Transient Phonology, CON and Child Phonological Processes

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Our goal: To provide a more explanatory analysis of child phonological patterns by considering them in the larger context of perceptual, physiological, and motor skill maturation.

I. Children's transient phonology

1) An unexplained phenomenon in phonology: Certain patterns that are common in child phonology violate generalizations from adult phonological typology.

2) Example 1: Positional velar fronting (PVF; data from Inkelas & Rose, 2007: 710-711)
   a. Velar place becomes alveolar in prosodically strong positions
      cup [ˈtʰʌp] 1;09.23
      again [əˈdɪn] 1;10.25
   b. Velar place is preserved in prosodically weak positions
      bagel [ˈbejgu] 1;09.23
      back [ˈbæk] 1;10.02
   - Adult generalization violated: Existence of a contrast in prosodically or perceptually weak position implies its existence in prosodically/perceptually strong position.

3) Example 2: Consonant harmony (CH; data from Smith, 1973; Pater, 2002):
   a. Regressive assimilation: Velar trigger, coronal or labial undergoer
      duck [gʌk] tickle [gɪːguː] pig [gɪg]
   b. Regressive assimilation: Labial trigger, coronal undergoer
      top [pap]
   c. Progressive assimilation: Velar trigger, coronal or labial undergoer
      cut [kʌk] cup [kʌk]
   - Adult generalization violated: Assimilation with respect to major consonant place of articulation may only be local.

4) These patterns cannot be captured without modifications to the formalism devised for adult grammars, e.g. positional faithfulness constraints that selectively protect weak position.

5) Question: Should we assume an expanded CON that includes the constraints needed to capture child-specific phenomena?
   - Example of typical reasoning (Morrisette, Dinnsen & Gierut, 2003): PVF is driven by a constraint *#k. Constraint starts out highly ranked and is demoted in response to adult evidence. Demotion explains absence of PVF from adult grammars.

6) Problem: If constraints driving child patterns are freely rankable elements in a universal, unchanging inventory, they should have some reflex in adult languages.
   - Demotion of a constraint can explain the absence of its effects in a specific language, but it cannot account for the non-attestation of effects in cross-linguistic typology.

7) *Interim conclusion 1*: The forces that drive child-specific patterns must be in some way <u>contingent</u> or <u>transient</u>, such that they are no longer in effect by the time the child reaches adulthood.

   - So where do child-specific patterns come from? What gives them their transient character?

II. Sources of divergence between child and adult phonology

8) The big picture: Acquiring the phonological system of a target language(s) is not just a question of learning a language-specific constraint ranking. Other tasks children must accomplish include:
   a. Acquiring the relevant perceptual categories and their various combinations (e.g. Gerken 2002);
   b. Acquiring a lexicon (required to learn the relevant morphophonological generalizations);
   c. Acquiring the articulatory (motor) plans required to reproduce the sounds and sound combinations in their spoken forms.

9) Child and adult speakers face different low-level phonetic pressures, particularly in the domain of articulatory control.
   a. Child's tongue has more anterior position, larger size relative to vocal tract (Crelin, 1987).
   b. Child's speech gestures are slower, more variable, less precise (Smith & Goffman, 2004).
   c. Child has more limited ability to plan complex movements or movement sequences (Fletcher, 1992).

   For the present, we will set aside…
   d. Perceptual differences
   e. Lexical differences (e.g. lower neighborhood density → less fine-grained representations)

10) Common child phonological processes like stopping, velar fronting, and consonant harmony can be analyzed in terms of children's immature speech-motor capabilities.
   a. Anterior position of tongue predisposes child to fronting of velar consonants.
   b. Ballistic gesture for a stop requires less precision than narrow constriction for fricative.
   c. Repeating the same place of articulation ([gæg] versus [bæg]) simplifies the motor planning task.

11) A phonetically motivated account can explain the transient nature of child patterns: As motor control matures, patterns driven by early limitations will fade.

12) Question: Are child-specific patterns purely performance errors, unrelated to grammatical competence? (e.g. Hale & Reiss, 1998, 2008)

13) Problems with this assumption:
   a. Performance errors are variable and unpredictable; the child patterns in question are systematic.
   b. Phonetically driven substitutions are gradiently conditioned by fine-grained factors (e.g. rate of speech, absolute vowel duration). Child patterns are conditioned by coarse-grained, phonologically defined factors (e.g. syllables, feet).
   c. Children's physical production abilities often exceed what they demonstrate in habitual speech.
      - Phonological learning may follow a U-shaped curve: early period of precocious correct production followed by period of systematic application of error pattern (Becker & Tessier, 2011).
      - Many children can imitate correct production of sounds and sound sequences they do not yet use spontaneously (e.g. Bedore, Leonard & Gandour, 1994).

14) *Interim conclusion 2*: At least some child errors can plausibly be analyzed as the consequence of child-specific articulatory limitations. However, these influences are not hard motor limitations; they have a systematic quality that suggests they have been grammaticalized.
   - How do these phonetic pressures become phonologized? What form do they take in the grammar?

III. On phonologization

15) We assume that the constraint inventory is dynamic: new constraints can be added on the basis of phonetic pressures or statistical generalizations (e.g. Becker & Tessier, 2011; Levelt & van Oostendorp, 2007; Pater, 1997).

16) Child's grammar trawls over the adult input; statistical generalizations it observes will be formalized as conventional markedness constraints (shared across child and adult speakers).
   - e.g. Exposure to a language with no dorsal codas would lead to projection of *Dorsal].

17) A first-pass account of phonologization of child-specific pressures: Child's grammar trawls over child's phonetic outputs and constructs constraints that represent generalizations over what the child produces.
   - e.g. Suppose that articulatory limitations prevent a child from realizing phonetically correct velars in strong positions. Grammar observes absence of initial velars and projects a constraint *[Dorsal.

18) Problem with this account: Why should the grammar form generalizations that single out the child's own output, to the exclusion of adult models?

19) Children show a persisting bias or conservatism favoring continued production of their own error forms (Tessier, 2008, 2012; Becker & Tessier, 2011).
   a. Lexical fossils: Specific words, usually early-acquired/high-frequency, continue to exhibit a pattern that has been eliminated elsewhere in the child's output.
      - Example (Tessier, 2008, citing Compton and Streeter, 1977): Trevor continued to exhibit /tr/→[tʃ] in his own name after other /tr/ clusters began to be realized faithfully.

truck	[trʌk]	2;2.23	Trevor	[tʃɛvə:]	2;3.04
train	[tre:n]	2;2.23	Trevor	[tʃɛvə:]	2;4.03
try	[trai]	2;4.03	Trevor	[tʃɛvə:]	2;4.13

   b. Child's habitual output is incorrect, but imitative or careful productions are more accurate.

20) Previous models have thus found it useful to assume that the child's own error forms are stored and can enter into competition with more faithful 'new' forms.
   a. Error-selective learning (Tessier, 2008, 2012; Becker & Tessier, 2011):
      - Every unique output of the child's grammar is stored in a buffer called the CACHE.
      - When the number of cached error forms favored by a particular markedness constraint exceeds some predetermined threshold, learning is triggered.
      - Learning: An error representing a minimal change to the grammar is selected and added to a repository called the SUPPORT, which is used as the basis for constraint re-ranking.
   b. USELISTEDERROR (Tessier, 2008): "Assign a violation to any output form that is non-identical to the input's stored loser form."

21) Not addressed by these accounts: What is the functional motivation for children's conservatism? (and how do we account for individual variation in the predetermined threshold for triggering learning?)
   a. Intuitively, it is related to *avoidance of performance failure*, which is in turn related to child's motor skill and the motor difficulty of the target being attempted.
   b. If child attempts to produce motorically demanding forms, many performance errors will result.
      - Hypothetical example: 6/10 of child's attempts at initial /k/ are realized with overly anterior lingual contact, perceived as /t/.
   c. Child can keep attempting something that is motorically too challenging for him to execute reliably, or he can revert to a simpler target that can be attained consistently.
   d. This choice is familiar to observers of child development (Vihman & Greenlee, 1987): Some children favor a systematic-stable trajectory of acquisition (child attempts only forms that are within his/her capacity for correct production); others favor an exploratory-variable trajectory (child attempts more complex forms, with inconsistent results).

22) Our contention: The balance between faithfulness to the adult target and avoidance of performance failure is negotiated within the grammar in a way that reflects tacit knowledge of the relative articulatory difficulty of targets.

IV. The A-map and RECYCLE

23) Proposal: Speakers possess an A(rticulatory)-map, analogous to Steriade's (2001) P(erceptual)-map, that is a tacit body of knowledge that certain sequences are more likely than others to result in performance error.
   a. Both are acquired through the experience of producing/perceiving speech.
   b. Both are sensitive to segmental/prosodic context (P-map encodes perceptibility of a contrast in a particular context; A-map encodes likelihood of performance error in a particular context).

P-map (fragment): Obstruent voicing	V_V	C_V	V_R	V_]	V_T	C_T
k/g	k/g	k/g	k/g	k/g	k/g	k/g

Font size reflects perceptibility of contrast (following Steriade 2001).

A-map (fragment): Dorsal cons. place	$_{Ft}$[_V	V_V̆	V_]
k,g	k,g	k,g	k,g

Font size reflects likelihood of performance error.

24) The likelihood of performance error is related to the articulatory difficulty of executing a given target.
   a. This will vary somewhat across speakers, based on individual differences in vocal tract shape/size, motor practice experience, etc.
   b. But certain statements about relative speech-motor difficulty are likely to be stable across speakers.
      - Cluster >> Singleton
      - Consonant harmony: Multiple places of articulation per planned unit (e.g. C_1VC_2) >> Single place of articulation (e.g. C_1VC_1)
      - Discrete gesture >> Undifferentiated gesture (linguopalatal contact spans alveolar/palatal/velar regions, here transcribed [t͡k]; Gibbon, 1999).
      - Controlled gesture (e.g. fricative) >> Ballistic gesture (e.g. stop)
      - Multiple lingual constrictions (e.g. /ɝ/) >> Single lingual constriction (e.g. /ɔ/)
   c. The A-map will shift substantially over development as motor abilities mature.

25) We propose to implement the A-map in the framework of Harmonic Grammar (Legendre, Miyata & Smolensky, 1990), where a single weighted constraint (27) assigns violations whose magnitude is determined by the child's experience of relative articulatory difficulty.

26) RECYCLE: "Penalize any output form whose probability of incurring a performance error is greater than that of the stored previous form."

27) A performance error is an instance in which the child's phonetic output does not match the form selected by his grammar, whether or not the grammar's output matches the adult target.

28) RECYCLE assigns real-valued violations whose magnitude is dictated by the difference in the likelihood of a performance error, encoded in the A-map, between a given candidate and a stored previous form.
   a. Since the A-map encodes probabilities, the greatest possible RECYCLE violation has magnitude 1.
   b. The lowest violation magnitude is 0; there are no negative violation scores.

29) How is the stored previous form determined? Each of the child's utterances of a particular target (e.g. a syllable or diphone sequence) is stored as part of an exemplar cloud associated with that target (Goldinger, 1997; Johnson, 1997; Pierrehumbert, 2001).
   a. Stored exemplars contain info about both the motor plan executed and its acoustic consequences.
   b. The stored error form that is used in computing RECYCLE violations represents an average across the properties of the cloud of previous productions.
   c. Stored error form can change over time, but only gradually—requires accumulation of enough new productions to shift the mass of the exemplar cloud.

30) We assume that the A-map and the P-map coexist and are in tension with one another.
   a. Certain child phonological substitutions reflect the influence of acoustic rather than articulatory similarity (e.g. click substitutes for a fricative; Bedore et al., 1994).
   b. We will implement the P-map through PMATCH, a weighted constraint whose violation magnitude is dictated by perceptual distance between the candidate acoustic output and the target acoustic output (cf. Steriade 2001, in which P-map was implemented through ranked correspondence constraints).

V. Positional velar fronting with A-map and RECYCLE

31) Using A-map and RECYCLE to capture a child-specific phonological pattern, positional velar fronting.
   a. Claim 1: Children's early attempts to produce lingual consonants frequently result in performance errors featuring undifferentiated linguopalatal contact, which can be perceived as coronal.
   b. Claim 2: Child can then choose to plan either a faithful or an undifferentiated gesture. Likelihood of performance error, encoded in the A-map, is lower for /t͡k/ than for /k/.
   c. Claim 3: Positional effects emerge from the fact that a velar gesture in strong position is motorically more challenging than a velar gesture in weak position, also encoded in the A-map.

32) Motor basis of velar fronting (McAllister Byun, 2012):
   a. Tongue control is motorically complex; jaw control is motorically simple. Young children's tongue movements may be parasitic on jaw (MacNeilage & Davis, 1990).
   b. Jaw-controlled movement is linked to an undifferentiated pattern of linguopalatal contact spanning alveolar/palatal/velar regions (Gibbon, 1999).
   c. Undifferentiated gestures can be perceived as coronal.
   d. Discrete coronal place is not simpler than discrete velar place in any obvious way. However, jaw-controlled movement resulting in undifferentiated contact is simpler than discrete movement of either functional region of the tongue.

33) Motor basis of positional velar fronting (Inkelas & Rose, 2007; McAllister Byun, 2012):
   Planning complexity of a discrete lingual gesture is greater when the target is high/forceful.
   a. When the tongue remains close to the jaw, some of its skeletal/ shaping needs are met passively through contact with the lower teeth.
   b. When aiming at a higher target, the tongue muscles alone must fill these requirements. This more complex motor task is associated with a higher likelihood of a performance error.

34) First time a child attempts a velar target in initial position:
   a. There is no stored error form, so RECYCLE is vacuously satisfied by all candidates.
   b. Child accurately perceives adult target with initial velar. Adult input gives no evidence for a ranking *k >> PMATCH (perceptually weighted faith), so the grammar selects the fully faithful candidate.

	Adult target: [ki] Child input: /ki/	PMATCH	RECYCLE	*H*
		w = 1	*w* = 1	
☞ a.	ki			0
b.	i	-1		-1
c.	ti	-.3		-.3
d.	t͡ki	-.3		-.3

35) However, child's motor limitations lead to <u>frequent performance errors in which the velar target is replaced by an undifferentiated lingual gesture, perceived as coronal</u>.

36) Once a sufficient number of performance errors accumulates, the stored error form / t͡ki/ competes with the fully faithful candidate. Influence of RECYCLE now favors undifferentiated candidate (d):

	Adult target: [ki] Child input: /ki/ Child stored error form: [t͡ki]	PMATCH	RECYCLE	*H*
		w = 1	*w* = 1	
a.	ki		-.6	-.6
b.	i	-1		-1
c.	ti	-.3	-.6	-.9
☞d.	t͡ki	-.3		-.3

37) Model with RECYCLE thus predicts that precocious faithful productions should appear before child's error form is well-established. Consistent with the U-shaped learning curve seen in many trajectories of phonological development, including PVF(Becker & Tessier, 2011; Inkelas & Rose, 2007).

38) In a prosodically weak context, a smaller lingual gesture incurs a smaller-magnitude RECYCLE violation; faithful candidate (a) is selected as most harmonic.

	Adult target: [pik] Child input: /pik/ Child stored error form: [pit͡k]	PMATCH	RECYCLE	*H*
		w = 1	*w* = 1	
☞ a.	pik		-.2	-.2
b.	pi	-1		-1
c.	pit	-.3	-.2	-.5
d.	pit͡k	-.3		-.3

- Note: Tableau (38) assumes that a final velar target has a stored error form with an undifferentiated gesture. It is also possible that an undifferentiated error form was never established in this context. Both possibilities converge on the same outcome, i.e. selection of the faithful candidate.

39) This grammar captures PVF without assuming *#k. Note: we do assume that there is a conventional markedness constraint *k, but it is low-weighted in a language that has velars, like English.

VI. RECYCLE and elimination of child phonological patterns

40) Two paths (not mutually exclusive) to elimination of child phonological processes:
   a. Decrease in weight of RECYCLE relative to PMATCH: As long as stored form favored by RECYCLE differs from adult target form, weight of RECYCLE is decreased incrementally in each cycle of evaluation, like any other markedness constraint. (We assume the Gradual Learning Algorithm for Harmonic Grammar, or HG-GLA; Boersma & Pater, 2008).
   b. Changes in A-map affect magnitude of RECYCLE violations.

41) When does the A-map change?
   a. As RECYCLE and PMATCH get closer together, child sometimes attempts fully faithful target. <u>If maturation has occurred</u>, rate of performance errors will be lower—can update numbers in A-map.
   b. Creates a cycle: Smaller magnitude of RECYCLE violation → faithful target selected more often → higher rate of successful execution stored in A-map → further decrease in RECYCLE violation, etc.
   c. Eventually faithful productions come to dominate the cloud of child's outputs, and the child's stored error form is identical to the adult target form.

42) If continuing motor difficulty keeps error rate high, however, RECYCLE may continue to drive substitution in spite of counterevidence from adult input.

43) Case study (Bedore et al., 1994): C, a 4;4-year-old English-acquiring female, replaced all stridents /s, z, ʃ, tʃ, ʒ, dʒ/ with the dental click /|/. Non-stridents retained fricative manner.

   a. /s, z/

saw	[|ɔ]	this	[ðɪ|]
preschool	[pwi|u]	sometimes	[|əmtaɪm|]

   b. /ʃ, ʒ, tʃ/

shark	[|ark]	treasure	[twɛ|ɚ]
fish	[fɪ|]	match	[mæ|]

44) Bedore et al. interpret click substitution as an attempt to match high-frequency acoustic energy of stridents, initiated when C was motorically incapable of producing complex tongue shape for stridents.

45) However, pattern remained in place even after C acquired motor ability to articulate stridents: "C was able to produce /s, z, ʃ, tʃ/ correctly when asked to imitate the examiner" (in her initial evaluation).

46) Difficult pattern to model with conventional markedness and faithfulness constraints.
   a. Inventory contained many sounds representing a closer featural match for stridents (e.g. /s/→ [t]).
      - Indicates need for PMATCH.
   b. C's input provided abundant evidence to demote a constraint *STRIDENT, and she was motorically capable of producing all stridents, but she continued to substitute clicks.
      - Suggests bias to produce old/easy forms expressed by RECYCLE.

- Recall our proposal that some children are naturally conservative in their phonology due to a high weight of RECYCLE. C certainly seems to be an example of such a child.

	Adult target: [si] Child input: /si/ Child stored error form: [|i]	RECYCLE	PMATCH	*H*
		$w = 2$	$w = 1$	
a.	si	-.8		-1.6
b.	ti		-1	-1
☞ c.	|i		-.5	-.5

47) Elimination of click substitution pattern: Bedore et al. tracked C's progress in speech therapy.
   a. C imitated clinician's model of /s/ in monosyllabic words.
   b. Words selected for practice were imitated with 100% accuracy during therapy.
   c. Minimal change was noted in spontaneous productions of stridents in the first two therapy sessions.
   d. In therapy session 3, though, C was noted to produce all stridents correctly in spontaneous speech.

sink	[sɪŋk]	spoons	[spunz]
dishwasher	[dɪʃwaʃɚ]	measuring	[mɛʒwɪŋ]
sandwich	[sænwɪtʃ]	giraffe	[dʒəwæf]

   e. Here we see that C's errors could not have been the result of perceptual errors or faulty lexical representations—only /s/ was targeted, but gains immediately extended to all stridents.

48) What changed during C's three sessions of therapy?
   a. In the therapy context, faithfulness may receive a temporary boost (McAllister Byun, 2012).
   b. Enhanced PMATCH outweighs RECYCLE; grammar selects forms with faithful stridents.
   c. Motor maturation has occurred since C last attempted stridents. Low rate of performance errors (0%, in fact) leads to rapid revisions in A-map for /s/, the target practiced in therapy.
   d. "Hey, that wasn't so hard after all!": C maintains a high weight of PMATCH relative to RECYCLE outside of the therapy setting. Similar revisions to the A-map follow for all strident targets.

VII. Future directions and unresolved questions

49) Through influence of RECYCLE, children's phonetically-motivated performance errors take on grammatical status. Eliminates need for constraints like *#k, which is problematic due to lack of reflex in adult typology.

50) Does RECYCLE remain active in adult phonology?
   a. The topography of the A-map becomes less extreme over time—likelihood of performance error is similarly low across targets.
   b. Other forces (conventional markedness and faithfulness constraints) emerge as the primary driving forces of grammar.
   c. However, a persisting role for Recycle can certainly be envisioned in the context of L2 learning, as well as in cases of lexical avoidance due to anticipated speech errors.
   d. Current conclusion is that RECYCLE and the A-map remain present in the grammar, although their effects are moderated and masked.

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