Isolating second language learning factors

Yevgen Matusevych
Afra Alishahi
Ad Backus

DGKL-6: Constructions and Cognition, Erlangen
Methodological problems in SLA

- How does learners' length of residence in L2 environment affect their L2 proficiency?
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  8. Participants should be spread homogeneously over the age ranges.
Methodological problems in SLA

Human subject research

- High individual variation between L2 learners
- Many confounds
- Approximate measures
Methodological problems in SLA

Human subject research

- High individual variation between L2 learners
- Many confounds
- Approximate measures

Computational modeling

- Simulating homogeneous populations
- High control over variables
- Precise measures
Existing models

- DevLex family of connectionist models [Zhao & Li, 2010]: semantics + phonology
- Model of entrenchment and memory development [Monner et al., 2013]: phonology + morphology
- Model of bilingual semantic memory [Cuppini et al., 2013]: lexis + semantics
- Other models [Li, 2013]
The model

- Missing: models of bilingual learning beyond the word level
The model

- Missing: models of bilingual learning beyond the word level

- Original model of child argument structure acquisition [Alishahi & Stevenson, 2008]

- Adapted version for bilingual learning
Learning argument structure constructions
Learning argument structure constructions
Learning argument structure constructions
Learning argument structure constructions

The bear gives you the ball!
Learning argument structure constructions

The bear gives you the ball
Learning argument structure constructions

The bear gives you the ball

Daddy's coming home!
Learning argument structure constructions

The bear gives you the ball  Daddy’s coming home
Learning argument structure constructions

- The bear gives you the ball
- Daddy’s coming home
- Grandma sent you some cookies.
- John passed you the ball!
- Mr. Rich donated us a thousand dollars.
Learning argument structure constructions

- Grandma sent you some cookies
- The bear gives you the ball
- Mr. Rich donated us a thousand dollars
- Daddy's coming home
- John passed you the ball
# Learning argument structure constructions

<table>
<thead>
<tr>
<th>Predicate meaning</th>
<th><em>changing object possessor</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of arguments</td>
<td>3</td>
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Grandma sent you some cookies

Mr. Rich donated us a thousand dollars

John passed you the ball

The bear gives you the ball

Daddy's coming home
Learning argument structure constructions

Ditransitive transfer construction

Daddy's coming home
Learning argument structure constructions: L2

- Ditransitive transfer construction
- Resultative construction
- ...

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Learning argument structure constructions: L2

- Ditransitive transfer construction
- Resultative construction
- ...

Meine Schwester lieh mir Geld.
(My sister lent me some money.)
Learning argument structure constructions: L2

Ditransitive transfer construction

Resultative construction

... Meine Schwester lieh mir Geld.
(My sister lent me some money.)
Learning argument structure constructions: L2

Das Geld gab ich meiner Mutter.
(I gave the money to my mother.)
**Learning argument structure constructions: L2**

- Ditransitive transfer construction
- Resultative construction
- Das Geld gab ich meiner Mutter

Das Geld gab ich meiner Mutter.  
(I gave the money to my mother.)
Learning argument structure constructions: L2
Evaluating language knowledge

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Evaluating language knowledge

The bear gives you the ball!

Giver: The bear
Verb: gives
Recipient: you
Theme: the ball!
Evaluating language knowledge

The bear gave you the ball!

Giver: The bear
Recipient: you
Theme: the ball!
Evaluating language knowledge

1. Prediction accuracy (predicate head)

Giver  verb  Recipient  Theme

The bear ___ you  the ball!
Evaluating language knowledge

Giver    verb    Recipient    Theme
The bear  ___  you  ___  the ball!

1. Prediction accuracy (predicate head)

Giver    verb    Recipient    Theme
The bear  gives  you  the ball!

2. Prediction accuracy (predicate meaning)
Evaluating language knowledge

1. Prediction accuracy (predicate head)

The bear ____ you ____ the ball!

1. Prediction accuracy (argument roles)

The bear gives you the ball!

2. Prediction accuracy (predicate meaning)

____ verb ____ ____

3. Prediction accuracy (argument roles)

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Evaluating language knowledge

1. Prediction accuracy (predicate head)
   The bear ____ you the ball!

2. Prediction accuracy (predicate meaning)
   The bear gives you the ball!

3. Prediction accuracy (argument roles)
   ____ verb ____ _______________

Language Proficiency Index (LPI): average for 3 tasks
## Data

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<tr>
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<th>Data Sources</th>
<th>Frame Instances</th>
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Both datasets can be used as either L1 or L2.

The actual input in each simulation is sampled from the data.
Learning scenarios

L1 input → Mixed L1 + L2 input
Learning scenarios

L1 input

Mixed L1 + L2 input

Testing L2 performance
Learning scenarios

L1 input → Mixed L1 + L2 input

Late L2 learner: immersion setting
Learning scenarios

Late L2 learner: immersion setting
- L1 input
- Mixed L1 + L2 input

Late L2 learner: instruction setting
- L1 input
- Mixed L1 + L2 input

Early bilingual
- L1 input
- Mixed L1 + L2 input
L1/L2 ratio

L2 English

- R=1
- R=2
- R=5
- R=10
- R=20

Input frames

LPI

0.6

0.4

0.2

0

100

200

300

400
**L1/L2 ratio**

Mixed input

L2 English

LPI

Input frames
L1/L2 ratio

L2 English

Mixed input

Mixed input

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**L1/L2 ratio**

L2 English

L2 German

Input frames

LPI

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Replicating the effect of L2 amount on L2 proficiency
L2 onset

L2 English

AO=0  AoO=100  AoO=200  AoO=300  AoO=400

LPI

Input frames
L2 onset

Mixed input

L1 input

Mixed input

L2 English

AO=0  AO=100  AO=200  AO=300  AO=400

LPI

Input frames

0  100  200  300  400  500  600  700  800

0.2  0.3  0.4  0.5  0.6
**L2 onset**

- **Mixed input**
  - L1 input → Mixed input
  - Mixed input → L2 onset

**L2 English**

- Graph showing LPI vs. Input frames for different AO values:
  - AO=0
  - AO=100
  - AO=200
  - AO=300
  - AO=400

**L2 German**

- Graph showing LPI vs. Input frames for different AO values:
  - AO=0
  - AO=100
  - AO=200
  - AO=300
  - AO=400

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Did not replicate the effect of late L2 onset
Summary

- “The more, the better”: higher L2 amount > better performance [Muñoz & Singleton, 2011]
Summary

- “The more, the better”: higher L2 amount $\rightarrow$ better performance [Muñoz & Singleton, 2011]

- No negative effect of late L2 onset – contrary to L1 entrenchment hypothesis [cf. Zhao & Li, 2010]
Frequency distribution in the input

- Language learners are sensitive to input frequencies

- Certain verbs occur in a certain construction much more often than other verbs [Ellis & Ferreira-Junior, 2009]
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I _____ it to someone.
Frequency distribution in the input

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I ____ it to someone.

give
show
send
lend
...
Frequency distribution in the input

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I _____ it to someone.

give  give
show  show
send  send
lend  lend
...

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Frequency distribution in the input

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Frequency distribution in the input

- German object-first ditransitive

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<th>PREDICATE</th>
<th>AGENT</th>
<th>PATIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>das Geld</td>
<td>gab</td>
<td>ich</td>
<td>meiner Mutter</td>
</tr>
<tr>
<td>the money</td>
<td>gave</td>
<td>I</td>
<td>my mother</td>
</tr>
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“I gave the money to my mother.”
Frequency distribution in the input

- German object-first ditransitive

THEME       PREDICATE       AGENT       PATIENT

das Geld    gab            ich         meiner Mutter
the money   gave           I           my mother

“I gave the money to my mother.”

- 15 different predicates appearing in this construction (10 training + 5 testing):

  - balanced: 1:1:1: ... :1

  - skewed: 20:20:1: ... :
Frequency distribution in the input

![Bar chart showing frequency distribution for different input frames]

- ** balanced
- ** skewed

Input frames:
- 50
- 100
- 150
- 200

LPI values:
- 0.40
- 0.50
- 0.60
- 0.70

Significance levels:
- ***
- **
- *
Frequency distribution in the input

Balanced input facilitates learning

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Review

- Implicit statistical learning
Review

- Implicit statistical learning

- A framework for studying concurrent learning of constructions in 2+ languages
Review

- Implicit statistical learning

- A framework for studying concurrent learning of constructions in 2+ languages

- Replicate human subject studies

- Provide additional insights from a highly controlled setting
Future work

- Additional language pairs (verb-framed vs. satellite-framed)

- Implementing construction alternations:
  
  I gave the car to my sister. vs. I gave her the car.
References


SLA modeling: opinions

- “We need models of acquisition that relate such … measures to longitudinal patterns of child language and second language acquisition” (Nick Ellis)

- “Future research on implicit learning must implement computer simulations of language learning” (Jan Hulstijn)

- “Modeling SLA is hardest problem in linguistics. It is only hoped that computational models may contribute” (Rens Bod)
An example frame

I ate a tuna sandwich.

<table>
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<tr>
<th>predicate</th>
<th>eat</th>
</tr>
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<tr>
<td>event properties</td>
<td>consume, take in, prep</td>
</tr>
<tr>
<td>arg. count</td>
<td>2</td>
</tr>
<tr>
<td>arg1</td>
<td>1</td>
</tr>
<tr>
<td>arg2</td>
<td>sandwich</td>
</tr>
<tr>
<td>arg1 lexical props</td>
<td>self, person, ..., entity</td>
</tr>
<tr>
<td>arg2 lexical props</td>
<td>snack food, dish, ..., entity</td>
</tr>
<tr>
<td>arg1 role props</td>
<td>living thing, entity, ..., organism</td>
</tr>
<tr>
<td>arg2 role props</td>
<td>solid, substance, ..., entity</td>
</tr>
<tr>
<td>arg1 case</td>
<td>N/A</td>
</tr>
<tr>
<td>arg2 case</td>
<td>N/A</td>
</tr>
<tr>
<td>syntactic pattern</td>
<td>ARG1 VERB ARG2</td>
</tr>
<tr>
<td>prepositions</td>
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Formal model

1. Find most likely construction for a given frame:

$$\text{BestConstruction}(F) = \arg \max_k P(k|F)$$

2. For this, use prior and conditional probability:

$$P(k|F) = \frac{P(k)P(F|k)}{P(F)} \propto P(k)P(F|k)$$

3. Prior probability = entrenchment:

$$P(k) = \frac{N_k}{N + 1}, \quad P(0) = \frac{1}{N + 1}$$

4. Conditional probability = similarity in terms of each feature:

$$P(F|k) = \prod_{i \in \text{Features}(F)} P(F_i|k)$$