition D the event occurs once at night, once not at night and once during the day. Conditions A to D are given in (11)–(14). The story belonging to Condition C is given in (15).

- (11) Condition A



- (12) Condition B



- (13) Condition C



- (14) Condition D



- (15) Ergens in een land hier ver vandaan wonen allemaal heksen. Heksen kunnen heel goed toveren. Deze heks heeft zin in een appel, maar de winkels zijn dicht. Daarom tovert ze een appel. ‘Hokus, pokus, pilatus pas,’ zegt de heks, ‘Ik wou dat er een appel was.’ En, kijk, daar is een appel.

De volgende nacht is er weer een heks die zin heeft in een appel. Maar ook nu zijn alle winkels dicht, omdat het nacht is. Daarom tovert deze heks ook een appel. Kijk maar! De volgende middag is er ook een heks. Deze heks staat te genieten van het zonnetje. En daar in het gras ligt een appel. Dus deze heks hoeft niet te toveren. De heks tovert geen appel.

Some witches were living, somewhere in a country far away. Witches are very good at magic. This witch fancies an apple, but the stores are closed and so she conjures up an apple. 'Hokus, pokus, pilatus pas', the witch says 'I wish there was an apple.' And look, there is an apple. The following night another witch fancies an apple. But again the stores are closed, because it is night. Therefore this witch conjures up an apple. See! The following afternoon there is yet another witch. This witch is enjoying the sun. And there is an apple lying in the grass. So, this witch doesn't need to conjure up apples. The witch does not conjure up an apple.

In addition, four test sentences targeting the classical spreading case for nominal quantification were administered, because we want to have a way of linking the child's behavior in nominal quantification with that in temporal quantification. Additionally, 10 fillers were used. The fillers contained no quantifiers.

The predictions made on the basis of different types of interpretation are given in the table in (16). Temporal quantification for *every night* gives the adult interpretation. Event quantification focuses on events (check whether every event is a conjuring event).<sup>4</sup> Condition C is the crucial case, because it distinguishes between the different ways of quantification. Taking temporal information (*nights*) into account one would accept the test sentence, since in every night situation conjuring takes place. However, if a subject only takes events into account, he or she would not accept the test sentence, because in the last situation there is no conjuring.

(16)		Condition A	Condition B	Condition C	Condition D
	temporal	T	T	T	F
	event	T	T	F	F

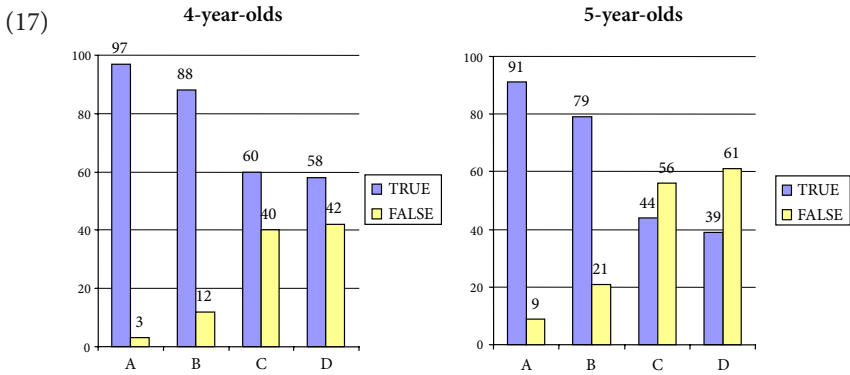
## 6. Results and Discussion

### 6.1 Results by age

The adults behaved as expected, applying the temporal quantification interpretation. There was one exception to what we predicted: 13% of the adults did

not accept condition B. The logical formula of the test sentence is  $\forall t$  (night( $t$ )  $\rightarrow$  witch conjure apple at  $t$ ). The adults who did not accept condition B might have turned the implication around, which is commonly found in natural reasoning.

Adults accept conditions A, B and C, but not D. Children have no trouble accepting conditions A and B, but the acceptance rate for C and D is much lower. Children do not make a significant distinction between Conditions C and D, as the adults did. The difference between Conditions A and B and Conditions C and D is that in A and B the event takes place in all three situations, which is not the case in C and D. Apparently, children only paid attention to the event: did it happen, or not. And they did not pay attention to temporal variables (or nominal variables (see below for further explanation)).



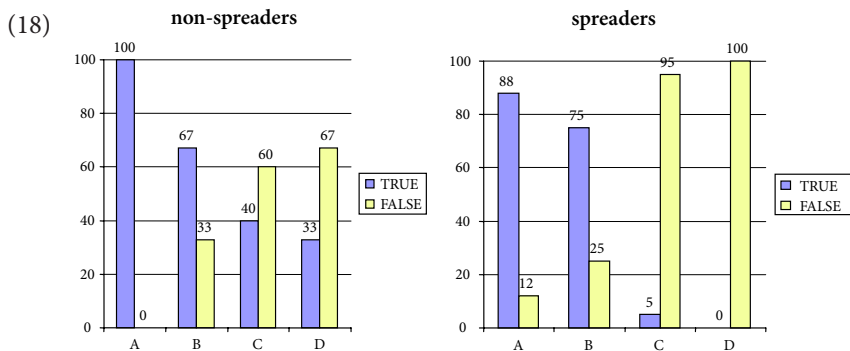
## 6.2 Results by spreaders and non-spreaders

These group results do not present a complete picture, because potential answer patterns are not included. We divided the data according to the children's behavior on the classical nominal spreading cases, of which all subjects were presented with 4 trials. Subjects were defined as spreaders if they scored 3 or 4 out of 4. Eight children (mean age: 5;1) showed spreading behavior, rejecting the sentences and explaining their answers by referring to the apple "without" a witch. Fourteen children accepted the nominal quantification sentence. However, only four of them (mean age: 5;8) gave explanations for accepting the test sentence that show quantification. Ten children (mean age: 4;9) pointed to a single event. It seems that these children did not quantify universally. They rather seem to give the test sentence an existential interpretation. We will return to this third group after we have discussed the spreaders and non-spreaders.

The results of the spreaders and non-spreaders are given in the graphs in (18). The spreaders differentiate between conditions A and B and conditions C and D (one-way ANOVA:  $p < 0,001$ ;  $F = 61,94$ ). The difference between conditions C and D is not significant, nor is the difference between conditions A and B. Spreaders do not seem to pay attention to the difference between the conditions A and B, which is time. Moreover they differ from the adults for C and D.

The non-spreaders make a distinction between the four conditions (one-way ANOVA:  $p = 0,001$ ;  $F = 6,12$ ). The difference between conditions A and B is significant (t-test (two-tail):  $p = 0,028$ ). However, they should have accepted condition B as often as condition A. The reason for the difference might be the same as for the adults (see the beginning of Section 6). The difference between conditions C and D is not significant.

The most important finding is that spreaders do not accept C and D, whereas non-spreaders waver around 33–40%. Adults make a sharp distinction between C and D. The only difference between C and D is night and day.



If it is true that these children do not take temporal information into account, as we predicted, there are two possible interpretations left. They might apply event quantification or they quantify over nominal variables. They either apply the analysis in (19b) or (19c).

- (19) a. Every night a witch is conjuring an apple.  
 b.  $\forall e (\text{conjure}(e) \rightarrow \text{witch conjure } e \text{ apple})$   
 c.  $\forall x \forall y ((\text{witch}(x) \wedge \text{apple}(y)) \rightarrow x \text{ conjure } y)$

We argue that spreading children apply an event quantification interpretation (19b). The clarifications given by the children are very insightful. Children overwhelmingly refer to events (*conjuring*), rather than to individuals (*witches* or *apples*). A typical explanations are *nee*, *daar niet* ('no, not there'), pointing to pictures.



Moreover the spreading-children do not very often refer to temporal information in their clarifications. The table in (20) shows the number of times children do refer to times, saying *hier is het geen nacht* ('here it is not night'). There is a striking difference across the groups: non-spreaders refer to times far more often than spreaders.

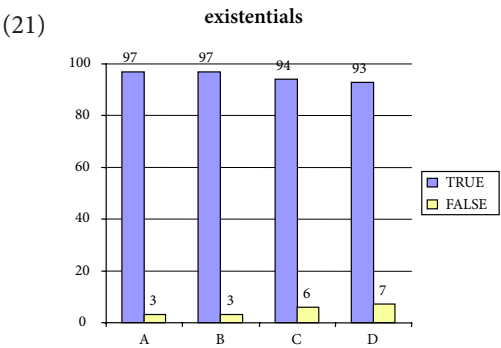
(20) Clarifications indicating times

	existentials n=10	spreaders n=8	non-spreaders n=4
raw number	4	6	20
average per child	0.4	0.75	5

6.3 Existentials

On the basis of the follow-up question to the nominal cases, a third group was established. These children accepted all test sentences, and consistently clarified their answers by pointing to one situation and not to more. We call them the existentials. This group was established on the basis of asking clarifications when the children accepted the test sentence. Usually clarifications are only asked in case of rejections (Philip, 1995; Drozd and Van Loosbroek, 1999). Asking clarifications after accepting a sentence might produce many different explanations. After all, there might be many reasons why a sentence matches a story. However, Hollebrandse and Smits (2006) found fairly coherent and certainly insightful explanations of children’s yes-answers.

When we look at their behavior on the test-sentences with temporal adverbials, they allow every case (21). They are not simply “yes-sayers”, because they reject fillers, which were false. We conclude from this that existential children accept test sentences as long as the event denoted by the predicate happens at least once.



Whether these children quantify at all remains an open question. They could arrive at their yes-answer by existential quantification (22a). Or they could interpret the test sentence as an example of (22b).<sup>5</sup>

- (22) a. There is a night at which a witch is conjuring an apple.  
b. This is a night at which a witch is conjuring an apple.

## 7. Conclusions

The results show that children differentiate the logical variables that occur in natural language. Spreading children ignore the variable denoting times completely. Non-spreading children are not up to target on it either, but use temporal information in their quantification.

The distinction between temporal variables on the one hand and nominal and event variables on the other is not a surprise from the viewpoint of cognition. Times are conceptually harder to grasp than individuals and events. Nominal variables denote individuals. Event variables denote situations/actions. Times must be a lot harder to quantify over, because they are more abstract and less visible in the world.

Furthermore, spreading-children seem to quantify over events rather than nominals. This was established on the basis of their clarifications to their accepting/rejecting of test-sentences. This supports Philip's (1995) proposal that spreaders apply event quantification in cases in which adults apply nominal quantification. We found that event quantification holds for more case (the temporal variables), than just the nominal ones.

Finally, we found a "new" group of children: the existentials. These children accept the nominal quantification cases, but their behavior is far from adult-like: they do not quantify at all.

## Notes

\* This paper benefited from discussions at the *Taalkunde in Nederland* dag and the *Groninger Language Acquisition Lab*. We especially want to thank Angeliek van Hout, Leontine Kremers and two anonymous reviewers. All errors remain ours.

1. This is a simplified version. What actually needs to be expressed here is that all "breakfast\_by\_witches" events contain a "witch\_conjures\_apple" event:

$$\forall e_1 (\text{have-breakfast}(\text{witch}, e_1) \rightarrow \text{conjure}(\text{witch}, \text{apple}, e_2) \wedge e_1 \subseteq e_2)$$

(Kamp and Reyle, 1993)

2. See Heim (1982) for tripartite structures.
  3. Thanks to children and teachers of the elementary school “*t Kruisrak*” in Buschoten-Spakenburg, The Netherlands.
  4. This is different from the view on event quantification given for example (2). However, it is more in line with Philip’s (1995) analysis of spreading.
  5. A similar case is the case of the interpretation of *wh*-words, as in (i). In this case children point to a single hat-wearer on a picture with, for instance 3 boys wearing a hat and 2 not wearing a hat (Schulz and Penner, 2002; Hollebrandse, 2002; Roeper, Pearson, Schulz and Reckling, forthcoming).
- (i) Who is wearing a hat?

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