On the role of frequency and similarity in the acquisition of syntactic constructions

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Structure of the talk

- Part 1: Networks and rules in morphology
- Part 2: The acquisition of English and German RCs
Networks and rules

The debate about networks and rules is concerned with linguistic productivity.

Language provides finite means to produce an infinite number of grammatical sentences.
   (Chomsky 1957)

Language is the infinite use of finite means.
   (Wilhelm von Humboldt)

Grammatical rules
What’s a rule?

Traditional view: linguistic rules are algorithms

<table>
<thead>
<tr>
<th>Rule Type</th>
<th>Example</th>
<th>Type of Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plural Noun</td>
<td>N-[s]</td>
<td>morphological rule</td>
</tr>
<tr>
<td>NP</td>
<td>DET (ADJ) N</td>
<td>phrase structure rule</td>
</tr>
<tr>
<td>Quantifier</td>
<td>$\forall x \ [\text{student}(x) \ \text{talks}(x)]$</td>
<td>semantic rule</td>
</tr>
</tbody>
</table>

$(4 \times 3) + 5 = 17$

The digital computer is an influential metaphor of cognition and (mental) grammar in cognitive science. (Bates and Elman 2002)
Is the (traditional) computer metaphor appropriate to account for grammar and linguistic productivity?
The acquisition of the past tense

<table>
<thead>
<tr>
<th>Regular verbs</th>
<th>Irregular verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>walk → walked</td>
<td>sing → sang</td>
</tr>
<tr>
<td>kiss → kissed</td>
<td>swim → swam</td>
</tr>
<tr>
<td>like → liked</td>
<td>buy → bought</td>
</tr>
<tr>
<td>hate → hated</td>
<td>hit → hit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Children’s errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>buy → buyed</td>
</tr>
<tr>
<td>buy → buyed</td>
</tr>
<tr>
<td>sing → singed</td>
</tr>
<tr>
<td>hit → hitted</td>
</tr>
<tr>
<td>go → goed_</td>
</tr>
</tbody>
</table>
The acquisition of the past tense

Conclusion: Children use rules to produce inflected word forms.
The acquisition of the past tense

But children are inconsistent:

- They vary in their use of the past tense.
- They also produce novel irregular forms (e.g. \textit{fring} \rightarrow \textit{frung}).

Hypothesis: The variation in children’s linguistic behaviour is due to performance factors.
The occurrence of children’s mistakes is not random. The errors correlate with two factors

- The frequency of individual verbs
- The phonetic similarity between verbs

Since frequent verbs are deeply entrenched in memory, they cannot be so easily changed.

But why does similarity affect the formation of the past tense?
Irregular verbs—such as *hit*, *eat*, or *find*—that end with an alveolar plosive, are less frequently used with the *-ed* suffix in the past than verbs that end in different speech sounds.

Children tend to regularize irregular verbs:

- If the verbs do not already look like (regular) past tense forms
- If there is little phonological overlap between present and past tense
These findings are difficult to reconcile with the traditional rule based account.

Bybee (1995): There is no past tense rule.

Later research in connectionism suggested that the different present and past tense forms are associated with each other by probabilistic links that are determined by two factors: frequency and similarity (Rumelhart and McClelland 1986; Plunckett and Marchman 1991, 1993).
Morphological network

- sking
- flink
- strin
- meek
- -æŋ(k)
- -Λη(k)
- -(ǝ)d
This idea is very popular in morphology (e.g. Bybee 1985, 2000; Hay 2003; Hay and Baayen 2005).

Can the network model be extended to syntax?

-> I will now present a network account for the acquisition of RCs that is similar to the network account in morphology.
A construction is a complex sign that combines a particular form with a particular function or meaning (Goldberg 1995).
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(1) Open the door!

<table>
<thead>
<tr>
<th>$[V_{\text{base}} [\text{NP}_{\text{non-subject}}]]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directive speech act</td>
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</table>
A construction is a complex sign that combines a particular form with a particular function or meaning (Goldberg 1995).

(1) Open the door!

[V\textsubscript{base} [NP\textsubscript{non-subject}]]

Directive speech act

(2) Sun

[s\textcopyright n]
If syntactic structure consists of signs, i.e. constructions, it is a plausible hypothesis that grammar is organized in the same (or similar) way as the mental lexicon.
Construction grammarians have adopted the network metaphor of grammar from morphology and cognitive psychology; but what they usually mean (by network) is a taxonomy, i.e. constructions at different levels of abstractness that are connected by ‘inheritance links’.

1. The boy who met John. Subject
2. The boy [who] John met. Direct object
3. The boy [who] John gave the book to. Indirect object
5. The boy [with whom] John played. Oblique
6. The boy whose friend John met. Genitive

All RCs instantiate a schema consisting of a nominal head and a subordinate clause in which one of the verb’s participants is coreferential with the head noun.
The boy who met John.
The boy [who] John gave the book to.
The boy [who] John went to.
The boy whose friend John met.
Hypothesis

Schema extraction is of central significance to grammar learning, …

… but the acquisition of RCs does not only involve the extraction of RC-schemas, it also involves horizontal relations between the various types of RCs and other constructions of the grammar network.
Study 1
Study 1

Stimuli in experimental research on the acquisition of RCs (adopted from Tavakolian 1977):

(1) The pig jumped over the horse that bumped into the lion.
(2) The horse that kicked the cow pushed the donkey.

Assumption: RCs are acquired late.

But surprisingly RCs appear quite early in spontaneous child language.
Relative clauses in spontaneous child language:

(1) *CHI: And here's a rabbit that I'm patting. Nina 3;0
(2) *CHI: And there's the penguins that we saw. Nina 3;1
(3) *CHI: Is that house that's on fire? Peter 2;10
(4) *FAT: No what did you eat? Abe 3;6
   *CHI: Some apples that were sweet.
(5) *MOT: What are those? Nina 3;2
   *CHI: Animals that are chasing that.
(6) *FAT: What lion face? Abe 3;11
   *CHI: The lion face you were gonna draw.

Children‘s early relative clauses include a single proposition.
Study 1

![Graph showing the percentage of one proposition and two propositions across different age groups. The graph indicates a decrease in the percentage of one proposition and an increase in the percentage of two propositions as age increases.]
Study 2
<table>
<thead>
<tr>
<th>Number</th>
<th>German Sentence</th>
<th>English Equivalent</th>
<th>Relative Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Der Mann, <em>der</em> mich gesehen hat.</td>
<td>The man who <em>met</em> the woman.</td>
<td>SUBJ-relative</td>
</tr>
<tr>
<td>2</td>
<td>Der Mann, <em>den</em> ich gesehen habe.</td>
<td>The woman who the man met *_.</td>
<td>OBJ-relative</td>
</tr>
<tr>
<td>3</td>
<td>Der Mann, <em>dem</em> ich das Buch gegeben habe.</td>
<td>The boy who the girl gave the ball to *_.</td>
<td>IO-relative</td>
</tr>
<tr>
<td>4</td>
<td>Der Mann, <em>zu dem</em> ich gegangen bin.</td>
<td>The girl who the boy played with *_.</td>
<td>ADV-relative</td>
</tr>
<tr>
<td>5</td>
<td>Der Mann, <em>dessen</em> Hund mich gebissen hat.</td>
<td>The man whose cat caught a mouse.</td>
<td>GEN-relative</td>
</tr>
</tbody>
</table>

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Diessel and Tomasello 2005
This is the farmer who fed the pig in the barn.

Subjects: 4-5 year-old English- and German-speaking children
Results

S        intrans. subj.
A       trans. subj.
P        direct obj.
IO      indirect obj.
ADV  adverbial
GEN  genitive

P vs. IO      p > 0.173
P vs. ADV    p > 0.169

P vs. IO      p > 0.061
P vs. ADV    p < 0.001
Error analysis

(1) Test item: This is the girl who the boy teased at school this morning.
CHILD: This is the girl who teased … the boy … at school this morning.

(2) Test item: Da ist der Mann, den das Mädchen im Stall gesehen hat.
CHILD: Da ist der Mann, der das Mädchen im Stall gesehen hat.

(3) This is the girl who bor/ Peter borrowed a football from.
(4) Da ist der Junge, der/ dem Paul … die Mütze weggenommen hat.

The conversion errors do not arise from lack of grammatical knowledge.

Hypothesis: Subject relatives are easier to activate than other types of RCs.
One factor that determines the ease of activation is frequency (Bybee 2006; Elman 2004).

Proportion of different structural types of relative clauses in the ambient language (Diessel 2004)
Subject relatives

Hypothesis: Subject relatives are easy to activate because they are similar to ordinary main clauses (Diessel & Tomasello 2005).

(1) The man [agent] who opened the door [patient].  
(2) The cat [patient] the dog [agent] chased around the garden.  
(3) The doctor [goal] the patient [agent] went to last night.  

SUBJ
OBJ
ADV
Object- and adverbial REL

the N [**who** saw NP] 
subject
the N [**who NP** saw] 
direct object
the N [**who NP** gave NP to] 
indirect object
the N [**who NP** played with] 
adverbial
the N [[**whose N**] chased NP] 
genitive

der Mann, **der** ... 
subject
der Mann, **den** ... 
direct object
der Mann, **dem** 
indirect object
der Mann, **mit/von dem** .... 
adverbial
der Mann, **dessen** N ... 
genitive
Object- and adverbial REL

- the N [who saw NP] → subject
- the N [who NP saw] → direct object
- the N [who NP gave NP to] → indirect object
- the N [who NP played with] → adverbial
- the N [[whose N] chased NP] → genitive

- der Mann, der ... → subject
- der Mann, den ... → direct object
- der Mann, dem → indirect object
- der Mann, mit/von dem .... → adverbial
- der Mann, dessen N ... → genitive
(1) This is the man whose dog bit me.

Genitive relatives are rare (or even absent) in the ambient language.

Indirect object relatives are also rare.

Genitive relatives caused more problems than indirect object relatives because they are very different from all other types of relative clauses, whereas indirect object relatives can easily be formed in analogy to subject and direct object relatives.
Summary

- Subject relatives caused few problems because they are frequent and similar to simple sentences.
- English direct object, indirect object, and adverbial relatives caused basically the same amount of errors because they have the same word order.
- Indirect object relatives caused relatively few problems because they are similar to direct object relatives.
- Genitive relatives and German adverbial relatives caused great problems because they are dissimilar from other relative clauses.
Why is similarity so important?

Similarity is important because relative clauses are grammatical constructions (i.e. signs) that are related to each other in an associative network like lexical expressions.

The development is crucially influenced by children's prior knowledge of simple SVO sentences.
SVO [main clauses]

[\[N \[ (GEN) \]_{RC}\]]

[\[N \[ (ADV) \]_{RC}\]]

[\[N \[ (IO) \]_{RC}\]]

[\[N \[ (DO) \]_{RC}\]]

[\[N \[ (SUBJ) \]_{RC}\]]
Traditionally, grammar learning is said to involve discrete categories and combinatorial rules.

But this view of grammar has been challenged by usage-based linguists who conceive of grammar as a network of interconnected constructions.

Building on this view, I have argued that the acquisition of RCs is crucially constrained by the relationships between the various types of RCs and other syntactic constructions.

Specifically, I have claimed that the acquisition of RCs does not only involve the extraction of constructional schemas and the emergence of a taxonomic network; it also involves horizontal relations between the various types of RCs and other constructions in the grammar network.
Thank you!