Why Do Children Misunderstand Reversible Passives? The CHILD Program Learns to Understand Passive Sentences

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ABSTRACT

As children learn language they initially misunderstand reversible passive sentences as if they were active sentences. This error is an important clue to possible mechanisms by which children learn to understand passives in general. This paper reports on how the CHILD program learns to understand passive sentences, initially misunderstanding reversible passives as it does so. It presents an explanation of children's performance based on CHILD, and presents a number of predictions which follow from this explanation.

I. Introduction

If a three or four year old child is asked which of two pictures corresponds to "The girl is followed by the boy," he will point to the one in which the girl is following the boy, rather than the one in which the boy follows the girl. That is, children of this age will misunderstand such passive sentences as if they were active. Such a sentence, in which there are two semantically distinct interpretations, is called reversible. By age five, the same child will correctly understand reversible passive sentences. An account of why younger children misunderstand reversible passives would be an important component of an account of their learning to understand passives in general. This paper describes how the CHILD program [7,8,9] learns to understand passive sentences following a progression similar to that children follow, and describes how it misunderstands reversible passives during this progression. It offers an explanation for how children learn passives and why they make this error, and it offers predictions which may confirm or deny this explanation.

Children's acquisition of the passive can be described as progressing through a sequence of stages (summarized and simplified from data presented by Bever (1970) and Strohrer and Nelson [10]). During the first stage, at about age two or three, the child understands passive sentences on the basis of semantic likelihood. During the second stage reversible passives are understood as if according to active syntax and are thus misunderstood, while their understanding of semantically unambiguous passives is correct. In the third stage, at about age five, the child understands reversible passives correctly. The question addressed by this paper is, what mechanism could account for this progression including this stage 2 error?

Previous research has not provided a satisfactory answer to this question (see [5] for a review of various approaches to modeling child language learning). There are a number of plausible proposals in the psychological literature (e.g. [2]) however none have been tested in a computer program. Previous work in computer modeling of language learning has not addressed this issue either. For example, Anderson [1] explores learning syntactic word classes, fragments of Latin, and verb auxiliaries in generating and understanding declaratives, but does not address the question of comprehension errors during acquisition of the passive.

II. The CHILD Program

CHILD is a computer model of the development of children's language comprehension and generation abilities written in Franz LISP and currently running on a DEC VAX 11/780. It begins with world knowledge and language experiences similar to those children receive and learns a subset of the word meaning and syntax which children learn. After learning, CHILD can correctly understand utterances which it previously misunderstood. CHILD manifests and offers explanations for a number of characteristics of child language learning. It therefore seems appropriate to study CHILD's ability to learn the passive.

CHILD's language comprehension process is a version of the CA program [3] which incorporates mechanisms derived from Wilks' [11] preference parsing. CHILD's analysis process combines Conceptual Dependency (CD) [6] word meanings to form a CD representing the meaning of the entire utterance. It retrieves semantic features associated with particular slots in a CD itself, and also syntactic features associated with those slots but specific to that particular word. It searches a short term memory for word meaning which best satisfies those features, and fills the empty slot with that CD. If it later finds that that CD should fill some other slot, it can retrieve it from the first slot, fill the second slot with it, and find the second best filler for the first slot. In this way it seeks the

best overall interpretation of an utterance.

CHILD's syntactic knowledge is represented using syntactic "features" associated with a slot in a particular word meaning. These features are formed from the positional predicates PRECEDES and FOLLOWS. These relate the position of a candidate slot filler to either the word whose meaning contains the slot being filled, a filler of another slot in that same meaning, or a lexical function word. Each slot in the meaning of a word has a collection of features describing where in the input a filler is expected to be. In order to understand different voices, CHILD learns and maintains disjunctive "feature sets" under the meaning of each word. Each is a set of features characterizing one way slot fillers can appear. Feature set selection occurs during understanding by considering which set most successfully characterizes the input.

To learn syntax CHILD must acquire syntactic features and also build disjunctive feature sets. CHILD applies its syntax learning procedures to each word whose meaning has empty slots. After having understood the utterance, CHILD uses a record of the input to find where in the utterance the filler of each such empty slot appeared. It describes this position using PRECEDES and FOLLOWS, and stores this description under the word whose meaning contains the slot being examined, associated with that slot. However, before storage is final, CHILD must decide whether the set of features comprising the positional descriptions extracted for the slots in a word from a particular input are a new feature set or should be merged with an already existing feature set. CHILD's strategy is based on a suggestion by Iba [4]. CHILD compares the features extracted from the current input with any existing feature sets. The rule used is that the current set is merged with a previous set only if one set is a subset of the other. Otherwise, the current set is added to the information under the word as a new feature set.

III. Learning to Understand Passives

The following example is edited from a complete run of the program during which it learns meanings for all the words it knows and learns their syntax. The example begins after CHILD has learned meanings for the words "fed", "Mom", Child", and "Rover". The CD representations of CHILD's understanding have been simplified to save space. The first part of the example corresponds to the first stage of children's acquisition of the passive. CHILD knows no syntax for "fed," and thus interprets passives according to semantic likelihood. According to CHILD's knowledge, it is more likely that "Mom" is feeding "Child," and this knowledge determines CHILD's understanding.

```
|CHILD hears: "Child was fed by Mom"
|CHILD's understanding is:
|(DO ACTOR  (PARENT1)
|    LEADTO (INGEST ACTOR (CHILD) OBJECT (NIL)))
|
|CHILD hears: "Mom was fed by Child"
|CHILD's understanding is:
|(DO ACTOR (PARENT1)
|    LEADTO (INGEST ACTOR (CHILD) OBJECT (NIL)))
```

CHILD learns active syntax by being given an example sentence whose interpretation is unambiguous. As far as CHILD knows, the only things that can feed anything are people, and thus there is only one interpretation possible for "Mom fed Rover." Given this sentence, CHILD notes the positions of the fillers, and stores them in a feature set under the word "fed."

```
|CHILD hears: "Mom fed Rover"
|CHILD's understanding is:
|(DO ACTOR (PARENT1)
|    LEADTO (INGEST ACTOR (DOG1) OBJECT (NIL)))
|
|CHILD learns syntax of "fed":
| (ACTOR) precedes "fed"
| (LEADTO ACTOR) follows "fed"
|
|ATTEMPTING MERGE OF CURRENT FEATURES
|     WITH EXISTING SET
|NO EXISTING FEATURES SETS
|CREATING NEW FEATURE SET
```

Having learned active syntax for "fed," CHILD's performance now corresponds to the second stage of learning to understand passives: it understands unambiguous passives correctly, but interprets reversible passives as if they were actives.

```
|CHILD hears: "Mom fed Rover"
|CHILD's understanding is:
|(DO ACTOR (PARENT1)
|    LEADTO (INGEST ACTOR (DOG1) OBJECT (NIL)))
|
|CHILD hears: "Child was fed by Mom"
|CHILD's understanding is:
|(DO ACTOR (CHILD)
|    LEADTO (INGEST ACTOR (PARENT1) OBJECT (NIL)))
|
|CHILD hears: "Mom was fed by Child"
|CHILD's understanding is:
|(DO ACTOR (PARENT1)
|    LEADTO (INGEST ACTOR (CHILD) OBJECT (NIL)))
```

CHILD progresses to the third stage by learning passive syntax for "fed." CHILD is given an unambiguous passive, and learns the alternative syntactic features which characterize the passive.

```
|CHILD hears: "Rover was fed by Mom"
|CHILD's understanding is:
|(DO ACTOR (PARENT1)
|    LEADTO (INGEST ACTOR (DOG1) OBJECT (NIL)))
|
|CHILD learns syntax of "fed":
| (ACTOR) follows "fed",
|         follows function word "by"
| (LEADTO ACTOR) precedes "fed",
|                precedes function word "was"
|
```

```
|ATTEMPTING MERGE OF CURRENT FEATURES
|     WITH EXISTING SET
|MERGE FAILS
|CREATING NEW FEATURE SET
```

From these experiences CHILD learns the syntactic features which characterize the position of slot fillers when the utterance is passive. It attempts to merge these features with the active feature set under "fed" and fails because no subset relation exists between the new features and the active set. It thus creates a new feature set of these features and stores them under the meaning of "fed." It now understands reversible passives correctly, as shown below.

```
|CHILD hears: "Mom was fed by Child"
|CHILD's understanding is:
|(DO ACTOR (CHILD)
|    LEADTO (INGEST ACTOR (PARENT1) OBJECT (NIL)))
|
|CHILD hears: "Child was fed by Mom"
|CHILD's understanding is:
|(DO ACTOR (PARENT1)
|    LEADTO (INGEST ACTOR (CHILD) OBJECT (NIL)))
```

As shown above, the CHILD program does progress through the same sequence of stages as is reported for children. In its first stage it understood passives according to semantic likelihood. It learned active syntax, and thus in its second stage, it understood reversible passives according to active syntax. It then learned passive syntax, which allowed it to correctly understand reversible passives.

IV. Why Are Reversible Passives Misunderstood?

To answer this question, consider a more general question: "How do children learn syntax?" The CHILD program offers the following answer to this more general question: children learn syntax by first noting the position in the input of slot fillers using independent syntactic features and then by storing those features under the meaning of the word which contains those slots. When a child notes features which are not compatible with features known already for a word, he creates a disjunctive feature set. This set contains features characterizing the alternative set of positions the fillers can occur in. Thus CHILD initially learns one such disjunctive set for the word "fed", the active, and later learns a second, the passive.

The CHILD model suggests that children misunderstand reversible passives at stage two because they first learn active syntax, and use active syntax to understand reversible passive sentences. They understand non-reversible passives correctly because the semantic requirements override the syntactic features. Children then learn the passive set of features after hearing non-reversible passives, and form a new feature set. When they again hear a reversible passive, their language analysis processes try to use both disjunctive sets of features, and the passive features are more successful, so they understand the sentence correctly.

This account of learning to understand passives makes a number of predictions. First, this model predicts that there will be an interval during which a child will correctly understand some reversible passives yet misunderstand other reversible passives. Since the CHILD model proposes that children learn passive syntax individually for each action word, it predicts that there will be a point when a child has learned passive syntax for some words and not for others. Second, this model predicts that children will not learn the passive for a word until either they hear that word used in a non-reversible passive, which allows them to correctly understand the sentence, or they hear the word used in a reversible passive in a situation which allows them to infer its meaning. This is because CHILD needs to understand the meaning of an utterance as a whole correctly before it learns syntax. Third, this model predicts that there will be an intermediate stage in understanding the passive for some word. In this stage, a child will correctly understand some reversible passives involving that word yet misunderstand others. The model predicts that at this intermediate stage the child will understand reversible passives in which both interpretations are equally likely, such as "The book was put on the magazine", yet will still misunderstand reversible passives in which the semantic likelihood of the syntactically correct interpretation is weak, as in "The table was put on the ball." This is because the understanding process uses preference applied to syntactic and semantic features to establish the appropriate interpretation, and it takes more experience to build up enough passive features to outweigh the semantic unlikeliness of putting a table on a ball.

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