Temporal Quantification in Child Language

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1. Introduction[1]

Nominal quantification received wide attention in Child Language research. Over and over it was found that four year old children do not apply the same restrictions to the domain of quantification as adults do. In sentences such as (1a) children include "apple" in the domain of quantification as well as 'witch'. This paper focuses on temporal quantification, which involves quantifying over times rather than individuals (1b).

(1) a. Every witch is conjuring an apple.
b. Every night a witch is conjuring an apple.

This paper is part of a larger research program, which focuses on the acquisition of variables. This program attempts to make generalizations across phenomena such as spreading of nominal variables and potential spreading of other variables. It also wants to make generalizations to work on the exhaustive nature of quantifiers (see Hollebrandse and Smits, 2006) and question words (see Hollebrandse, 2002).

At least three variables in natural language: nominal, temporal and event variables (De Swart, 1991). Quantifiers themselves do not distinguish between the variables they bind. The universal quantifier can bind any kind of variable. The difference lies in the nature of the variable that gets bound. Nominal variables denote sets of individuals, for instance, the set of WITCHES in (2). Event variables denote sets of events. They are introduced by predicates (Davidson, 1967). In (3) the variable denotes the set of events of CONJURING. Temporal variables denote sets of times (or better time-intervals). In (4) the temporal variable denotes sets of NIGHTS.

(2) a. Every witch is smiling.
b. $\forall x$ (witch(x) $\rightarrow$ smile(x))

(3) a. A witch always conjures an apple for breakfast.
b. $\forall e$ (have-breakfast(witch,e) $\rightarrow$ conjure(witch,apple))[2]

(4) a. Every night a witch is laughing.
b. $\forall t$ (night(t) $\rightarrow$ laugh(witch,t)

Despite the different denotations, all variables are treated equally by the logical system, i.e., the universal quantifier is not influenced by the set denoted by the variable. Universal (and also existential) quantifiers apply similarly to variables introduced by nominals (2), variables introduced by events (3) and variables introduced by temporal phrases (4). Put it differently, there is no specific quantifier for temporal variables, or one for nominal ones.

The difference between the different variables lies in the nature of the sets they denote. It is conceivable that nominal variables are conceptually easier to grasp than temporal ones, because nominal variables denote sets of individuals. Temporal variables denote time intervals, which are far more abstract than individuals. Event variables, which denote sets of situations or actions and they might be easier to grasp than time intervals.

This paper explores the domain restrictions on quantification for sentences such as (4). Does the quantifier only quantify over times, or are the nominal variables and the event variable in its scope as well? The main finding of this paper is that children ignore the temporal variable. The explanation for this could be simple cognitive one: temporal variables denote times and times are harder to "see"/grasp in the world around us, than individuals and events. The

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[2] 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:
$\forall e_1$ (have-breakfast(witch,e_1) $\rightarrow$ conjure(witch,apple,e_2) $\wedge$ $e_1 \subseteq e_2$) (Kamp and Reyle, 1993)

same data was discussed in Hollebrandse and Visser (2006) who tried to argue that these children quantified over event variable, which would be in the line of Philips (1995). In section 6 a slightly different view is sketched.

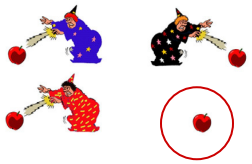
This paper also makes an important secondary observation, namely that children not always seem to quantify. The methodology of the experiment in this paper included asking questions of clarification, also after positive answers. Though the explanations rendered a fair amount of "noise" –sentence could be true for several reasons-, they also gave insight in the quantification abilities of children. A high number of the tested children did not seem to quantify.

2. Quantification

The starting point of this research is the work in the nominal quantification. It is a well-known observation that children reject the sentence in (5) as a description of the picture in (6). In their explanation children refer to the apple not "participating" in the event of conjuring (encircled in (6)). This essentially goes back to Inhelder and Piaget (1964), though they tested it in a different design.

(5) Every witch is conjuring an apple.

(6)



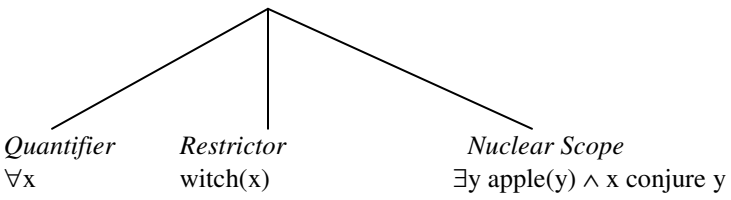
The same observation was made across various different studies (Donaldson and Lloyd, 1974; Freeman, Sinha and Stedmon, 1982; Philip, 1995; Brooks and Braine, 1996; Crain, Thornton, Boster, Conway, Lilli-Martin and Woodams, 1996; Drozd and Van Loosbroek, 1999, Hollebrandse, 2004, Hollebrandse and Smits, 2006).

This shows that children have different domains of quantification than adults. Explanations for this vary. Some proposals seek the explanation in the pragmatics of how children view and interpret pictures (Crain et. al., 1996). Others seek the solution in the presuppositions children derive in these cases (Donaldson and Lloyd, 1974; Freeman, Sinha and Stedmon, 1982; Drozd and Van Loosbroek, 1999). And other studies propose explanations in the linguistic domain (Roeper and De Villiers, 1993; Philip, 1995; Hollebrandse, 2004; Hollebrandse and Smits, 2006).

This paper is in the line of the proposal by Philip (1995). He proposes that children who include the extra object quantify over events. According to Philip this includes the individuals denoted by subject and object. His proposal is that the quantifier quantifies over the event and its participants. Roeper and De Villiers's (1993) term *spreading* would be still appropriate for this phenomenon. It reads as the effect of the quantifier spreads over other variables in the sentence. In the remainder of this paper the term *spreading* will be used, as well as the term *spreaders* for children showing the spreading phenomenon.

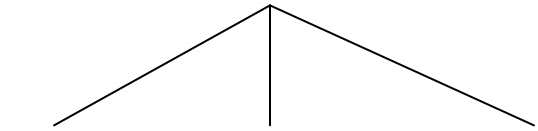
Philip' event quantification can be well depicted in a tripartite structure (Heim, 1982). Such a structure breaks up a sentence with a quantifier into three parts: *quantifier*, *restrictor* and *nuclear scope*. The adult tripartite structure for a sentence such as (1a) would be (7) in which the restrictor part is filled with the entity *witch*. This expresses is that the domain of quantification is restricted to the set of WITCHES.

(7) Nominal (adult-like) quantification



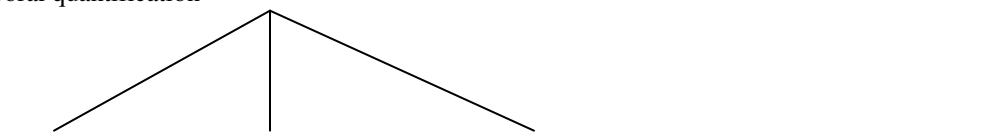
A tripartite structure for Philip's event quantification is given in (8). Here the restrictor part is filled by the event CONJURING, which on Philip's account includes the event participants WITCHES and APPLES.

(8) Event (child) quantification



A sentence with a temporal adverbial, as in (1b) has the tripartite structure in (9). This structure states that the domain of quantification is restricted to time intervals with the property NIGHT.

(9) Temporal quantification



We expect spreading children to show more freedom in the interpretation of quantified sentences, because they allow more freedom in what they put into the restrictor in a tripartite structure. The next section shows an experiment testing this.

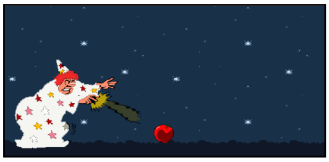
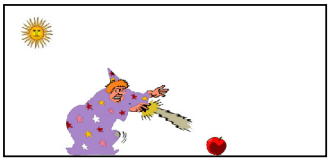
3. Methodology and Design

Twenty-two Dutch speaking children in the ages between 4;1 and 6;1 were tested in an experiment using a truth-value judgment task.[3] Twenty-six adults were tested as a control group. Twenty-six Dutch adults were tested as a control group. The test sentences were introduced by short stories accompanied by pictures. The relevant test sentences contained temporal adverbial phrases (10). An example of a trail is given in (11).[4]

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

[3] Thanks to children and teachers of the elementary school "*t Kruisrak*" in Buschoten-Spakenburg, The Netherlands.
[4] Throughout this paper the predicate *to conjure an apple* is used. And although this does not seem to be a very kid's kind of word, the Dutch version of it, *toveren*, really is a kid's word.

(11)

Weet je wat heksen heel goed kunnen? Toveren. Als een heks ergens zin in heeft, kan ze het gewoon toveren. Vannacht heeft deze heks zin in een appel. Ze tovert een appel. De volgende middag heeft een andere heks zin in een appel. 'Hokus, pokus, pilatus, pas! Ik wou dat er een appel was,' zegt de heks. En, poef, daar verschijnt een appel. De volgende nacht heeft een heks honger, maar alle winkels zijn dicht. Nou, denkt ze bij zichzelf, dan tover ik toch eten! 'Hokus, pokus, pilatus, pas!' murmelt de heks, 'Ik wou dat er een appel was.' De toverspreuk werkt! De heks tovert een appel.	  	Do you know what witches can do? Perform magic. If a witch fancies something, she can just conjure it. Tonight this witch fancies an apple. She conjures up an apple. The following afternoon another witch fancies an apple. 'Hokus pocus Pilatus pas. I wish there was an apple.' the witch says. And, poef, there was an apple. The following night a witch is hungry, but all the stores are closed. 'Well' she thinks, 'then I just conjure up an food' 'Hokus, pokus, Pilatus, pas' the witch murmured 'I wish there was an apple' It worked! The witch conjured up an apple.
hand puppet: Elke nacht tovert een heks een appel.		hand puppet: Every night a witch is conjuring an apple.

All answers to test sentences were followed up by questions of clarification. This is an innovation to previous methods. Previously these questions were only asked after rejecting the test sentence. In this experiment accepting a test sentence would also be followed up by a question of clarification.

Four different contexts were tested. In these contexts (and stories) nights were alternated with afternoons. Also the order of nights verses days were alternated. Actual trials from the experiment are given as examples in (11). Context A is a sequence of three situations, which perfectly match with the described event and time intervals in the test sentence (12a). This context aimed for a yes answer for all subjects.

The three situations in context B do not perfectly match the test sentence. One situation does not match the time interval and is therefore irrelevant (11). Only the time intervals which match the time interval denoted in the test sentence are relevant. We expect both children and adults to accept this situation, but they might accept it for different reasons. Children might, contrary to adults, include the day-time situation.

For context C the three situations do not fully match the test sentence. Two time intervals and events match with the sentence, but the third situation has a different time interval as well as a different event, than the ones denoted by elements of the test sentence (12b) Adults are expected to accept this, since the day-time situation is irrelevant. Spreading children are expected to reject this since for them it the day time situation is relevant and in context C the event does not take place.

Finally only one situation in context D fully matches the test sentence. One other situation matches only for the time interval, but not the event and the other situation only matches for the event and not for the time interval (12c). All subjects are expected to reject this.

(12) a. context A

Elke middag zit een hond voor zijn hok.
every afternoon sits a dog in front of his doghouse
"Every afternoon a dog is sitting in front of his doghouse."

b. context C

Elke nacht leest een jongen een boek
every night reads a boy a book
"Every night a boy is reading a book."

c. context D

Elke nacht springt een man op een bed
every night jumps a man on a bed
"Every night a man is jumping on a bed."

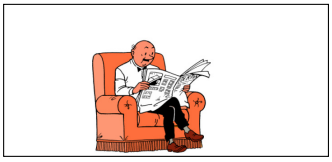
Other predicates we used included *zitten op* ('to sit on'), *vallen over* ('to fall over'), *liggen op* ('lie on'), *rennen naar* ('run to'), *slaan* ('hit'), *eten* ('eat'), *vliegen op* ('fly on').

A total of 28 test sentences were presented to the child: three for context A, B, and D; five for context C; four classical spreading cases (6); ten fillers. For the fillers sentences without quantifiers were used. They were equally divided between false and true statements. Examples of pictures and filler sentences are given in (13a) and (13b).

(13) a.

hand puppet:
De politieagent blaast op een fluitje.
the police officer blows on a whistle
"The police officer is blowing on a whistle."

b.



hand puppet:
De man kijkt televisie.
the man watches tv
"The man is watching tv."

Under the temporal quantification hypothesis we predict that context A through C will be accepted. We expect adults to fall in this category. Under the spreading hypothesis we predict that context A and B are true since the event occurs in all three situations. The difference between context A and B versus context C and D is the event occurring or not. In the first two contexts the event always occurs and in the second two contexts it does not.

4. Results

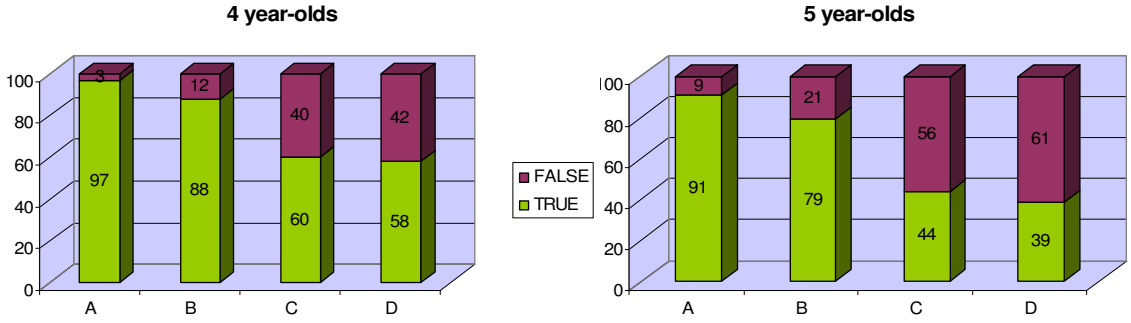
The results will first be discussed by age and then by spreading. Recall that all subjects were tested on classical spreading. It turns out that the classical spreaders show an interesting pattern: they do not take along the temporal information in interpreting the sentence. The quantifier then quantifies (or spreads) over the other variables.

Finally, an interesting group emerged by looking at the classical spreading data. A third group could be identified, which did not quantify at all.

4.1 Results by age

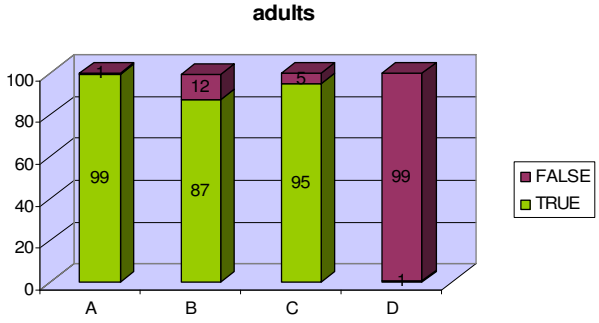
The results of the four and five year-olds are plotted in (14). They show that children more readily accept context A and B, than context C and D. A pattern of not paying attention to the temporal information seems to emerge in this data. At least there is no significant difference between context C and D here. It is the difference between these two contexts, or rather context A through C versus context D that tells the impact of temporal information.

(14)



As predicted adults accept the first three contexts and reject context D. This clearly shows that they restrict their quantifier by the temporal information given in the sentence. The data is given in the graph in (15).

(15)



The data shows an interesting dip for context B. Some of the adults do not readily accept this case. An explanation for accepting context B might be that logical implications are often turned around. Consider the implication in (16). The situation in which we went to the movies does not tell us anything about the weather situation. Quite often adults turn such implications around.

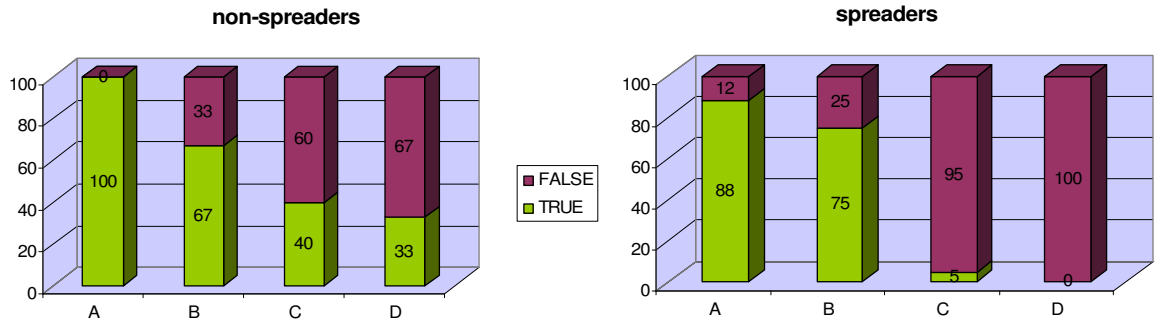
(16) If it rains, we will go to the movies.

4.2 Results by spreading

The data is much more revealing when we break them up in another way than by age. Recall that all subjects were also tested on classical spreading. In this section the results are presented broken up by spreading. Eight children (mean age: 5;1) were labeled as spreaders. Fourteen children accepted the classical spreading trials. Only four of them (mean age: 5;8) gave an adult-like justification for it. They were labeled as non-spreaders. The remaining ten (mean age: 4;9) did not seem to quantify and they will be discussed in the next section. The criterion to determine the spreaders was 3 or 4 out of 4. And even with a loose criterion as this, a striking pattern emerges.

The data from the spreaders clearly shows the distinction between context A and B versus context C and D. They accept context A and B and reject context C and D. The pattern is significant (one-way ANOVA: $p<.001$; $F=61.94$). The difference between context A and B, as well as the difference between context C and D is not significant. The right graph in (17) shows the spreader's data. The left graph is the non-spreader's data.

(17)



The conclusion that can be immediately drawn from this data is that children ignore the temporal information given in the test sentence. This comes out most clearly when the data is broken up in spreaders versus non-spreaders. Spreaders do not take the temporal information into account when they interpret the sentences. In the experiment it did not matter to them whether it was day or night. They only paid attention to whether the event occurred or not.

An additional observation can be made on the basis of the clarifications the children gave. The chart in (18) gives the number of utterance per child which contained temporal phrases. The table also gives the average of the use of temporal phrases. The subject group is divided in three. The table clearly shows that non-spreaders are using more phrases referring to times. Spreaders and non-quantifiers refer far less to times. This indicates that non-spreaders pay more attention to temporal information than spreaders and non-quantifiers do.

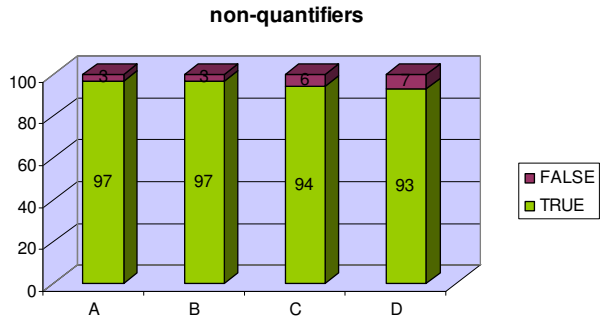
(18) Clarifications indicating times

	non-quantifiers n=10	spreaders n=8	non-spreaders n=4
raw number	4	6	20
average per child	0,4	0,75	5

5. Non-quantifiers

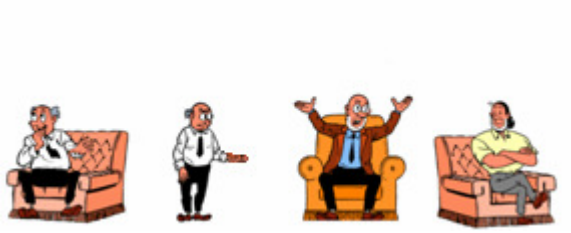
On the basis of the clarifications to the classical spreading cases, a third group was established. These children accepted all test sentences, and consistently clarified their answers by pointing to one situation and not to more.
The method of asking follow-up questions to yes-answers might render a lot of "noise" since there are many explanations why a sentence could be true. However, this method gave us surprising data. I have called these subjects non-quantifiers because they do not quantify. They also accept almost everything in the experiment (19). These children did correctly reject the false fillers. So, they are not merely yes-sayers.

(19)



This group was formed by looking at the yes-answers of the children. These children would generally be labeled as adult-like. It is important to see that they are not. The group can also be singled out by testing them on another case which differs from (6) in not having an extra object, but an extra subject (20). We predict that non-quantifiers accept the sentence *Every man is sitting on a chair* and justify their answer by pointing to one.

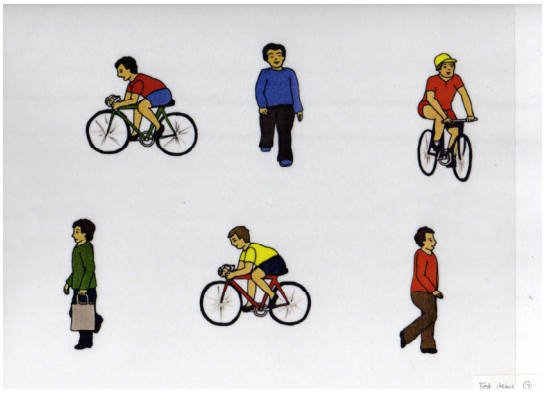
(20)



This finding is quite similar to another finding. Data from interpreting single wh-constructions also suggests that they do not quantify at all. In an experiment children had to judge (21) with regard to picture (22). Young children point to a singleton. They point to one bike-rider. Adults point to all bike-riders. This was originally done for German (Schulz and Penner, 2002) and replicated for English (Roeper, Pearson, Schulz and Reckling, 2005) and Dutch (Hollebrandse, 2002). Roeper et. al. (2005) point out similar relations to double wh cases, such as *Who bought what?*

(21) Who is riding a bike?

(22)



original picture from Schulz and Penner (2002)

6. Nominal versus event quantification

Although it is clear that spreaders do not apply temporal quantification in this experiment, it is really difficult to tell whether they distinguish between quantifying over events or individuals. The crucial case is the rejection of context

C, which is repeated in (23). They refer to the third picture, which shows that their domain of quantification is not limited to time intervals (night times in (23)).

(23) context C

Elke nacht leest een jongen een boek
every night reads a boy a book
"Every night a boy is reading a book."

Children overwhelmingly clarify rejecting context C on the basis of the third picture and refer to both agent and event. They indicate that "the boy is not running" in (23). They never refer to the agent alone (boy in (23)). It is also worthy to note that they never refer to the extra object (the non-read book in (23)). This would be the equivalent to pointing to the extra object in the classical spreading cases (the non-conjured apple in (6)).

7. Conclusion

The results show that children differentiate between 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. 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. Times are conceptually harder to grasp than individuals and events.

We also found a "new" group of children: the non-quantifiers. These children accept the nominal quantification (classical spreading) cases, but their behavior is far from adult-like: they do not quantify at all. This is an important finding, because it means that a number of children previously labeled as adult-like in the classical spreading trials might not be adult-like at all.

The important finding of this paper is that young children disregard temporal information in quantified sentences. The nature of this lies in the cognitive complexity of times and time intervals.

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