Age effects in statistical learning of Japanese: Evidence from the cross-situational learning paradigm

Patrick Rebuschat, Helena Farrimond, and Padraic Monaghan
IASCL, July 19, 2017
Outline

Background
• What is cross-situational learning?
• Rebuschat, Schoetensack, & Monaghan (in prep): CSL of everything in adults.

Rebuschat, Farrimond, and Monaghan (in prep)
• Part of larger study on individual differences in language learning
• Children and adolescents
• CSL of Japanese
Background
Our ability to make use of statistical information in the environment to acquire (linguistic) knowledge.

SL well attested in infants, children, adults, and non-human primates.

We can use SL to succeed in a wide variety of linguistic tasks:

- word segmentation and word learning
- phonological development
- syntactic development
Cross-situational learning
Yu and Smith (2007); Smith and Yu (2008)

Our ability to keep track of information across many learning trials (situations) and to make use of this information to learn language.
Cross-situational learning
Yu and Smith (2007); Smith and Yu (2008)

2x2 condition: two referents, two words
Cross-situational learning
Yu and Smith (2007); Smith and Yu (2008)

Adults can easily track cross-trial statistics and use this information to learn words (nouns).

Three conditions
- 18 words condition
- Each word occurs 6 times
- Exposure time: Less than 6 mins

Results:
- 2x2 condition = learn 16 words
- 3x3 condition = learn 13 words
- 4x4 condition = learn 10 words
Yu and Smith demonstrate that infants (12 to 14 months) can use cross-situational learning to acquire novel nouns.

Scott and Fisher (2012) further showed that 2.5-year-old children can use CSL to acquire novel verbs.

Monagahan et al. (2015) confirms that adults can learn both nouns and verbs simultaneously from cross-situational statistics.

But what about other lexical items like function words? And what about syntax?
Rebuschat, Schoetensack, & Monaghan (in prep): Can we learn words (nouns, verbs, adjectives, function words) and syntax simultaneously via cross-situational learning?

Part of larger project on individual differences in language learning across the lifespan.

Participants:
• Twenty adult NS of English, no background in Japanese

Materials:
• Developed novel artificial language
Methods: Novel artificial language
Methods: New artificial language

Aliens are depicted performing one of four actions (hiding, jumping, lifting, pushing) in dynamic scenes.

Lexicon = 16 pseudowords
• Eight nouns, four verbs, two adjectives, two function words

Grammar = Japanese (SOV, OSV)

Sixteen training and test blocks:
• 192 training items, 92 test items
• Subjects are tested four times throughout experiment → Allows to check what is learned first and to later shorten exposure phase.
Cross-situational learning task
Example cross-situational learning trial

No feedback!
Results: Exposure trials

- Performance above chance from block 3 onwards.
- 48 exposure trials enough to reach above-chance performance.
Results: Lexical and syntactic tests

Performance strongest for...
1. Syntax and verbs
2. Nouns
3. Adjectives
4. Marker words

Rapid learning of word order, nouns, verbs, adjectives and markers without feedback.
Spacing effect and IDs
Neil Walker (PhD student, Lancaster)

- Performance on massed condition replicates previous expt
- Delayed PT confirm acquired knowledge robust after 24 hrs
- Confirms learning sequence: Syntax and verbs > nouns > adj > markers
Summary

Rebuschat, Schoetensack, & Monaghan (in prep)
• Adults can use cross-situational statistics to learn words and grammar simultaneously.

Two questions
• What about children?
  • Dunn, Belteki, Rebuschat & Monaghan (in prep)
• Why not just use a natural language?
Rebuschat, Farrimond, & Monaghan (in prep)
Rebuschat, Farrimond, & Monaghan (in prep)

- Can we use a natural language to explore statistical learning of words and syntax?
- Does age make a difference in cross-situational learning?
- (Select stimuli and age cohort for subsequent studies)
Methods
Methods: Participants

Participants:
- Forty-five NS of English across three age cohorts (each n = 15):
  - 8-9 years
  - 11-12 years
  - 17-18 years

No background in Japanese or any other VF language.

Participants were recruited and tested at local schools.
Methods: Mini-Japanese

- Six animal cartoon characters used in experiment
Methods: Mini-Japanese

Animals are depicted performing one of four actions (hiding, jumping, lifting, pushing) in dynamic scenes generated by E-Prime.
Methods: Mini-Japanese

Lexicon = 12 words

• Six nouns (one per animal)
  – niwatori, chicken; ushi, cow; zou, elephant; kame, turtle; shimauma, zebra; fukuoru, owl

• Four verbs (one per action)
  – kakusu, to hide; tobikueru, to jump; mochiageru, to lift; taosu, to knock down

• Two morphological markers
  – ga = subject marker; o = object marker

Japanese words controlled for length: Half the nouns and verbs three morae in length, the other half five morae.
Methods: Mini-Japanese

Syntax based on Japanese:

- Sentences either SOV or OSV
- Noun phrases have noun as head, followed by obligatory case marker, attached to noun.

Example:
Scene: Zebra jumping over chicken.

Possible descriptions:
- “Shimaumaga niwatorio tobikueru“(SOV)
- “Niwatorio shimaumaga tobikueru“(OSV
Methods: Mini-Japanese

- Generated 72 training sentences and 72 test sentences.

  → Less training than Rebuschat, Schoetensack, & Monaghan (in prep): 48 trials was enough to reach above chance performance

- Lexical frequencies, agent-patient assignment, and word order carefully counterbalanced.
Methods: Materials

Cross-situational learning task

- Four exposure blocks [EXP] → exposure trials only
- Four mixed blocks [M] → exposure trials and lexical test trials
- Four test blocks [ST] → syntactic test trials

<table>
<thead>
<tr>
<th>Block</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Block type</strong></td>
<td>Exp</td>
<td>Exp</td>
<td>M</td>
<td>ST</td>
<td>Exp</td>
<td>Exp</td>
<td>M</td>
<td>ST</td>
</tr>
<tr>
<td><strong>Nr of trials</strong></td>
<td>12</td>
<td>12</td>
<td>12+14</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12+14</td>
<td>12</td>
</tr>
</tbody>
</table>
Exposure trials and lexical test trials

- Participants informed that they would learn a new language.
- They observed two dynamic scenes and hear a sentence in the new language over headphones.
- Task: Decide, as quickly and accurately as possible, which scene the sentence referred to.

<table>
<thead>
<tr>
<th>Block</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block type</td>
<td>Exp</td>
<td>Exp</td>
<td>M</td>
<td>ST</td>
<td>Exp</td>
<td>Exp</td>
<td>M</td>
<td>ST</td>
</tr>
<tr>
<td>Nr of trials</td>
<td>16</td>
<td>16</td>
<td>40</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>40</td>
<td>16</td>
</tr>
</tbody>
</table>
Example trial
Methods: Procedure

*Exposure trials and lexical test trials*

- In the lexical test trials, the scenes were identical with one difference.

<table>
<thead>
<tr>
<th>Noun test</th>
<th>Animals</th>
<th>Actions</th>
<th>Agent-patient assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun test</td>
<td>Different</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>Verb test</td>
<td>Same</td>
<td>Different</td>
<td>Same</td>
</tr>
<tr>
<td>Marker test</td>
<td>Same</td>
<td>Same</td>
<td>Different</td>
</tr>
</tbody>
</table>

No feedback!
Methods: Procedure

**Syntactic test trials**

- Subjects see one dynamic scene and hear a sentence.
- Task: Decide, as quickly and accurately as possible, whether sentence sounds “good” or “bad” (in relation to the previous sentences).
- Patterns: SOV, OSV vs *SVO, *OVS, *VSO, *VOS

<table>
<thead>
<tr>
<th>Block</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block type</td>
<td>Exp</td>
<td>Exp</td>
<td>M</td>
<td>ST</td>
<td>Exp</td>
<td>Exp</td>
<td>M</td>
<td>ST</td>
</tr>
<tr>
<td>Nr of trials</td>
<td>16</td>
<td>16</td>
<td>40</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>40</td>
<td>16</td>
</tr>
</tbody>
</table>
Results
Performance on training trials

- Performance not sig above chance across blocks.
- No effect of training in CSL task. → More exposure necessary.

Note: In sequence learning, absence of training effect is common when exposure period brief (e.g. Destrebecqz, 2004).
Performance on noun tests

- Sig learning effect in 8-9 year olds and 11-12 year olds.
- Sig advantage for younger learners over 17-18 year olds.
Performance on verb tests

- Learning effect only for 11-12 year olds.
- 11-12 year olds sig outperform 17-18 year olds.
Performance on marker tests

- Learning effect only for 11-12 year olds.
- 17-18 year olds get sig worse.
- Sig difference btw 11-12 and 17-18 year olds.
Performance on syntax tests

- No evidence of learning across groups.
Discussion
Discussion

We investigated children, adolescents learning real Japanese via cross-situational learning paradigm (without feedback)

What have our participants learned?

• 8-9 year olds: Nouns
• 11-12 year olds: Verbs > nouns, marker words
• 17-18 year olds: (...)
• 11-12 year old outperformed older learners
• Nobody learns syntax...
Discussion

Rebuschat, Schoetensack, & Monaghan (in prep)
• Adults learning pseudowords and Japanese syntax
• Acquisition sequence:
  Syntax and verbs > nouns > adj > markers.

Rebuschat, Farrimond, & Monaghan (in prep)
• Children and adolescents learning real Japanese
• Only 11-12 year olds show same acquisition sequence as adults, except syntax
Discussion

Why are our participants doing worse?

- Lexicon was simpler (no adjectives, only 6 nouns) but they received less exposure.
- Difference could be due to reduced exposure.
  - 72 training trials (child study)
  - 192 training trials (adult study)
Discussion

Why is the acquisition sequence different?

- Adult study: Syntax and verbs > nouns > adj, markers
- 11-12 year olds: Verbs > nouns, markers. No syntax!
- 8-9 year olds: Nouns only
- 17-18 year olds: No learning (in the right direction)

- Noun advantage well documented in developmental literature so there is expectation that they should do well with nouns.
- But: Verbs are very prominent in this language → Sentence final, associated with overt movement on screen.
- Surprising that only 11-12 year olds learn this.
Discussion

Why is the acquisition sequence different?

• Absence of syntax learning effect surprising.
• Adults learn basic word order rapidly, typically strongest learning effect for verbs and syntax.
• Here, 11-12 year olds show learning effect for verbs but chance performance on syntax tests.

• Perhaps use different test to measure syntactic development? → L2 grammaticality judgments could be more challenging for younger learners (literature suggests 3-5 year olds can do L1 grammaticality judgments).
Discussion

Why are the 17-18 year olds not outperforming the younger learners?

- Expectation was that 17-18 year group should perform very similar to adult subjects in previous studies (mean age ≈ 20)
- Instead: “Sweet spot” for performance in 11-12 year old children.

- Interference from prior knowledge more likely in older learners, e.g. L1 and metalinguistic knowledge.
Different strategy use?

Could older learners use different strategies?  
→ Explicit hypothesis-testing

Explicit learning works well in simpler systems...
Next steps

- Follow-up studies with mini-Japanese
- Focus on ages 10-13 years
- Increased exposure: 18 training and testing blocks, over two days
Thanks!

Padraic Monaghan
Helena Farrimond,
Katharina Braungart, Christine Schoetensack,
Neil Walker.
AMLaP 2017
Lancaster 7-9 September 2017
http://wp.lancs.ac.uk/amlap2017

Invited Speakers:

• Jeff Elman (UCSD), Susan Goldin-Meadow (Chicago)
• Florian Jaeger (University of Rochester)
• Núria Sebastian-Galles (Universitat Pompeu-Fabra)