Abstract

Since English and Japanese speakers have different word order biases in heavy NP shift, language acquisition must play a role in the development of the shift. To explore how this might happen, a connectionist model of syntax acquisition and sentence production was trained to produce English or Japanese sentences, and the resulting models were tested for their heavy NP shift behavior. The behavior of the models matched the human biases in each language and language-specific features of the input were found to be important in the development of these word order behaviors.

Heavy NP Shift in English and Japanese

- Heavy NP shift is a tendency for speakers to place long “heavy” noun phrases in non-canonical sentence positions.
- Ungrammatical/Awkward: “The boy gave the girl the book”
- Grammatical: “The boy gave the girl the book that he bought last week”
- English speakers tend to place long noun phrases LATER in sentences (Studds, MacDonald, & O`Searaghla, 1996).
- These language-specific heavy NP shift biases seem to manifest early in language development in both languages (de Marneffe et al., 2007; Hakuta, 1981).

A Connectionist Model of Syntax Acquisition and Sentence Production

Chang, Dell, & Bock (2006) provided a connectionist model of syntax acquisition and sentence production that learns abstract syntactic representation in order to map between meaning/messages and word sequences.

- N-Path Architecture: sequencing system that learns syntactic representations, meaning system that learns lexical-concept lines.
- Model accounts for a wide range of data (structural priming, syntax acquisition, aphasia).
- Model trained on message-sentence pairs generated from input grammar.

Japanese and English Input for the Model

- The message encoded the concept-role bindings in the event as well as event-semantic information like tense and aspect. The message was paired with an English and Japanese sentence. Below is an example.

```
English: The father gave the girl the book that he bought last week.
Japanese: 父に本を贈った。
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- Unlike previous models, the present model can handle message sentences with two propositions.

```
MESSAGE: 0A=SEND; 0X=GIRL; 0Y=BOY, INDEF 0Z=LAST WEEK, AA, XX, YY

ENGLISH: The father gave the girl the book that he bought last week.
JAPANESE: 父に本を贈った。
```

- New message-sentence pairs were added to test the model.

Accuracy of English and Japanese Models over development

- Twenty training sets were created (each 40000 message-sentence pairs) and used to create twenty model subjects. Model was tested on 400 test sentences. Accuracy in terms of grammaticality and in terms of appropriate message was accessed.
- Although the languages differ greatly, the model can learn both to similar levels of accuracy.

Why did the model learn these biases?

- Japanese model depends on event-semantic features more than English model.
- Event-semantic features emphasize first bias.
- Properties of language learned contribute to bias.

- Japanese: Verb-final, No Articles, Relative Clause (RC) before head
- English: Not Verb-final, Articles, Relative Clause after head

- Train models on languages that vary all three of these features. All three features interact with weight (RC position * weight, t = 6.49, p < 0.001; Article * weight, t = 6.57, p < 0.001; Verb position * weight, t = 6.33, p < 0.001).
- Verbs and articles provide structural cues. Moving verb to end or removing articles reduces their influence, and increases role of event-semantic.
- Placing RC before head means that the embedded clause information is more important at the choice point, and event-semanics has extra information about embedded clauses.

Testing Heavy NP shift

- Heavy NP shift was tested in the model by presenting descriptive messages with Long Patient, Long Recipient, or All Light. Below is an example of a Long Patient message.

```
Message: 0A=SEND; 0X=GIRL; 0Y=TOY, INDEF 0Z=LAST WEEK, AA, XX, YY

ENGLISH: The girl sends a toy that floated in the water to the boy.
```

- The dependent measure was the number of Recipient before Patient structures. The English data show that this recipient early order is more common with long patients than long recipients, and the Japanese data show the reverse bias. This pattern is significant over the whole of development (weight-language interaction, t = 13.89, p < 0.001) and is consistent with developmental data in both languages (de Marneffe et al., 2007; Hakuta, 1981).

What causes heavy NP shift in the model?

- Structure selection in the model is guided by the activation of roles at the position where structural alternatives differ (the choice point is shown in blue below).

- English choice point = noun phrase after verb.
  - a girl sent a toy to a boy (ROLE = PATIENT, RECIPIENT)
  - a girl sent the toy to a boy (ROLE = PATIENT)

- Japanese choice point = noun phrase after subject.
  - a girl sent the toy to a boy (ROLE = PATIENT, RECIPIENT)
  - a girl sent the toy to a boy (ROLE = PATIENT, RECIPIENT)

- Links between Event-semanics and Roles at the choice point by weight and language.

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Conclusion

- A connectionist model of syntax acquisition was able to explain the different direction of heavy NP shift in English and Japanese.
- During language acquisition, the model learns how meaning and syntax influence decisions about word order at different positions in a sentence.
- The position where heavy NP shift is determined is different in the two languages, and the relative bias of meaning and syntax at this position yields the difference in the direction of the shift in each language.

References


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