Children's Interpretation of Negative Determiners as a Window into Q-Spreading

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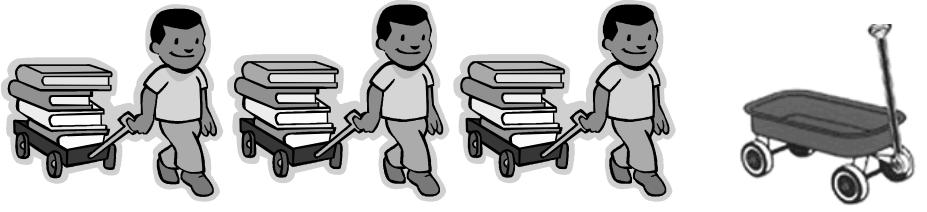
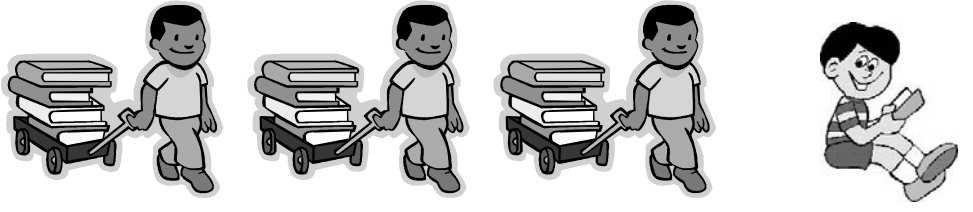
1. Introduction

The experiment reported here is aimed at investigating a phenomenon known as "quantifier spreading". I will primarily focus on the so-called classic spreading illustrated in (1) and (2).



(1) Experimenter: *Is every boy pulling a wagon?*
Child: *No, not this one* (points to the extra wagon).



(2) Experimenter: Is a boy pulling every wagon?
Child: No, not this one (points to the extra boy).

It is well-known that children, unlike adults, would frequently give a no-answer to questions like those in (1) and (2) if they are presented without overt linguistic context, but become significantly more successful if the stimuli are presented in a context enriched (or otherwise manipulated) in various ways (Crain et al. 1996, Philip and Lynch 2000, Drozd and van Loosbroek 1998, Sugisaki and Isobe 2001, Rakhlin 2004).

The main questions with regards to quantifier spreading, which have not yet been fully resolved, are whether it is a manifestation of children's misinterpreting or misanalyzing the universal quantifier in some way (via a mechanism that has been placed at the level of syntax (Roeper et al. 2004), semantics (Philip 1995), or syntax-to-semantics mapping (Geurts 2004)), and if not, what causes such errors. An issue that had not been previously addressed with regards to "classic spreading" is the role played by indefinites in triggering it, the avenue that I propose to pursue. The hypothesis that the present experiment is aimed at testing was put forward in Rakhlin 2004. According to that hypothesis, interpreting universally quantified sentences with indefinites in conditions of contextual asymmetry, particularly visual asymmetry, causes "classic spreading", the term I will continue to use for convenience. I believe this approach can account for a wide range of existing experimental data, which was difficult to unify previously. One question that is especially intriguing and that can be answered straightforwardly within this account is why the children's rate of errors declines if the picture shown

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to them has multiple extra objects instead of a single extra object, as was reported by Sugisaki and Isobe 2001.

In Rakhlin 2004 I hypothesized that visual asymmetry triggers "spreading" responses not because of children's deviant semantic form, in which the universal ranges over both the agent and theme NPs and consequently requires the denotations of the two to be 'symmetrical' (i.e. members of the agent-set exhaustively paired with those of the theme-set and vice versa). Instead, I suggested that contextual asymmetry (an unpaired individual with the property denoted by the indefinite) causes "q-spreading" because children use the asymmetry in the visual context as a pragmatic clue when deciding how to select domain restrictions for the indefinite. Thus, if the picture contains a number of boy/wagon pairs and a salient unpaired wagon (in case of the sentence "every boy is pulling a wagon"), children are likely to see its visual salience as an indication of its relevance for the speaker and construct the domain restriction for the indefinite to include exactly one object – the extra wagon. Consequently, the sentence receives "wide scope" indefinite interpretation, false in the situation depicted in this scenario.

1.1 Quantifier Domain Restrictions

It is well known that semantics of quantification must reflect the fact that quantifiers range over relevant individuals. Covert quantifier domain restrictions are the linguistic mechanism of expressing the notion of "relevant" (Westerstål 1984, von Fintel 1995). The question of how covert domain restrictions work has not been fully settled in semantic literature. However, under one standard view, they are represented as silent pronoun-like elements, adjoined as a sister to the common noun phrase argument of the quantifier. A common notation for covert domain restrictions is a subscripted C next to the common NP, as shown in (3). A simplified semantic form of the expression 'every boy rode a pony' is given in (4):

(3) Every boy_C rode a pony.
↑
context supplies its value: e.g. ***"who came to Sam's birthday party"***

(4) Every [C & boy][rode a pony],
where C={x: x is a guest at Sam's birthday party}

1.2 What about indefinites?

Similarly to other quantifiers, indefinites also come with domain restrictions. Thus, complete semantics of (3) involves not only a choice of the relevant boys (the value of C), but also of the relevant ponies, which may be expressed as the value of C'. The choice of value for C' has particularly important consequences for the interpretation of (3) when the choice in question is between including multiple individuals or a single individual in C'. This is illustrated in (5):

(5) $\forall x$ [x is in C & x is a boy $\rightarrow \exists y$ [y is in C' & y is a pony & x rode y]]
↑
$Context_1$: "*the ponies Sam's parents hired for the birthday party*" or
$Context_2$: "*the white pony with a red saddle blanket*"

If C' receives the value of a set containing multiple ponies, this would give a non-specific interpretation for the indefinite and allow co-variation of boys and ponies:

(6) For every relevant boy x, there is a (possibly different) pony y, such that y is a member of the set containing $Pony_1$, $Pony_2$, $Pony_3$… and x rides y.

If it receives the value of a singleton set, this would give a "referential" or specific indefinite, identical to one in which the indefinite has syntactic wide scope:

(7) For every relevant boy x, there is a pony y, such that y is a member of the singleton set containing $Pony_1$, and x rides y.

1.3 Singleton indefinites

This theory of indefinites was put forward by Schwarzschild 2001, who maintained that all indefinites are existential quantifiers, and the notorious 'quantificational'/'referential' ambiguity of indefinites is due to their ability to alternate between domain restrictions containing multiple individuals and the narrowed singleton ones. The narrowing can be done either explicitly or implicitly, further obscuring the picture. Indefinites with narrowed singleton domains ("singleton indefinites") may appear to be referential and to have exceptional scope-taking properties. This analysis was put forward in order to account for certain unexpected readings sentences with indefinites can have. Thus, singleton indefinites can account for the unexpected readings in examples like (8) (from Fodor & Sag 1982), in which the indefinite takes scope out of an extraction island, with its exceptional scope reading shown in (9):

(8) *If a relative of mine dies, I will inherit a fortune.*
(9) ∃x [x is a relative of mine and [if x dies, I will inherit a fortune]]

According to Schwarzschild, indefinites are able to scope out of islands semantically, without covert syntactic movement. If the context provides a restriction for the domain of the indefinite that makes it a singleton set, then (8) will be truth-conditionally equivalent to a sentence in which the indefinite has syntactic wide scope over the conditional, making it unnecessary to posit a scope altering syntactic operation. Surface scope will suffice to get such readings:

(10) If ∃x [C(x) and relative-of-mine(x) and dies(x)], I will inherit a fortune;
where C={Aunt Petunia}

Even if the 'singleton indefinite' analysis is not necessary for examples like (8) since they can be accounted for simply by positing lexical ambiguity between quantificational and referential indefinites, it has the advantage over the ambiguity theory with respect to handling the intermediate scope readings. Thus, sentence in (11) has a reading in which the indefinite appears to scope above the conditional, but not above the universal, as shown in (12):

(11) *Every member of the club is convinced that if a (particular) relative of his dies, he will inherit a fortune.*

(12) ∀x [member-of-the-club(x) → ∃y [C(y) & relative-of-x(y) & x is convinced that if y dies, x will inherit a fortune]]

Here the indefinite scopes over the conditional, but is clearly not referential since there is co-variation between club members and the relatives whose death would bring a financial windfall to their beneficiaries. However, if the context supplies the domain restriction relativized for each x (C_x) and containing exactly one individual, then we would get the desired reading without having to move the indefinite out of the conditional into the intermediate position, as shown in (13):

(13) ∀x [member-of-the-club(x) → x is convinced that if ∃y [C_x(y) & relative-of-x(y) & y dies], x will inherit a fortune]

The conclusion we should make from examples like (11) is that indefinites with unexpected wide scope interpretations are simply singleton indefinites with a contextual domain restriction supplementing the overtly expressed restriction. As noted by Schwarzschild, any indefinite in principle can have a singleton domain restriction, introducing a vagueness that, as I suggest, makes them difficult for children, particularly when context is deficient.

1.4 What about children?

We have established that when the context provides a unique individual for the domain restriction of the indefinite, the syntactic scope is neutralized (i.e. reversing the scope relations syntactically would result in the identical truth conditions), and the indefinite appears to have wide scope. This observation is important for the question of q-spreading because it illuminates how the child, while possessing full semantic competence of quantification, including the knowledge of context dependency of quantifier domains, would err when integrating contextual information to fix quantifier domains. It is quite plausible that children would make mistakes in their judgments about what counts as relevant or salient to others, given their developing ability to 'read' other minds. In regular discourse, there are strong pragmatic clues helping the child in this task. However, in experiments providing poor linguistic context, such as those in which context is represented schematically as a picture of individuals participating in an activity, and with no information about the relative relevance of the individuals shown in a picture, they may construct 'singleton indefinites' when not intended by the experimenter. This approach explains why the errors are minimized in those experiments in which rich linguistic context is provided or in which the picture relative relevance of participants is clarified in some way, e.g. by placing the irrelevant individuals in the background or by minimizing their visual salience in other ways (such as increasing their number).

2. Experiment

If this hypothesis is correct in maintaining that the main culprit in q-spreading is not the universal quantifier, but the indefinite, we can ask ourselves whether children will respond in a "q-spreading"-like manner to sentences containing an indefinite and a quantifier of another type, instead of the universal, given that the sentences are presented under the typical "spreading" inducing conditions, e.g. visual context with a salient single "extra" individual.

Goal: to test the following hypotheses:

- Q-spreading-like errors can be elicited with sentences containing the negative determiner given that the sentence contains an indefinite and the context contains a salient single individual to be a potential candidate for a singleton domain restriction for the indefinite.
- The error rate can be manipulated by controlling the degree of visual salience of the extra individual.

Method: a version of the standard Truth Value Judgment Task. After a training session, children were shown pictures similar to those in (16) – (17) and were asked to judge the truth-value of target sentences like those in (14) - (15). The variable property across two of the main experimental conditions I will discuss first was the degree of visual salience of the extra individual in the object set (salient single extra object and non-salient multiple extra objects). Each experimental condition consisted of 4 sentence/picture pairs presented in a fixed random order plus the same number of control items. No linguistic context was given (no background story) to replicate the contextual paucity that typically gives rise to q-quantifier-spreading errors. Prior to presenting the target sentence, children were asked to point out who was in the picture to ensure its full comprehension. After that, the puppet uttered the test sentence, and the child was asked to judge whether the puppet's description of the picture was correct.

Subjects: 19 preschool children (M=4;6); 3 were excluded after failing the training, bringing the size of the sample to 16. Five adult control subjects have also been interviewed.

Materials: sentences like those in (14) and (15) presented in the contexts of pictures like those in (16) and (17):

(14) No boy is hugging a dog.
(15) No girl is holding a cat.

(16) Salient (single) extra object:

(17) Multiple (non-salient) extra objects.

Control condition:

(18) No boy is hugging a dog (No-control)

(19) No boy is holding a cat (Yes-control)

Results: According to the pattern of responses, the children were divided into the following two groups:

- The adult-like group, who correctly rejected all but the NO-control sentences - 6 children (and all of the adults in the control group).

- The 'spreading' group - 10 children, who judged as true at least three out of 4 test items of at least one type.

In a typical 'q-spreading' experiment, the errors, which for convenience I will call instances of 'q-spreading'**,** are odd 'no'-responses given by many children if the picture-contexts show participants in an event and their schematic relationships with each other (e.g. boys riding ponies), and in which there is a distribution of participants across sub-events, but with a lack of one-to-one correspondence between the members of the restrictor set of the universal quantifier and that of the indefinite, e.g. there is an extra theme-type individual. We obtained strikingly similar responses, which were odd 'yes'-responses to sentences with the negative determiner when the picture contained an extra theme-type individual. Such responses were given even though the children had successfully pointed out the multiple dog-hugging boys before the test sentence was presented. Similar to the 'q-spreading' children in typical tests on universally quantified sentences (e.g. Philip 1995), these children often accompanied their 'spreading'-like responses with pointing to the extra individual and saying, "not this one" or "he means this one". This finding suggests that there is a reason to regard both the negative determiner errors and the universal quantifier errors as stemming from the same underlying cause.

The second finding was that, as predicted, the condition in which the extra individual was salient (the 'single extra object condition') produced the highest rate of errors, analogous to the findings with universally quantified sentences in Sugisaki and Isobe (2001). This suports the idea that the nature of 'spreading' errors is independent from children's grammatical competence, and is tied to a pragmatic strategy they use to narrow domain restrictions of quantifiers, in this case of indefinites. The varying rates of errors across the experimental conditions are shown in figure 1.

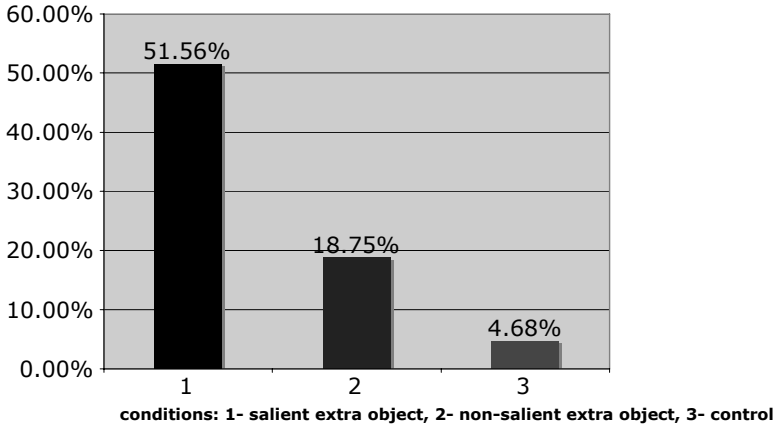


fig. 1 Error rate across conditions

3. Discussion

We can ask whether the adverbial theory of universal quantification (Philip 1995) can be extended to account for these errors. The answer seems to be that we cannot, at least not without drastically modifying the lexical semantics of "no" (such as making it to mean something along the lines of 'not every'). If we simply adopt the event quantification semantics for sentences with the negative determiner preserving their meaning of an empty intersection between sets, we would get the semantic form like that in (20):

(20) ∀e [a boy or a dog participates in e] [it's not the case that boy hugs dog in e]
"For every event in which a boy or dog is a participant, it is not the case that a boy hugs a dog".

A sentence construed this way would be falsified by any dog-hugging boy, which leaves the 'yes' responses we elicited unexplained. The correct truth conditions can, however, be captured by means of a contextually narrowed quantifier domain without altering the regular adult semantics of the negative determiner. For those children who accepted (14), the sentence is interpreted as containing an implicit domain restriction, something like the one given in (21):

(21) "No boy is hugging a *fluffy white* dog *over here*".

The abbreviated semantic representation of this sentence is shown in (22):

(22) ∀x [boy(x) → ¬∃y[C(y) & dog(y) & x hugs y]]
C={x: x is a fluffy white dog}

A conclusion that I suggest we should make is that visual asymmetry is responsible for the negative determiner errors (and I would argue for 'classic spreading' in general), particularly when the asymmetric individual is highly salient. This happens because the visual context serves as a pragmatic clue, particularly when the experimental design offers no linguistic context to supply that information. This asymmetry is interpreted as an indication of the relative relevance of the individuals in the picture: the salient extra dog is perceived as the most relevant and included into the singleton domain restriction for the indefinite. This allows for a yes-response, since there clearly is a dog such that no boy is hugging it (or no-response if the target sentence is universally quantified).

3.1 Finding values for the domain restriction variables

If children's semantics of the negative determiners is adult-like, we can ask why adults don't make the same type of errors. The answer has to do with the observation that for adults, sentences like the one in (14) uttered in the context of a picture is most readily understood as being about all of the individuals in the picture. As was observed by Kratzer (2004) in her discussion on covert domain restrictions in adult grammar, the utterance in (23) is most readily understood as being about everybody in the room where the sentence is uttered. It would be judged false if only a subset of the people present in the room is smiling, even if there is a highly salient feature distinguishing the group of smilers (e.g. everyone who is smiling is wearing a red hat). Likewise, (24) would be judged false if there are any smilers in the room, even if the non-smilers share a highly salient feature.

(23) Everybody$_C$ is smiling.
(24) Nobody$_C$ is smiling.

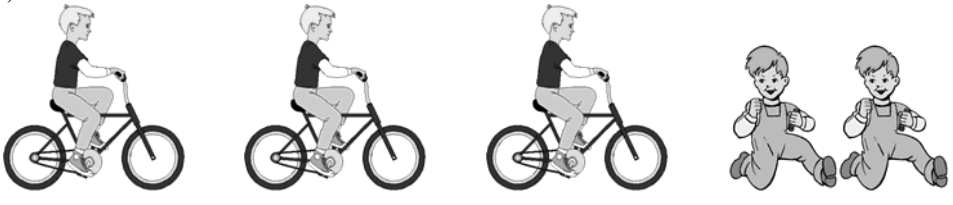
These examples show that for adults, properties of individuals, even very salient ones, are not readily picked up as values for domain restriction variables. This is, however, exactly what I claimed occurred with the children in the present experiment. The contrast between adults and children, however, becomes less drastic if we consider the following observation. The difficulty of picking up sub-properties as values for covert domain restrictions holds true only in an out-of the-blue context. Thus, if one utters 'every boy is smiling', and points at a picture, the listener would obligatorily interpret 'every' as ranging over all of the boys in the picture, and not any subset thereof, regardless of any visually distinctive features some of them may share. However, such narrowing is possible in natural discourse. Let's imagine example given in (26) uttered in the following situation:

(25) *Situation*: department meeting where both students and faculty are present. The head of the department announces that according to the new regulations, the students who miss generals' deadlines will no longer receive department funding.
(26) A person present in the room: Now everybody is worried.

There is intuition that the sentence may be judged true even if only the students present at the meeting are worried. From this, we see that in a natural discourse, there are contextual clues when domain restrictions are narrowed. Without such overt clues, adults assume that the maximal set of individuals present in the situation has to be filled as the value for the domain restrictions. Children, on the other hand, do not always obey this strategy and may adjust domain restrictions without overt linguistic context. This may be, as I stipulated earlier, due to their over-interpreting the visual information as a pragmatic clue that can be read by the interlocutors. One additional piece of evidence that this unexpected domain narrowing occurs comes from the so-called under-exhaustive errors, another type of errors usually included under the umbrella term of quantifier spreading. The error is illustrated in (27):

(27) Experimenter: Is every boy riding a bike? (uttered in the context of (28))
Child: Yes

(28)

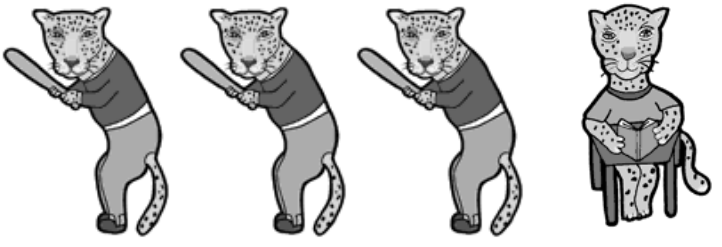


While it is difficult to explain this type of response under the event quantification theory, it can be straightforwardly analyzed as the child's having narrowed the domain for 'every' to include only the boys deemed relevant, something an adult would do only if the context contained explicit clues for such narrowing.

I would like to suggest that the freedom with which children behave when making assumptions about narrowing domain restrictions in situations of contextual paucity is the property in which they differ from adults and which is responsible for "q-spreading". This phenomenon may be related to children's weaknesses in the area of the Theory of Mind, which I understand broadly as a cognitive module responsible for our making fairly accurate conjectures about the content of others' minds, including gauging how much is known to others in a given situation. I would like to suggest that the underlying issue responsible for children's mistakes in constructing quantifier domain restrictions is their weakness in attending to others' access to information and making a connection between the sources of information and their epistemic effects on others, well-documented in the Theory of Mind literature (e.g. Wimmer, Hogrefe, & Perner 1988, Taylor 1988 among others). Given this weakness, it is not unreasonable to expect children to be freer than adults in narrowing the domain restriction without overt linguistic context.

I have found additional evidence that children's domain restrictions are more flexible than those of adults (Rakhlin 2006 in preparation). When the children were shown pictures like those in (29) and asked to judge the truth of the sentence below, they unanimously accapted it as true:

(29) Puppet: One jaguar is reading a book, but every jaguar is playing baseball.
Child: True (≈100% in the 16 3-5-year-old children tested).



In contrast, their responses to the following controls were nearly 100% corect. The difference is that for 'both', the size of the quantifier domain restriction is fixed by lexical semantics, and "both" requires it to consist of exactly two individuals:

(30) Puppet: One cat is eating, but both cats are sleeping.
Child: No, only one is sleeping.

Adult controls responded to (30) with squeamishness equal to that with which they responded to (29), judging both as contradictions.

3.2 Experiment, Part II: the extra subject condition

In addition to the general 'flexibility' of quantifier domains, there was another non-adult-like property I have uncovered in the experiment, namely in the 'extra subject' condition I will present next. In this condition, the target sentences had the same structure as in the two test conditions discussed above, but the pictures contained an extra individual of the same sort as the agent, illustrated in (31):

(31) Puppet: No boy is hugging a dog.
Child: Yes (points to the extra boy)




In our sample, this type of response was given at the rate of 26.56 %, lower than in the 'salient extra object' condition, but higher than in the 'non-salient extra object' condition. Here again, the non-adult-like children seem to narrow the domain, but in this case it is the domain of the negative determiner that is narrowed to include a single boy, an option normally rejected by adults. This suggests another difference between adults and children: children allow singleton domain restrictions for those quantifiers that disallow them in adult gramamar. Thus, for adults, sentences with the negative deteriminer like that in (31), denote empty intersections, in our example between a set of boys and a set of dog-huggers, and require the set of boys to be non-singelton. The sentence is odd in a situation in which there is only one boy as a denial that the one contextually relevant boy hugged a dog (it is acceptable if understood as 'non-specific', denying that any boy huged a dog). Children do not seem to have this 'anti-uniqueness' requirement.

There is independent evidence that children do not obey the 'anti-uniqueness' for another quantifier that requires it for adults, namely the universal quatifier 'every'. In the study by Yatsushiro and Sauerland (2004), children were shown to allow singleton domain restrictions for "every", an option disallowed by adults. In their study, Y&S investigated children's knowledge of the presuppositions of 'every' – the existence and the anti-uniquness presuppositions. The former requires the context for a universally-quantified sentence to contain a non-null set of individuals of the sort denoted by the common noun of the universally quantified NP. The latter requires this set not to have the cardinality of one. These properties of the universal quantifier are illustarted in the following example. Both (33) and (34) are true in the context of (32), but each violates one of its presuppositions:

(32) Context**:** a boy named Johnny, his parents, his one red-headed sister, two brothers, no grandparents.

(33) Johnny: Every grandma of mine is wearing red pants. (existence presupposition is violated).

(34) Johnny: Every sister of mine has red hair. (anti-uniquness presupposition is violated).

Y&S found that while children had a high rate of correct responses with (33) - 72% correct, with (34) there was only a low 32% of correct responses. Based on these results, as well as the results we obtained on the 'extra subject' condition, we can conclude that children allow "every" and "no" to combine with singleton domains, which are disallowed by adults. This conclusion is consistent with the Yatsushiro and Sauerland's hypothesis, which is based on the theory of presuppositions in Heim (1991). It holds that some presuppositions are inherent in the lexical semantics of the expressions, while others are implicated. The two types of presuppositions follow separate acquisition paths, with the implicated presuppositions being harder. Thus, the existence presupposition, which children know, is lexically encoded for "every", while the anti-uniqueness is derived as an implicature via Heim's principle "Maximize Presupposition". It states that if there are logically equivalent expressions that differ only with respect to their presuppositions, the one with the strongest presuppositions that are satisfied must be used. Consequently, using the expression with a weaker presupposition entails that the stronger presuppositions are not satisfied. According to this, the anti-uniqueness of "every" (and "no") arises as an implicature because a potential more informative alternative ("the") is not used. According to the findings by Y&S, as well as the result from the present study, children do not reliably calculate this implicated presupposition and hence lack the anti-uniqueness requirement or "every" and "no".

4. Conclusion

The experiment presented here showed that when asked to judge the truth-value of sentences with the negative determiner, children produce errors strikingly similar to those elicited with universally quantified sentences. In the analysis that I proposed, children are adult-like in

- formal semantics of quantification, including
- the knowledge that domain restrictions are contextually determined.

The errors are caused by the following properties in which children are different from adults:

- Children allow the value of the covert domain restrictions to be set with subsets of the given individuals if these individuals share a salient property. Such domain narrowing (including narrowing it to a singleton set) occurs under the conditions in which adults may not allow it (e.g. if the context is too poor);
- Due to a weakness in their ability to calculate implicated presuppositions, children allow singleton domains for the quantifiers that in adult grammar do not allow them.

I have conjectured that the root cause of these differences lies in certain aspects of children's developing Theory of Mind (TOM). The aspect of TOM, which, I believe, is of relevance to the phenomena I am investigating is children's ability to attend to others' access to information and to use it to monitor and update their representation of others' mental states. Research has shown that children have difficulty extrapolating the contents of one's beliefs and knowledge from observing one's access to information. Some researchers found this problem to be so extreme that they claimed that children under 4 years of age "have no idea of where knowledge and belief come from" (Wimmer, Hogrefe, and Sodian 1988). This deficiency diminishes slowly and gradually until the adult-like level is reached some time between at the ages of 8 and 12.

One experiment investigating children's ability to make correct connections between sources of information and their epistemic effects on others was conducted by Taylor 1988. In her study, she tested children ages 3- to 8-years-old. The child was shown a picture of two animals, which was subsequently covered, with only a detail showing through the cover. Then the child was asked whether a puppet (who the child was told had not seen the picture before) knew whether the picture contained the animals by looking at the picture with a cover on. The question was repeated with the visible part of the picture of varying size – an empty one, one showing only an edge of a line, one with a small non-descript part of one of the two objects, one with small non-descript parts of both objects, and finally one with a part sufficient to identify one of the objects. Results showed that only the 8-year-old group consistently gave correct answers, denying knowledge in all but the last condition – when an identifiable part of the object was showing. Children in all other age groups (3-, 4-, 5-, and 6-year-olds) over-attributed knowledge in all but the "empty" conditions.

The conclusion we can draw from such experiments is that tasks in which children have to figure out what others know present significant difficulty for them, causing them to use some faulty strategy. Further research is needed to investigate children's ability to infer the epistemic effects of linguistic context on another person and the consequences for semantic interpretation that may arise from any deficiency in this area. In the light of the previous studies, it is plausible to expect deficits in being able to make correct assumptions about what another person would know after being exposed to a certain context. This deficit has interesting implications for research in children's semantic competence since many aspects of interpretation rely on the interlocutors' ability to "read" each other's mind, i.e. to understand what information is salient, relevant, and/or sufficient for one's listeners to be able to interpret their contributions to discourse correctly. I believe that studying correlation between such phenomena as q-spreading and the weakness in knowledge attribution presents a productive avenue for further research and can lead to a better understanding of other types of interpretive errors, currently being attributed to non-adult-like grammar.

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