A model with three grammars

Perception grammar: maps raw auditory data to discrete phonological representations
Recognition grammar: maps discrete phonological representations to lexical forms
Production grammar: maps underlying forms to articulatory forms by taking into account their perceptual results
improve ease of recognition of economic lexical representations.

2.1 Categorization constraints in perception

Task: create covert phonological structure, i.e. features and segments.

Faithfulness:

Example:

\[ \text{WARP (f: x, y)} \]  

"Do not perceive a value \( x \) on the auditory tier \( f \) as the category \( y \)."

Correspondence:

Example:

\[ \text{PERCEIVE (f: x)} \]  

"If the auditory input contains the value \( x \) on the tier \( f \), the output of the perception grammar should contain a corresponding value."

2.2 Functionally desirable ranking of categorization constraints

Functional drive: minimization of confusion.

Example:

\[ \text{WARP (F1: 450 Hz, /i/)} >> \text{WARP (F1: 400 Hz, /i/)} \]

Perception into a near category (\( /e/ \) occurs three times as often as \( /a/ \)):

\[ \text{PERCEIVE \text{WARP (480 Hz, /a/)}} \]

The ranking of OCP should be negatively, and the ranking of LCC positively, correlated with the amount of intervening material.

### Table

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<tr>
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<tbody>
<tr>
<td>( /a/ )</td>
<td>( /e/ )</td>
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<tr>
<td>( \text{WARP} )</td>
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<td>( \text{PRECEDE} )</td>
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<tr>
<td>( /a/ )</td>
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<td>( /i/ )</td>
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</table>

### Example

\[ \text{PERCEIVE \text{WARP (480 Hz, /a/), /e/ + /a/)} \]

2.3 Sequential abstraction constraints

Task: create covert phonological structure, i.e. segments, syllables, feet, autosegments.

Example:

\[ \text{OCP (f: x; cue1 | m | cue2)} \]  

"A sequence of two acoustic cues \( \text{cue1} \) and \( \text{cue2} \) is perceived as a single value \( x \) on the perceptual tier \( f \), despite the presence of some intervening material \( m \)."

Def. \( \text{LCC (f: x; cue1 | m | cue2)}, \)  

"A sequence of two acoustic cues \( \text{cue1} \) and \( \text{cue2} \) is not perceived as a single value \( x \) on the perceptual tier \( f \), because of the intervening material \( m \)."

2.4 Functionally desirable ranking of categorization constraints

Integrate sequences that commonly go together:

\[ \text{OCP > LCC} \]

Example:

\[ \text{OCP (place: labial; transition ñ silence ñ burst)}, \text{LCC (place: labial; transition ñ silence ñ burst)} \]

Separate sequences that do not commonly go together:

\[ \text{LCC > OCP} \]

Example:

\[ \text{LCC (place: labial; transition ñ silence ñ burst)}, \text{OCP (place: labial; transition ñ silence ñ burst)} \]

Language-specific:

\[ \text{[\[ a p|_/p a \]/]} \rightarrow [\[ a p|_/p a \]/ (Italian)] \]

The ranking of OCP should be negatively, and the ranking of LCC positively, correlated with the amount of intervening material.

2.5 Functional drive: minimization of confusion.

2.6 Functionally desirable ranking of categorization constraints

Example:

\[ \text{OCP (place: labial; transition ñ silence ñ burst)}, \text{LCC (place: labial; transition ñ silence ñ burst)} \]

The ranking of OCP should be negatively, and the ranking of LCC positively, correlated with the amount of intervening material.
3. The adult recognition grammar

3.1 Phonological (faithfulness) constraints in recognition

Similarity:

Def. \[ \text{REPLACE} (f, x, y/\text{cond}/\text{left}_-\text{right}) : \]

"do not recognize an input feature value \( x \) on the perceptual tier \( f \) as a different value \( y \) on the same tier, under the condition \( \text{cond} \) and in the environment between \( \text{left} \) and \( \text{right} \)."

Example: a language with nasal place assimilation:

\[ /\text{ampa}/ \rightarrow /\text{an}\_\text{pa}/ \]

violates \[ \text{REPLACE} (\text{place}: \text{labial}, \text{coronal}/\text{nasal}/\text{_ consonant}) \]

Correspondence:

Def. \[ \text{RECEIVE} (f, x/\text{cond}/\text{left}_-\text{right}) : \]

"if the perceptual input contains a feature value \( x \) on the tier \( f \), the underlying form should contain any corresponding value on the same tier."

Def. \[ \text{DONTRECEIVE} (f, x/\text{cond}/\text{left}_-\text{right}) : \]

"if the underlying form contains a feature value \( x \) on the tier \( f \), the perceptual input should contain any corresponding value on the same tier."

Combined correspondence & similarity for binary features:

Def. \[ \text{DELETE} (f, x/\text{cond}/\text{left}_-\text{right}) : \]

"if the perceptual input contains a feature value \( x \) on the tier \( f \), the underlying form should contain the same value on the same tier."

Def. \[ \text{INSERT} (f, x/\text{cond}/\text{left}_-\text{right}) : \]

"if the underlying form contains a feature value \( x \) on the tier \( f \), the perceptual input should contain the same value on the same tier."

3.2 Semantic (lexical-access) constraints

Def. \[ \text{LEX} (x/\text{context}) : \]

"do not recognize an utterance as the lexical item \( x \) in the given semantic \( \text{context} \)."

Example:

\[ \text{LEX} (|\text{h/1007/1106}|'\text{hair'}/'\text{cut'}) \]

3.3 Functionally desirable ranking of faithfulness in recognition

Functional drive:

minimization of perceptual confusion.

By detectability of perceptual features in the acoustic signal (lang.-indep.):

\[ \text{REPLACE} (\text{place}: \text{lab}, \text{cor}/\text{plosive}) \succ \text{REPLACE} (\text{place}: \text{lab}, \text{cor}/\text{nasal}) \]

Explanation:

for a maximum-likelihood perceiver, the correction probability if \( /\text{p}/ \) was perceived is

\[
P (|t| \text{ given } /\text{p}/) = P (/\text{p}/ \text{ given } |t|) \cdot P (|t|) / P (/\text{p}/) = \frac{(\text{light shaded area}) \cdot 3}{4} = 0.241 = 0.096.
\]

the correction probability if \( /\text{t}/ \) was perceived is

\[
P (|p| \text{ given } /\text{t}/) = 0.042.
\]

Acoustic correlate of perceptual place (arbitrary units)

3.4 Functionally desirable ranking of \( \text{LEX} \)

Functional drive:

minimize the probability of misrecognition.

By frequency:

\[ \text{LEX} (|\text{h/1007/1106}|'\text{hare'}) \succ \text{LEX} (|\text{h/1007/1106}|'\text{hair'}) \]

By semantic context:

\[ \text{LEX} (|\text{h/1007/1106}|'\text{hair'}/'\text{fields'}) \succ \text{LEX} (|\text{h/1007/1106}|'\text{hare'}/'\text{fields'}) \]

3.5 Interaction between phonology and semantics

Functionally desirable ranking of \( \text{LEX} \)

context = 'turn'

\[ \text{LEX} (|/\text{3022/1002t}|'\text{rat'}/'\text{turn'}) \text{ REPLACE (height)} \]

\[ \text{LEX} (|/\text{3022/1002d}|'\text{wheel'}/'\text{turn'}) \text{ INSERT (+voice)} \]

\[ \text{LEX} (|/\text{1028il}|'\text{wheel'}/'\text{turn'}) \]

...(Continued)
4. The adult production grammar

4.1 Faithfulness in the production grammar

Similarity:

Def. *REPLACE (f: x, y/cond/left_right):
"do not realize a feature value x on the perceptual tier f in the underlying form as something that you will perceive as a different value y on the same tier in the perceptual output."

Correspondence:

Def. TRANSMIT (f: x/cond/left_right):
"if the underlying form contains a feature value x on the tier f, the perceptual output should contain any corresponding value on the same tier."

Def. DONTTRANSMIT (f: x/cond/left_right):
"if the perceptual output contains a feature value x on the tier f, the underlying form should contain any corresponding value on the same tier."

Combined correspondence & similarity for binary features:

Def. *DELETE (f: x/cond/left_right):
"if the underlying form contains a feature value x on the perceptual tier f, the perceptual surface form should contain the same value on the same tier."

Def. *INSERT (f: x/cond/left_right):
"if the perceptual surface form contains a feature value x on the tier f, the underlying form should contain the same value on the same tier."

4.2 Functionally desirable ranking of faithfulness in production

Functional drive: minimization of confusion.

Ranking of faithfulness in production reflects the ranking in recognition:

\[
\begin{array}{c|c|c|c|c|c|c|c}
 & \text{Recognition grammar} & \text{Production grammar} \\
\hline
\text{REPLACE (f: x, y/cond/left_right)} & \text{REPLACE (f: x, y/cond/left_right)} \\
\text{RECEIVE (f: x)} & \text{DONTTRANSMIT (f: x/cond/left_right)} \\
\text{DONTRECEIVE (f: x)} & \text{TRANSMIT (f: x/cond/left_right)} \\
\text{DONTINSERT (f: x/cond/left_right)} & \text{DELETE (f: x/cond/left_right)} \\
\text{INSERT (f: x/cond/left_right)} & \text{DELETE (f: x/cond/left_right)} \\
\end{array}
\]

Example:

\[
\text{REPLACE (place: cor, lab/plosive)} \rightarrow \text{REPLACE (place: cor, lab/nasal)}
\]

4.3 Articulatory constraints

Def. *GESTURE (a: g/distance/duration/velocity/precision):
"a certain articulator (or combination of articulators) a does not perform the gesture g, over a certain distance, during a certain duration, and with a certain velocity and precision."

Example: nasal place assimilation.

Nasals assimilate:

\[
\text{ñan+pa} \rightarrow \text{/anpa/}
\]

Plosives do not assimilate:

\[
\text{ñat+ma} \rightarrow \text{/atma/}
\]

4.4 Functionally desirable ranking of articulatory constraints

Functional drive: maximize ease of articulation.

By effort:

\[
\text{*GESTURE (tongue: groove)} \rightarrow \text{*GESTURE (tongue: non-groove)}
\]

or:

\[
\text{*[s] } \rightarrow \text{*[1519]}
\]

By training:

\[
\text{TRANSMIT (/[1519]/) } \rightarrow \text{*[s] } \approx \text{*[1519] } \rightarrow \text{TRANSMIT (/[s]/)}
\]

Corollary: markedness constraints do not exist.

Perceptual control loop:

\[
\text{ñ} \rightarrow \text{*[r] } \rightarrow \text{*[s]} \rightarrow \text{*[1519]} \rightarrow \text{*[r] } \rightarrow \text{ñ}
\]

\[
\text{ñ} \rightarrow \text{*[s]} \rightarrow \text{*[f]} \rightarrow \text{*[s]} \rightarrow \text{*[f] } \rightarrow \text{ñ}
\]

4.5 Articulatory constrains
Acquisition of phonology

Ingredients:
1. Initial state: the three grammars are substantively empty.
2. Gradual Learning Algorithm: deaf, dumb, and blind. The learner will take action as soon as she discovers that an adult form is different from the one produced by her own grammar.
3. Perception Acquisition Device (PAD).
4. Language Acquisition Device (LAD).

Acquisition process: seven processes in parallel.

6. Acquisition of categorization

6.1 Origin
Origin of categorization constraints
As soon as a feature value is perceived, the Perception Acquisition Device will supply the perception grammar with constraints for its categorization.

6.2 Ranking
Ranking of categorization constraints
GLA will automatically lead to a realistic probability-matching maximum-likelihood criterion.

Example:
Suppose that the intended /e/ and /a/ categories are equally common, but that the *WARP (F1) constraint family is ranked completely incorrectly:

\[
\begin{align*}
F1 &= 420 \text{ Hz} \\
\text{intended:} & \quad \text{\( e \)} \quad \rightarrow \quad \text{\( e \)} \\
\text{\( a \)} \\
\text{\( a \)} \rightarrow \quad \text{\( a \)}
\end{align*}
\]

Suppose that the intended /e/ and /a/ categories are equally common.

Solved: optimal multi-dimensional cue integration.
Not solved: category creation, category split, category merger.

7. Acquisition of sequential abstraction

7.1 Origin
Origin of sequential abstraction constraints
As soon as a perceptual category is created, the Perception Acquisition Device will supply the perception grammar with constraints that control sequential abstraction (OCP and LCC).

Example:
The learner already has the low-level perceptual categories:
- \([a]\) (high F1),
- \([p|]\) (labial implosion),
- \([_]\) (silence),
- \([p]\) (labial explosion),
and she hears the acoustic sequence \([ap|_pa]\) for the first time.

She will create OCP and LCC constraints for all pairs of acoustic cues:

\[
\begin{align*}
\text{a. OCP (place: lab; } p|_p \text{). If ranked higher than its LCC counterpart, this causes the perception of a single labial value on the place tier:}
\text{place: lab} & \quad \text{cues: } ap|_pa
\end{align*}
\]

\[
\begin{align*}
b. OCP (\sigma_2; p|_p). \text{ This may cause the perception of a single "segment" } /p/, \text{so that } [ap|_pa] \text{ may be } /ap/\text{ on the language-specific second level of abstraction.}
\text{σ_2: } a \quad \text{cues: } ap|_pa
\end{align*}
\]

\[
\begin{align*}
c. OCP (\sigma_5: p|_a). \text{ This may cause the perception of a single 'syllable' } /pa/, \text{which may be a unit in the language-specific fifth level of abstraction, so that}
\text{σ_5: } a \quad \text{σ_2: } a \quad \text{cues: } ap|_pa
\end{align*}
\]

\[
\begin{align*}
d. OCP (height: low; a|p|_p). \text{ This may cause the perception of } /a/ \text{ as a single vowel across an intervening consonant, i.e. vowel harmony:}
\text{height: low} & \quad \text{σ_2: } a \quad \text{cues: } ap|_pa
\end{align*}
\]

Note: all these sentences are covert.

\[
\begin{align*}
\text{Note: although the speaker’s intention was } /e/, \text{ the perception device perceived } /a/ \text{ on the language-specific first level of abstraction.}
\end{align*}
\]

\[
\begin{align*}
\text{Note: the problem of } /e/ \text{ was not solved due to zero detection threshold.}
\text{Result:}
\text{the learner knows that although she perceived } /a/, \text{ the speaker’s intention had been } /e/.
\end{align*}
\]

6.2 Ranking

6.1 Origin
Origin of sequential abstraction constraints

Language Acquisition Device (LAD) will automatically lead to a realistic probability-matching maximum-likelihood criterion.

6.2 Ranking

6.1 Origin
Origin of sequential abstraction constraints

Note: all these sentences are covert.
7.2 Initial ranking

The initial ranking OCP \( \gg \) LCC tends to simplify hidden structure.

8. Acquisition of lexical access

Initially, only the constraints RECOGNIZE and LEXICALIZE exist.

The initial state of the recognition grammar and the first lexical item are obtained.

Later on, the learner may reconstruct the new item as [\( \text{wheel} \)] on the basis of morphological information.

9. Acquisition of lexical access

9.1 Origin

The Language Acquisition Device supplies the recognition grammar with a constraint (LEX) against its recognition. The semantic contexts contribute dynamically and additively to the ranking of this constraint.

9.2 Initial ranking of lexical access constraints

Whereas OCP constraints are low ranked, when entering the recognition grammar, OCP constraints are high ranked.

8. Origin of lexical access constraints

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECOGNIZE</td>
<td>1</td>
</tr>
<tr>
<td>LEXICALIZE</td>
<td>2</td>
</tr>
</tbody>
</table>
The learner will create a constraint `LEX (|/3022/1002t| 'wheel')` and a thousand rankings of `LEX (|/3022/1002t| 'wheel' / 'turn')`, `LEX (|/3022/1002t| 'wheel' / 'bite')`, and half a million additive rankings like `LEX (|/3022/1002t| 'wheel' / 'turn' & 'bite')`.

9.2 Ranking by frequency

GLA will automatically rank each lexical access constraint according to frequency. The recognition of more frequently occurring words will be preferred.

Example: suppose that an adult `|/3022/1002t| 'rat'` means `|/3022/1002t| 'rat'` 70% of the time, and `|/3022/1002d| 'wheel'` 30% of the time, but that the learner nevertheless has the ranking `LEX (|/3022/1002t| 'rat') >> LEX (|/3022/1002d| 'wheel')`. In 70% of the cases, there will be a misrecognition: `|/3022/1002t| 'rat'` intended: `|/3022/1002t| 'rat'` `LEX (|/3022/1002t| 'rat')` `LEX (|/3022/1002d| 'wheel')` √ `|/3022/1002t| 'rat'`! → *

This will lead to probability matching, i.e. the learner will end up recognizing `|/3022/1002t| 'rat'` 70% of the time.

9.3 Ranking by semantic context

GLA will automatically determine the weight with which each semantic context contributes to the ranking of each `LEX` constraint.

Example: suppose that the learner has the anti-functional ranking `LEX (|/3022/1002d| 'wheel' / 'turn') >> LEX (|/3022/1002t| 'rat' / 'turn')`: context = 'turn' intended: `|/3022/1002d| 'wheel'` `LEX (|/3022/1002d| 'wheel' / 'turn')` `LEX (|/3022/1002t| 'rat' / 'turn')` * `LEX (|/3022/1002t| 'rat')` ← √ `|/3022/1002d| 'wheel'`! → *

This will lead to probability matching.

10. Acquisition of faithfulness in recognition

10.1 Origin

Origin of faithfulness constraints in recognition

As soon as a perceptual category is created, the Language Acquisition Device supplies the recognition grammar with several faithfulness constraints (FAITH), which favour the similarity between the perceived form and the lexical form (with respect to the presence of features, their co-occurrence, and their sequencing).

Example: when the learner creates the category `|labial| on the perceptual place tier, with nasality categories already in place, the recognition grammar will be supplied with a constraint `REPLACE (place: lab, cor / nasal)`, or `→ |n|`, and faithfulness constraints for the surfacing of underlying temporal order.

10.2 Ranking

GLA will automatically rank these constraints according to the frequency of occurrence of the associated phonological feature values.

Example: suppose that an intended `|n|` occurs three times as often as an intended `|m|`, and that there is a 9.6% probability for a perceived `/m/` to have been intended as `/n/`, and that there is a 4.2% probability for a perceived `/n/` to have been intended as `/m/`, and that there is a 9.6% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063m| 'seam')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outrank `LEX (|si/9063n| 'scene')`, or there is a 4.2% probability for the constraint `REPLACE (lab, cor) / |n| >> |m|` to outran...
The probability that this happens, given the perception of a certain perceptual result, is 90.4% · (1 – $p_d$).

This will ultimately lead to $p_d = 9.6\%$, i.e., *REPLACE (lab, cor) will come to outrank *LEX (seam) by 1.8 standard deviations of the evaluation noise.

Analogously, *REPLACE (cor, lab) will come to outrank *LEX (scene) by 2.5 noise standard deviations.

*REPLACE (cor, lab) will end up at 0.7 standard deviations above *REPLACE (lab, cor).

11. Faithfulness in production

11.1 Origin

The Language Acquisition Device forces the use of the same faithfulness constraints, perhaps with the same ranking, in the production grammar as well as in the perception grammar.

11.2 Ranking

If perception and lexicalization are adult-like, but perceptuomotor knowledge fails:

*DELETE (sibilant)

Note: the candidate list does not contain any form that is perceived as /s/.

12. Articulatory effort

12.1 Origin

As soon as the child learns the result of an articulatory gesture, she will create a constraint *GESTURE (tongue: groove), and rank it high in her production grammar.

Example: when the child learns that a certain tongue-grooving gesture, in combination with some already known laryngeal and velar gestures, produces the sibilant noise that she perceives as /s/, she will create a constraint *GESTURE (tongue: groove), and rank it high in her production grammar.

12.2 Ranking

GLA will usually lower the gestural constraints and automatically raise the corresponding faithfulness constraints. Thus, ranking the constraints in the OT learning curve.

<table>
<thead>
<tr>
<th>Percentage correct (solid)</th>
<th>Constraint ranking (dotted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0</td>
</tr>
<tr>
<td>50%</td>
<td>50</td>
</tr>
<tr>
<td>100%</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time after invention of gesture (number of learning pairs)</th>
<th>Constraint ranking (dotted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

*DELETE (sibilant)

Note: the candidate list does not contain any form that is perceived as /s/.

<table>
<thead>
<tr>
<th>Constraint ranking (dotted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

The Language Acquisition Device forces the use of the same faithfulness constraints in production.

<table>
<thead>
<tr>
<th>Constraint ranking (dotted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>
13. Summary

13.1 Innate

a. The capability of perceptual categorization and its translation into PERCEIVE and *WARP constraints.
b. The capability of perceptual abstraction and its translation into OCP and LCC constraints.
c. Motor skills in the speech tract (or for sign languages the upper half of the visible body) and their translation into *GESTURE.
d. Initial high ranking of OCP in the perception grammar and *GESTURE in the production grammar.
e. The capability of storing items in a large lexicon, and its translation into *LEXICALIZE.
f. The capability of accessing items in the lexicon, and its translation into *LEX.
g. Equal ranking of faithfulness in recognition and production (perhaps).
h. Local ranking of faithfulness constraints by perceptual confusability, and local ranking of gestural constraints by articulatory effort.
i. A gradual constraint-ranking learning algorithm that causes probability matching.

13.2 Not innate

a. Language-specific perceptual features and feature values and their simultaneous and sequential combinations.
b. Language-specific articulatory gestures and their simultaneous and sequential combinations.
c. The capability for learning arbitrary language-specific generalizations.

13.3 Conclusion

It is plausible that the innate language acquisition device supplies the learner with a number of generic constraint templates in three grammars. The substantive content of these constraints is learned by the child with the help of a theory of autosegmental phonology that separates articulatory from perceptual representations and principles.