# Children’s Restrictions on the Meanings of Novel Determiners: An Investigation of Conservativity

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## 1. Introduction

Testing children’s abilities to acquire novel words tells us about the word meanings that children will and won’t entertain as hypotheses, and therefore about the range and limits of the word meanings permitted by the language faculty. We examine children’s learning of determiner meanings, in order to investigate whether a well-established typological generalisation might derive from a constraint on language learning. Specifically, all attested natural language determiners are conservative (defined below), and we compare children’s abilities to learn a conservative determiner with their abilities to learn a nonconservative one. We find that children succeed in learning a novel conservative determiner but fail to learn a novel nonconservative determiner, suggesting that the typological generalisation is a result of constraints on children’s hypothesis space of determiner meanings.

The paper proceeds as follows. In section 2, we review the relevant background concerning determiners and conservativity. In section 3, we introduce two novel determiners, *gleeb* and *gleeb*$'$, which are conservative and nonconservative, respectively; in section 4, we present an experiment where we attempt to teach children these determiners. We present the results in section 5 and conclude in section 6.

## 2. Determiners and conservativity

The class of determiners includes words such as *every*, *some* and *most*. These words can occur in the syntactic frame illustrated in (1).[1]

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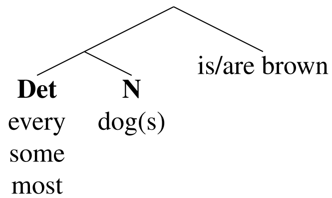
[1] We remain agnostic about many of the details of the syntax of these sentences, and for this reason limit our attention to quantifiers in subject positions. What is important is just that “determiner” is defined distributionally as something that combines with a noun to form a noun phrase.

(1)

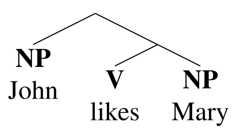



Sentences with this form express a relation between two sets: the set of dogs, and the set of brown things. If we represent these sets by $\mathrm{DOG}$ and $\mathrm{BROWN}$ respectively, the truth conditions of the three sentences abbreviated in (1) can be expressed as in (2).

(2) *every dog is brown* is true iff $\mathrm{DOG} \subseteq \mathrm{BROWN}$
*some dog is brown* is true iff $\mathrm{DOG} \cap \mathrm{BROWN} \neq \varnothing$
*most dogs are brown* is true iff $|\mathrm{DOG} \cap \mathrm{BROWN}| > |\mathrm{DOG} - \mathrm{BROWN}|$

An analogy can be made between the syntactic role of determiners and that of a transitive verb such as *like*. A determiner expresses a relation between two **sets**, much as a transitive verb expresses a relation between two **individuals**: (3) indicates that a particular relation holds between John and Mary.

(3)




The transitive verb *like* combines first with *Mary* and then with *John*, resulting in a sentence that expresses a relation between the two corresponding individuals. If we ignore the linear order of the trees and consider only the hierarchical relations, we see that the determiners in (1) likewise combine first with *dog(s)* and then with *is/are brown*, resulting in a sentence that expresses a relation between the two corresponding sets. We call *Mary* and *dog(s)* the **internal** arguments, and call *John* and *is/are brown* the **external** arguments.

Standard approaches to natural language semantics (eg. Heim and Kratzer (1998) and Larson and Segal (1995) among many others, following Mostowski (1957) and Montague (1974)) postulate that knowing the meaning of a determiner is knowing which of all the conceivable two-place relations on sets the determiner expresses, just as knowing the meaning of the transitive verb *like* is knowing that it expresses “the liking relation” on individuals. Thus the three determiners in (1) are associated with the following three relations on sets:

(4)
$$\mathcal{R}_{\text{every}}(X)(Y) \equiv X \subseteq Y$$
$$\mathcal{R}_{\text{some}}(X)(Y) \equiv X \cap Y \neq \varnothing$$
$$\mathcal{R}_{\text{most}}(X)(Y) \equiv |X \cap Y| > |X - Y|$$

and so the sentence *every dog is brown*, for example, in which the internal argument of *every* denotes the set DOG and the external argument of *every* denotes the set BROWN, is true if and only if $\mathcal{R}_{\text{every}}(\mathrm{DOG})(\mathrm{BROWN})$ is true.

When the determiners of the world's languages are analysed in this way, a surprising generalisation emerges (Barwise and Cooper, 1981; Higginbotham and May, 1981; Keenan and Stavi, 1986): every attested determiner expresses a relation that is conservative, as defined in (5).[2]

(5) A two-place relation on sets $\mathcal{R}$ is **conservative** if and only if the following biconditional is true:

$$\mathcal{R}(X)(Y) \iff \mathcal{R}(X)(X \cap Y)$$

For example, consider the English determiner *every*. This determiner is conservative[3] because the relevant biconditional holds.

$$\mathcal{R}_{\text{every}}(X)(Y) \iff X \subseteq Y \iff X \subseteq (X \cap Y) \iff \mathcal{R}_{\text{every}}(X)(X \cap Y)$$

To think about this more intuitively we can express the crucial biconditional in natural language. Since the requirement entails that $\mathcal{R}_{\text{every}}(\mathrm{DOG})(\mathrm{BROWN})$ holds if and only if $\mathcal{R}_{\text{every}}(\mathrm{DOG})(\mathrm{BROWN} \cap \mathrm{DOG})$ holds, and since $(\mathrm{BROWN} \cap \mathrm{DOG})$ is the set of brown dogs, the crucial biconditional is "every dog is brown if and only if every dog is a brown dog". This is trivially true, and so *every* is conservative.

Another intuitive view of what it means for *every* to be conservative is that in order to determine whether a sentence like *every dog is brown* is true, it suffices to consider only dogs. The brownness or otherwise **of dogs** is relevant, but the brownness of anything else is not. Barwise and Cooper (1981) call this "living on the internal argument", since DOG is the set denoted by the internal argument of *every* in this sentence. Other members of the set denoted by the external argument, BROWN, can be ignored.

We can now observe that both *some* and *most* are also conservative: to determine whether *some/most dogs are brown* it is safe to ignore any brown things are not dogs. Alternatively, we can note that both the following biconditionals are true: (i) "some dogs are brown if and only if some dogs are brown dogs", and (ii) "most dogs are brown if and only if most dogs are brown dogs".

For comparison, consider a fictional determiner *equi*. The relation that this determiner expresses is illustrated in (6).

[2] Two apparent counterexamples are *only* and *many*. Closer examination quickly shows that *only* is not a determiner, as defined distributionally. While at first *only dogs are brown* looks superfically like *some dogs are brown*, *only* can appear in many other positions where *some* and *every* cannot, eg. *dogs only/*some/*every are brown*, and *dogs are only/*some/*every brown*. The case of *many* is less clear, complicated by context-dependence, but can also plausibly be made to fit with the conservativity generalisation; see for example Keenan and Stavi (1986) and Herburger (1997).

[3] We systematically overload the term "conservative", using it to apply both to relations as defined in (5) and to determiners that express such relations.

(6) a. $\mathcal{R}_{\text{equi}}(X)(Y) \equiv |X| = |Y|$

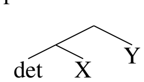
b. *equi dogs are brown* is true iff $|\text{DOG}| = |\text{BROWN}|$

So *equi dogs are brown* is true if and only if the number of dogs (in the relevant domain) is equal to the number of brown things. Note that brown things that are not dogs **are** relevant to the truth of this sentence. To verify this claim it does not suffice to consider only dogs, so *equi* does not "live on" its internal argument. We can also observe the falsity of the crucial biconditional: $|\text{DOG}| = |\text{BROWN}| \iff |\text{DOG}| = |\text{DOG} \cap \text{BROWN}|$, or "the number of dogs is equal to the number of brown things if and only if the number of dogs is equal to the number of brown dogs". Thus *equi* is not conservative.

The absence of nonconservative determiners is problematic for standard theories of semantics, on at least one view of what these theories aim to account for: ideally, it would be desirable for the mechanics of a semantic theory to allow determiners with all and only the meanings that the human language faculty allows. Following familiar reasoning about the relationship between innate properties of the language faculty and linguistic typology, a reasonable hypothesis to consider is that the lack of nonconservative determiners in the world's languages derives from the inability of the human language faculty to associate the structure in (1) with the claim that a nonconservative relation holds between the set of dogs and the set of brown things. The overwhelming majority of current theories, however, are equally compatible with conservative and nonconservative determiners, essentially predicting that the language faculty should be able to associate the structure in (1) with either kind of relation (but see Pietroski (2005), Bhatt and Pancheva (2007) and Fox (2002) for some exceptions).[4]

In this paper, we investigate whether children allow the structure in (1) to express nonconservative relations. If children permit (1) to be associated with a nonconservative meaning, then a semantic theory which permits nonconserva-

[4]To elaborate, a theory of semantics might in principle allow the words of a certain syntactic category too small a range of possible meanings, or too large. A theory might allow determiners **too small** a range of meanings by, for example, requiring that the structure in (i) is associated with a claim that a relation expressible first-order predicate logic holds between $X$ and $Y$. This would incorrectly exclude the meaning we need to associate with *most*, which requires a more powerful logic. Alternatively, a theory might allow determiners **too large** a range of meanings by permitting the structure in (i) to either express a two-place relation between the set $X$ and the set $Y$, or a three-place relation between the set $X$, the set $Y$, and some other set. We never see the human language faculty making use of this latter three-place option, so we suppose that the option is not there and prefer theories that do not allow it. The case of conservativity is analogous: if we never see the human language faculty making use of the ability to learn nonconservative determiners, we would prefer theories that do not allow it.

(i)


tive determiners would appear to be an accurate reflection of the workings of the human language faculty, and the lack of nonconservative determiners in natural languages would need to be explained by something else. However, in the experiment we report below, we find that children do not consider nonconservative meanings for novel determiners, supporting the hypothesis that the language faculty is unable to associate the structure in (1) with a nonconservative relation and strengthening the case that semantic theories should be revised to reflect this.

## 3. Two novel determiners: *gleeb* and *gleeb′*

The question we aim to address is whether children permit structures like (1) to have nonconservative meanings. While it has been shown that children will sometimes accept non-adult-like interpretations of quantificational sentences (Inhelder and Piaget, 1964), previous research is silent with respect to the specific question of conservativity.[5] Therefore, it is an open question whether children come to the word-learning task with inherent restrictions on the relations that determiners can express.

To investigate this question, we attempted to teach children novel determiners. If children have no inherent restrictions on determiner meanings, then we would predict that they will be able to learn both novel conservative determiners and novel nonconservative determiners. However, if the typological generalisation that we observe reflects a restriction imposed by the language faculty, then we predict that children will succeed in learning novel conservative determiners, and will not succeed in learning novel nonconservative determiners.

In order to test these predictions we created two novel determiners, one conservative and one nonconservative. The conservative one, *gleeb*, expresses the relation $\mathcal{R}_{\text{gleeb}}$ as illustrated in (7).

(7) a. $\mathcal{R}_{\text{gleeb}}(X)(Y) \equiv X \not\subseteq Y \equiv \neg(X \subseteq Y)$

b. *gleeb girls are on the beach* is true iff $\text{GIRL} \not\subseteq \text{BEACH}$

[5] The findings in Inhelder and Piaget (1964) do not tell us anything about the hypothesised conservativity constraint. The reported finding was that some children judge *every boy is riding an elephant* to be true if and only if (i) every boy is riding an elephant, and (ii) every elephant is ridden by a boy. On this reading, *every* is not expressing a two-place relation between the set of boys (the denotation of its internal argument) and the set of elephant riders (the denotation of its external argument, *is riding an elephant*); and if it is not expressing a two-place relation between these two sets, then it is certainly not expressing a nonconservative relation between them (like *equi* would). On the (questionable) assumption that *every* was indeed being analysed as a determiner in these sentences, this finding would be evidence against the standard restriction on determiner meanings that permits only relations between the sets denoted by their internal and external arguments — let alone the stronger restriction to only conservative relations — perhaps in favour of an account involving quantification over elephant-riding events as in Philip (1995) or over elephants as in Drozd and van Loosbroek (1998). But further experiments have suggested that these interpretations are a methodological artefact resulting from infelicitous contexts in any case (Crain et al., 1996).

So *gleeb girls are on the beach* is the negation of *every girl is on the beach*: it is true if and only if the set of girls (GIRL) is **not** a subset of the set of beach-goers (BEACH), so we might paraphrase it as *not all girls are on the beach*. For example, it is true in the scene shown in Figure 1(a), but false in the scene shown in Figure 1(b). Since *gleeb* is the "negation" of the conservative determiner *every*, it is also conservative[6]: anything on the beach that is not a girl is irrelevant to the truth of the sentence in (7b), so *gleeb* does live on its internal argument, and the biconditional "not all girls are on the beach if and only if not all girls are girls on the beach" is true.

The novel nonconservative determiner, written *gleeb′* but pronounced identically to the conservative determiner *gleeb*, expresses the relation $\mathcal{R}'_{\text{gleeb}}$ as illustrated in (8).

(8) a. $\mathcal{R}'_{\text{gleeb}}(X)(Y) \equiv Y \nsubseteq X \equiv \neg(Y \subseteq X) \equiv \mathcal{R}_{\text{gleeb}}(Y)(X)$
b. *gleeb′ girls are on the beach* is true iff $\text{BEACH} \nsubseteq \text{GIRL}$

So *gleeb′ girls are on the beach* is the "reverse" of *not all girls are on the beach*: it is true if and only if not all beach-goers are girls. For example, it is true in the scene shown in Figure 1(b), but false in the scene shown in Figure 1(a). Since the "lived on" set (the beach-goers) is not expressed as the **internal** argument of *gleeb′* in (8b), *gleeb′* is **not** conservative.[7] To determine whether the sentence in (8b) is true, one cannot limit one's attention to the set of girls; beach-goers who are not girls are relevant. And the crucial biconditional, which we can paraphrase as "not all beach-goers are girls if and only if not all beach-going girls are girls", is false since the first clause can be true while the second cannot.

Our experiment will compare children's ability to learn *gleeb* with their ability to learn *gleeb′*, based on equivalent input. Note that since the conditions expressed by these two determiners are just the "mirror image" of each other, there is no reason to expect a difference in how easily they can be learnt — **unless** there are constraints on the semantic significance of specifically being the internal or external argument of a determiner, since this is all that distinguishes *gleeb* from *gleeb′*. A finding that children are able to learn *gleeb* but not *gleeb′* would therefore be difficult to explain by any means other than such a restriction on the way internal and external arguments of determiners are interpreted.

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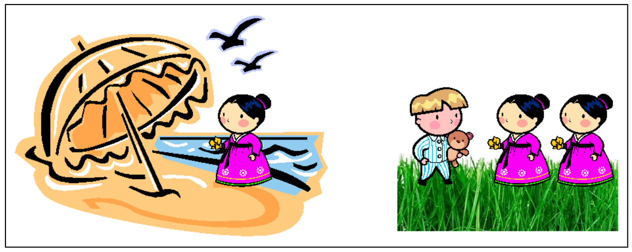
[6]Suppose that $\mathcal{R}$ is conservative, and that $\mathcal{R}'(X)(Y) \equiv \neg\mathcal{R}(X)(Y)$. Then

$$\mathcal{R}'(X)(Y) \iff \neg\mathcal{R}(X)(Y) \iff \neg\mathcal{R}(X)(X \cap Y) \iff \mathcal{R}'(X)(X \cap Y)$$

so $\mathcal{R}'$ is also conservative.

[7]The fact that *gleeb′* happens to live on its external argument makes it anticonservative — unlike *equi*, which is neither conservative nor anticonservative — but this is not relevant here.


(a)

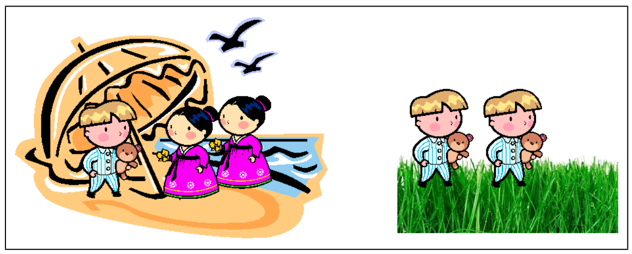

(b)

**Figure 1: Two sample cards. In the conservative condition, the puppet would like only the card in (a): *gleeb girls are on the beach* is true in (a), but false in (b). In the nonconservative condition, the puppet would like only the card in (b): *gleeb′ girls are on the beach* is false in (a), but true in (b).**

## 4. Experiment design and methodology

Each participant was assigned randomly to one of two conditions: the conservative condition or the nonconservative condition. Participants in the conservative condition were trained on *gleeb*, and participants in the nonconservative condition were trained on *gleeb′*; each participant was then tested on whether he/she had learnt the determiner he/she was exposed to.

To assess the participants' success in learning, we used a variant of the "picky puppet task" (Waxman and Gelman, 1986). The task involves two experimenters. One experimenter controls a "picky puppet", who likes some cards but not others. The second experimenter places the cards that the puppet likes in one pile, and the cards that the puppet does not like in a second pile. The child's task is to make a generalisation about what kinds of cards the puppet likes, and subsequently "help" the second experimenter by placing cards into the appropriate piles.

The experimental session was divided into two phases: warm-up and target. During the warm-up phase, the experimenter ensured that the child could sort cards into piles. For example, in one warm-up item the child would be told "The puppet only likes cards with yellow things on them", and would be asked to sort a number of cards into "like" and "doesn't like" piles. The warm-up phase contained three items; the cards, and the criterion to be met for the puppet to like them, differed from each item to the next.

The target phase used cards like those shown in Figure 1, and was divided into a training period and a test period. The child was told that the puppet had revealed to the experimenter whether he liked or disliked some of the cards, but not all of them. The child was told that the experimenter would sort what they could, but that the child would then have to help by sorting the remaining cards that the puppet was silent about. During the training period the experimenter sorted five cards, according to the criterion appropriate for the condition: in the conservative condition, the puppet likes cards where *gleeb girls are on the beach* is true, and in the nonconservative condition, the puppet likes cards where *gleeb′ girls are on the beach*. The experimenter places each card into the appropriate pile in front of the participant, providing either (9a) or (9b) as an explanation as appropriate.[8]

(9) a. The puppet told me that he likes this card because gleeb girls are on the beach.

b. The puppet told me that he doesn't like this card because it's not true that gleeb girls are on the beach.[9]

Having placed all the training cards (the cards that "the puppet had told the experimenters about") in the appropriate piles, the experimenter turned the task over to the child for the test period. The experimenter handed five new cards to the child, one at a time, and asked the child to put the card in the appropriate pile, depending on whether or not the child thought the puppet liked the card. The experimenters recorded which cards the child sorted correctly and incorrectly according to the criterion used during training. The cards that the experimenter had sorted during the training period remained visible throughout the testing period.

The same training cards and the same testing cards were used in both conditions, though whether the puppet liked or disliked the card varied from one condition to the other. Table 1 shows, for each card, the number of girls and boys on the beach and on the grass, and whether each condition's relevant criterion is met or not. These were designed to be as varied as possible, while maintaining the pragmatic felicity of the two crucial target statements. The total number of characters on each card was also kept as close to constant as possible: either five or six for each card. The number of training cards that the puppet likes is the same in each condition (three), so the situation that the participant is presented with during the training phase is analogous across conditions.

The participants were 20 children, aged 4;5 to 5;6 (mean 5;0). Each condition contained 10 children: ages of those in the conservative condition ranged from 4;5

[8] We do not distinguish between the conservative *gleeb* and the nonconservative *gleeb′* in writing (9), to illustrate that the explanations were homophonous across the two conditions.

[9] Negation was always expressed in a separate clause to avoid any undesired scopal interactions.

**Table 1: The distribution of girls and boys on each card in the experiment**

| Card | beach | | grass | | *gleeb girls are on the beach* | *gleeb′ girls are on the beach* |
|---|---|---|---|---|---|---|
| | boys | girls | boys | girls | | |
| Train 1 | 2 | 0 | 1 | 2 | true | true |
| Train 2 | 0 | 2 | 3 | 0 | false | false |
| Train 3 | 0 | 1 | 2 | 3 | true | false |
| Train 4 | 2 | 3 | 0 | 0 | false | true |
| Train 5 | 2 | 1 | 1 | 2 | true | true |
| Test 1 | 3 | 0 | 0 | 2 | true | true |
| Test 2 | 0 | 3 | 3 | 0 | false | false |
| Test 3 | 2 | 3 | 0 | 2 | true | true |
| Test 4 | 1 | 2 | 2 | 0 | false | true |
| Test 5 | 1 | 2 | 0 | 2 | true | true |

**Table 2: Summary of results from the experiment**

| Condition | Conservative | Nonconservative |
|---|---|---|
| Cards correctly sorted (out of 5) | above chance ($p < 0.001$, mean 4.1) | at chance ($p > 0.17$, mean 3.1) |
| Subjects with "perfect" accuracy | 50% | 10% |

to 5;5 (mean 4;11), and ages of those in the nonconservative condition ranged from 4;11 to 5;3 (mean 5;1).

## 5. Results

The results indicate that children exposed to the novel conservative determiner successfully learnt it, and that children exposed to the novel nonconservative determiner did not. The results are summarised in Table 2.

First we can consider how many cards children in the two conditions sorted correctly. If children never succeeded in learning the determiner's meaning, we would expect performance to be at chance (namely 2.5 cards correctly sorted out of 5). Children in the conservative condition performed significantly better than chance ($p < 0.001$), sorting an average of 4.1 cards correctly, whereas children in the nonconservative condition did not ($p > 0.17$), sorting an average of 3.1 cards correctly.

Alternatively, we can consider how many children in each condition performed "perfectly", sorting all five test cards correctly. Of the children in the conservative condition, five out of ten sorted all test cards correctly, whereas only one child out of ten in the nonconservative condition sorted all test cards correctly, indicating a correlation between conservativity of the determiner and success in learning ($p = 0.07$, Fisher's exact test).

The results are even more telling when we look more closely at the responses of the one child who sorted all five test cards correctly in the nonconservative condition. This child told the experimenters that the puppet was confused about which characters on the cards were boys and which were girls. Recall that in this condition the true criterion for the puppet to like a card was *gleeb′ girls are on the beach*, or equivalently *not all beach-goers are girls*. But another statement equivalent to these is *some boys are on the beach*. So if the child thought that the puppet intended the internal argument of *gleeb′* in the crucial sentence to denote the set of boys, then she in fact learnt a **conservative** meaning for *gleeb′*, with a meaning like *some* has. One might even be tempted to suggest that she was led to believe that the puppet was confusing boys with girls **because of** a requirement that *gleeb′* be understood conservatively.

Of course, these results should only bear on the issue of determiner meanings to the extent that we are confident that the participants really did understand the relevant parts of the explanations in (9) to have the structure shown in (1). Had we found no difference between the conservative and nonconservative conditions, one might be hesitant to **reject** the hypothesis that determiners are restricted to conservative meanings, because of the possibility that participants were not analysing the crucial word as a determiner. But it is unlikely that we would have found results consistent with the independently motivated restriction to conversative determiner meanings if participants had not been using determiner structures.

## 6. Conclusion

We found no evidence of children successfully learning the nonconservative determiner *gleeb′*, but significant evidence of children successfully learning its conservative cousin *gleeb*. This supports the hypothesis that the range of possible meanings that children consider for novel determiners includes only those that express conservative relations, and gives us reason to prefer theories of semantics from which this constraint follows.

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