Appears in J. Lidz, W. Snyder & J. Pater (eds, 2016) *The Oxford handbook of developmental linguistics.* Oxford: Oxford University Press, pp. 43-67.

Phonological Processes in Children's Productions: Convergence with and Divergence from Adult Grammars

Heather Goad
McGill University

Abstract

This chapter overviews some of the ways that children's phonological processes converge with and diverge from those attested in adult grammars. Processes in segmental and prosodic phonology are examined: contextually-determined segmental substitutions, patterns of consonant cluster reduction and stages in the development of word structure. The paper starts from the position that children's grammars abide by the same principles and constraints as adult grammars, even if they bear only some resemblance to the target grammar. Sources of explanation outside the grammar proper for mismatches between child and adult outputs play a central role, notably for rogue behaviour, where children display patterns in development that are unexpected when viewed from the perspective of adult grammars. A central question that emerges is whether childrens' systems differ in fundamental ways from adult grammars or whether rogue behaviour can be explained through examining how perceptual and motor development interface with the acquisition of a phonological grammar.

1 Introduction

A body of evidence shows that children's early phonological grammars are unmarked vis-à-vis adult grammars (Jakobson 1941/1968; Stampe 1969); and although learners may take different paths toward the target grammar, the patterns they show largely reflect the typological options displayed in end-state grammars (Gnanadesikan 1995/2004). Accordingly, most research in the generative tradition has examined children's behaviour in relation to some adult grammar, typically the target grammar. This perspective is particularly evident in Optimality Theory (OT) (Prince and Smolensky 1993/2004) where children's initial grammars, stages in development, and variation observed within and across learners are formally expressed in the same manner as cross-linguistic variation in adult grammars: through differences in constraint ranking. Children's grammars are thus typically viewed as "possible grammars" (White 1982; Pinker 1984), as systems that respect the same principles and constraints as do adult grammars, even if they bear only some resemblance to the target grammar. Indeed, coupled with the idea that development involves minimal constraint reranking over time, this approach predicts the existence of intermediate grammars that are neither entirely unmarked nor completely target-like (e.g. Levelt et al. 2000; Rose 2000).

The OT approach has been fruitful in accounting for certain types of patterns that motivated some researchers to abandon the view that developing grammars are on a trajectory toward the adult grammar in favour of the alternative that children's grammars are self-contained systems subject to their own constraints (Stoel-Gammon and Cooper 1984; Vihman 1996). At the same time, however, this approach has generally placed the burden of explanation for productions that deviate from adult forms on a non-target-like phonological system. A central problem with this emerges in situations where children display patterns in development which, when viewed from the perspective of adult grammars, are unexpected and possibly universally illicit (Drachman 1978; Hale and Reiss 1998; Buckley 2003). The question that arises, thus, is whether children possess "rogue grammars" in the phonological domain (Goad 2006), systems that differ in fundamental ways from adult grammars, or whether rogue behaviour can be explained through examining how perceptual and motor development interface with the acquisition of an adult-like grammar.

This chapter overviews some of the ways that children's phonological processes converge with and diverge from those attested in adult grammars. Although we will consider children's productions in relation to some adult target, sources of explanation outside the grammar proper for mismatches between child and adult outputs take centre stage, specifically the developing perceptual system and immature vocal tract (Locke 1993).

Development in perception is not complete at the onset of production (Shvachkin 1948/1973; Garnica 1973; Edwards 1974; Brown and Matthews 1993; Fikkert 2010). Nonetheless, in production studies, it is typically assumed (since Smith 1973) that, in the absence of evidence to the contrary, children accurately perceive the ambient input. Accordingly, the stored forms linguists propose for children correspond to adult outputs. In cases where development in production mirrors development in perception (Pater 2004), this supposition is not fatal: mispronunciations may at early stages have as their source misperception, but the parallels observed between the perception and production components of the grammar mean that when the perceptual challenges are overcome at a later stage, mispronunciations will be due to the same constraints operating in production. However, there are cases that do not fit this parallel perception-production view of the grammar. We consider, in this context, velar substitution: Amahl's production of 'puddle'-type words as [pʌɡəl] (Smith 1973). In this case, misproduction, if stemming from target-like perception, will lead to characterisation of the child's system as a rogue grammar. Instead, following Macken (1980), it will be argued that some rogue behaviour like this has as its source misperception alone; once the perception problem is overcome, target-like production emerges.

Poor motor control is considered as another source of explanation for rogue behaviour. On one hand, vocal tract immaturity may impact the shape of an otherwise adult-like phonological system yielding non-adult-like behaviour. We will examine consonant harmony and velar fronting in this context. We will also consider the possibility that some unexpected substitutions or deletions in children's productions do not involve substitution or deletion at all but, instead, reflect "covert contrasts" (Kornfeld 1976; Macken and Barton 1980; Scobbie 1998; Munson et al. 2010). Covert contrasts are genuine contrasts produced by a non-adult-like vocal tract that are detectable through instrumental analysis but are misanalysed by transcribers because they are filtered through the mature perceptual system of the adult. Here, we will focus on children who produce putative glides in place of target liquids; as will be discussed, if these substitutions are authentic and are attested in branching onsets (e.g. 'try'→[twaɪ]), the result will be a rogue grammar. If, however, instrumental analysis were to reveal that the putative glides have liquid properties, this unwanted conclusion would be avoided.

Since this chapter views children's phonological processes from the perspective of whether they parallel or depart from those attested in adult grammars, it sees linguistic theory as essential both to interpret data from developing grammars and to predict which patterns are and are not analysable as grammar-driven. I will adopt OT, as core assumptions from this theory, combined with assumptions about acquisition, lead to predictions about the types of behaviour that could –and should not– be observed in developing grammars. We turn to these assumptions next.

2 Children's grammars as possible grammars

The following OT premises are of interest. (i) All constraints are universal in the sense that they are universally present in the grammars of all languages.[1] Since constraints refer to structures (e.g. hierarchical relationships holding in prosodic constituency) and primitives (features, prosodic constituents) and express restrictions on representations (e.g. deletion, feature agreement), these must be universal as well. (ii) Constraints are rankable and therefore violable. Following from this, cross-linguistic variation is primarily captured through differences in constraint ranking. (iii) Constraints are principally of two types: markedness constraints, which strive for structurally- and/or phonetically-defined well-formedness, and faithfulness constraints, which strive to maintain identity between input and output.

Some core assumptions about acquisition are as follows. (iv) As mentioned, children's grammars are possible grammars in the sense that at every stage in development, they abide by the same constraints as do adult grammars; while children's grammars may contain processes not present in the target language, these processes must have direct correlates in other adult languages. (v) Children learn through exposure to positive evidence only (Wexler and Culicover 1980; Pinker 1984). (vi) Early grammars are unmarked (Jakobson 1941/1968; Stampe 1969).

If we pair the OT premises in (i)-(iii) with the acquisition assumptions in (iv)-(vi), testable predictions about the shapes of early grammars follow. If we couple (i) with (iv), we predict that all linguistic systems, both developing and end-state, have access to the same toolkit. Children's grammars contain *no more* than adult grammars; that is, only constraints present in end-state grammars should be present in the child's initial grammar: there should be no child-specific constraints (cf. Pater 1997; McAllister Byun 2011) or child-specific interpretation of constraints (cf. Pater and Werle 2003). Conversely, children's grammars contain *no less* than adult grammars: there should be no late emergence of constraints or of the structures, operations and primitives they refer to (cf. Demuth 1995; Goad 1996). If we combine (ii) with (v), we predict that development involves minimal constraint reranking over time (Pater 1997; Bernhardt and Stemberger 1998), parallel to what is observed in adult language typology (Rose 2000; Levelt and van de Vijver 2004), through exposure to positive evidence. Finally, if we pair (iii) with (vi), we conclude that there is an initial ranking of constraints, markedness >> faithfulness, the starting point assumed by most researchers (following Demuth 1995; Gnanadesikan 1995/2004; Smolensky 1996; cf. Hale and Reiss 1998; Buckley 2003).

In the following sections, we examine these predictions. We will see that the relation between developmental behaviour and grammatical theory, as envisioned by OT, is well-supported on some fronts and questioned on others. We begin with the positive results (sections 2.1-2.2), then turn to the challenges (sections 3-5).

---

[1] Universal is typically interpreted as innate (e.g. Tesar and Smolensky 1993, Gnanadesikan 1995/2004). However, the position that (all) constraints are innate has been challenged. Hayes (1999), for example, proposes that phonetically-grounded markedness constraints are induced by language learners as they process the ambient data and thereby emerge from the learner's articulatory and perceptual limitations. Given the position that children's grammars are possible grammars, I assume at the outset that all constraints are innate. We return to this issue in section 3.2.

2.1 High-ranking markedness

As mentioned in section 1, it has commonly been observed that early grammars are unmarked. We pointed out in section 2 that in the optimality-theoretic literature, this has formally been expressed through high-ranking markedness constraints whose satisfaction comes at the expense of faithfulness. Below, we demonstrate that a frequently attested pattern in development –onset selection in cluster reduction– finds parallels in adult language behaviour that is, itself, deemed to be cross-linguistically unmarked.

Parallels between early grammars and unmarked adult systems and the consequent formal expression in OT as markedness over faithfulness was first empirically demonstrated by Gnanadesikan (1995/2004) in her analysis of G's patterns of cluster reduction (age 2;3-2;9). When learning languages with left-edge clusters, perhaps all children initially reduce the cluster to a singleton. Although children could select either member of the cluster, the pattern that G follows is particularly common: the least sonorous member survives, as in (1a) (see also Fikkert 1994; Barlow 1997; Gierut 1999; Ohala 1999; Goad and Rose 2004). Gnanadesikan shows that this pattern finds an exact parallel in Sanskrit perfect reduplication: left-edge clusters, which are permitted in bases, are reduced to the least sonorous consonant in the reduplicant; see (1b) (Whitney 1889; glosses provided by Brendan Gillon p.c.).

(1) a. G's grammar:

[fɛn]	'friend'
[bɪw]	'spill'
[so]	'snow'
[sɪp]	'slip'

b. Sanskrit reduplication:

[pa-prac^{h}]	'asked'
[pu-sp^{h}uṭ]	'burst'
[sa-snaː]	'bathed'
[ši-šliṣ]	'clasped'

The patterns in (1) are consistent with the cross-linguistically supported observation that onsets of low sonority are favoured over those of high sonority and that singleton onsets are preferred over clusters (Clements 1990). In OT terms, this supports a ranking of the markedness constraint(s) responsible for reducing clusters over segmental faithfulness, with other constraints responsible for selecting the onset of lowest sonority. (2) indicates that this holds in the initial state and is maintained in (some components of) some adult grammars. In the case of Sanskrit, it holds only in reduplication and thus reflects emergence of the unmarked (McCarthy and Prince 1994). In Sanskrit more generally and in English, the target grammar for G, faithfulness to input clusters prevails and no effect of sonority is therefore visible.

(2)

Markedness constraints yield:	Initial state: G	End-state grammars: Sanskrit reduplicants	Sanskrit bases	English
Cluster reduction	respected	respected	not respected	not respected
Sonority-driven onset selection	respected	respected	–	–

Although we have only scratched the surface (see Gnanadesikan 1995/2004 for details), sonority-driven onset selection in cluster reduction demonstrates that cross-linguistically unmarked patterns also characterise children's grammars. This holds even when there is no evidence that the particular constraints involved must be satisfied in the grammar being acquired.

In the next section, we formally exemplify markedness >> faithfulness, coupled with an examination of minimal demotion of markedness constraints over the course of development.

2.2 Development as minimal constraint reranking

As mentioned in section 2, if acquisition involves minimal constraint reranking over time, parallel to what is observed in adult language typology, children's intermediate grammars can contain patterns not present in the ambient input, as long as these patterns are attested in other end-state grammars. Here, we provide evidence for this from the development of branching onsets in Québec French (Rose 2000). We will see that minimal demotion of the markedness constraint against branching onsets yields an intermediate grammar which is neither completely unmarked nor target-like, yet is attested in other adult languages.

The typology in (3) shows that three options are found concerning the distribution of branching onsets in relation to stress. Japanese and French fall at opposite ends in either forbidding or permitting branching onsets regardless of stress, while Southeastern Brazilian Portuguese falls in the middle: branching onsets are only permitted in stressed syllables (Harris 1997).

(3)

	Stressed syllables	Unstressed syllables
Japanese	no	no
SE Brazilian Portuguese	yes	no
French	yes	yes
Unattested	no	yes

The Southeastern Brazilian Portuguese pattern will be of central interest when we examine development, so we exemplify it in (4). In diminutive constructions, stress shifts rightward, which affects whether or not an underlying branching onset in the root can surface.

(4)	[ˈpratu]	'plate'	[ˈlivu], *[ˈlivru]	'book'
	[paˈtʃiɲu], *[praˈtʃiɲu]	'small plate'	[liˈvretu]	'small book'

Consider now the acquisition data. The forms in (5) reveal that Théo, a learner of Québec French, goes through three stages in the development of branching onsets (Rose 2000). At Stage 1, the cluster is reduced to the first consonant; at Stage 3, clusters are produced as target-like. Most interesting is the intermediate stage in (5) where Théo produces branching onsets in stressed syllables only, parallel to Southeastern Brazilian Portuguese. Théo is uniformly exposed to French, where branching onsets are robustly attested in unstressed syllables. Clearly, we are not seeing an effect of the ambient input; rather, we are observing a grammar-driven effect that reflects positional constraints on the distribution of branching onsets.

(5) Acquisition of branching onsets:

	Target:	Théo:	
Stage 1 (1;10.27-2;05.11):	[kle]	[ke]	'key'
	[bʁiˈze]	[pɪˈz̯e]	'broken'

Stage 2 (2;05.29-2;11.29):	[plœʁ]	[plœᶷ]	'cry'-3SG
	[gʁyˈjo]	[kʰœˈjɔ]	'oatmeal'
Stage 3 (from 3;00.07):	[pʁəˈne]	[pʁəˈne]	'take'-2PL

This pattern involves minimal demotion of the constraint against branching onsets, *COMPLEX(ONSET), relative to two faithful constraints opposing deletion: MAX-IO, which states that every segment in the input has a correspondent in the output, and a positional faithfulness constraint, STRESSMAX-IO, which forbids deletion from an output stressed syllable.[2] The tableau in (6) shows that, at Stage 1, *COMPLEX dominates both faithfulness constraints, ensuring that candidate (b) is selected over the faithful (a).[3]

(6) Stage 1:

/kle/	*COMPLEX	STRESSMAX	MAX
a. ˈkle	*!		
☞ b. ˈke		*	*

Although *COMPLEX must end up below both faithfulness constraints in French, minimal demotion of this constraint will result in children passing through the Southeastern Brazilian Portuguese pattern en route to target French. See (7); with *COMPLEX ranked between STRESSMAX and MAX, branching onsets only survive in stressed syllables.

(7) Stage 2:

Stressed syllables:

/plœʁ/	STRESS MAX	*COMP	MAX
☞ a. ˈplœᶷ		*	
b. ˈpœᶷ	*!		*

Unstressed syllables:

/gʁyjo/	STRESS MAX	*COMP	MAX
a. kʁœˈjɔ		*!	
☞ b. kʰœˈjɔ			*

At Stage 3, the target grammar is reached, indicating that *COMPLEX has been demoted to its appropriate place for adult French:

(8) Stage 3:

/pʁəne/	STRESSMAX	MAX	*COMPLEX
☞ a. pʁəˈne			*
b. pəˈne		*!	

---

2 Rose uses MAXHEAD(Foot) instead of STRESSMAX, which demands that every element in the head of the foot in the input have a correspondent in the head of the foot in the output. This constraint requires that inputs be prosodified, counter to Richness of the Base (Prince and Smolensky 1993/2004). For the data at hand, STRESSMAX, which makes no claim about input prosodification, is sufficient (cf. Pater 1997).

3 An additional constraint requiring the head of the onset (Rose 2000) or least sonorous member of the cluster (section 2.1) to survive is needed to select [ke] over [le].

Théo's data support the position that children's phonological processes mirror those observed in adult grammars, as was seen earlier for G. Moving beyond G's data, however, the present case shows that development as minimal reranking reflects the typological options that adult languages display, in spite of no evidence in the ambient data for the intermediate pattern observed.[4]

3 Do children's grammars contain the same toolkit as adult grammars?

As mentioneed above, the observation that languages differ from one another in limited and systematic ways is formally expressed in OT through all systems having access to the same toolkit: they manipulate the same set of constraints and have access to the same primitives and principles of organisation. If children's grammars are possible grammars, they should employ the same toolkit as adult grammars. In the preceding sections, we provided examples that are consistent with this position. In the rest of the chapter, we examine some challenges: processes in early grammars which appear not to show convergence with those in adult grammars. We first discuss processes which suggest that developing and end-state grammars may be formally different: children may contain both less (section 3.1) and more (section 3.2) in their grammatical toolkit than adults. We then turn, in section 4, to other types of divergent behaviour which we argue are very likely consistent with the view that children have access to the same grammatical apparatus as adults, once additional factors are considered: the developing perceptual system and motor control.

3.1 Children's grammars may contain less than adult grammars

If children's grammars are possible grammars, they should contain no less than adult grammars: there should be no late emergence of constraints or the structures, primitives and operations they refer to. The "CV stage" in acquisition, during which some children tolerate a significant number of CV outputs, challenges this view.

Children's ability to control a variety of prosodic shapes develops in a systematic way over time, from less to more complex, seemingly consistent with an initial markedness >> faithfulness ranking. If children's grammars contain the same toolkit as adult grammars, unmarked outputs in the former should arise from high-ranking markedness constraints targeting particular prosodic constituents; it should not be necessary to posit that children begin acquisition with an impoverished prosodic hierarchy (cf. Demuth and Fee 1995). Support for this comes from the "minimal word stage", when the binary foot (σσ or μμ) defines an upper and lower bound on learners' outputs (see Kehoe and Stoel-Gammon 1997 for a review; Ota this volume).

For children learning English-like languages that respect word minimality (lexical words do not fall below a binary minimum), the minimal word stage typically manifests itself through truncation of longer words (e.g. [teːdo] for 'potato' (Trevor at 1;10.02) (Pater 1997)). For

---

[4] Modelling the intermediate stage presents challenges. The Gradual Learning Algorithm (Boersma and Hayes 2001), a probabilistic version of OT, runs into difficulties because *COMPLEX must be demoted below a positional faithfulness constraint (STRESSMAX) before its general counterpart (MAX). The problem is that the number of violations of the positional constraint will always be a subset of that of its general counterpart. Jesney and Tessier (2011) provide a solution where the strictly-ranked constraints of standard OT are replaced with weighted constraints: lower-weighted constraints (MAX and STRESSMAX) can 'gang up' and triumph over higher-weighted constraints (*COMPLEX).

children learning Japanese-like languages that tolerate monomoraic words, truncation appears alongside augmentation of CV targets (e.g. [tadaima]→[meda] 'I'm back', [ki]→[ɟiː] 'tree' (Kenta at 1;11.02, 2;2.27) (Ota 2003)). The minimal word stage can be straightforwardly captured in OT if markedness constraints regulating the shapes of words (FTBIN: feet are binary; PARSE-σ: syllables are parsed into feet; ALL-FEET-LEFT: the left edge of every foot is aligned with the left edge of the prosodic word) dominate MAX as well as DEP, which prohibits epenthesis (cf. Pater 1997). The result is that all PWds are exactly one binary foot in size:

(9) FTBIN, PARSE-σ, ALL-FT-LEFT >> MAX: [(teːdo)$_{Ft}$]$_{PWd}$, [(meda)$_{Ft}$]$_{PWd}$
DEP: [(ɟiː)$_{Ft}$]$_{PWd}$

Prior to the minimal word stage, many children's productions are maximally CV in size. Although such outputs form optimal syllables, because they are not binary, they do not form optimal feet nor, therefore, optimal PWds. Below, we show that a solution to this problem employing high-ranking markedness constraints is spurious. An alterative solution is thus entertained: children begin acquisition without the full set of prosodic constituents available to adult grammars.

At the CV stage, only core syllables are attested (e.g. Jakobson 1941/1968; Ingram 1978; Fikkert 1994; Demuth and Fee 1995). Representative examples from Mollie (Holmes 1927) are in (10). While the ban on complexity yields syllables that are relatively unmarked, CVX(C) targets typically undergo deletion of offending material rather than triggering epenthesis and are thus rendered as CV *words*.[5]

(10) CV stage:

	Target:	Mollie:	
a.	[gʊd]	[gu], [guˑdː]	'good'
	[wɑnt]	[wɑ]	'want'
	[kout]	[ko]	'coat'
b.	[bɛd]	[bɛ], [bɛˑtː]	'bed'
	[ðæt]	[dæ]	'that'

Not all children begin acquisition with a significant number of productions of this shape. Some English-speaking children (e.g. Kyle (Salidis and Johnson 1997)) have few CV outputs. The same holds for the Japanese children studied by Ota (2003) and for French-speaking Clara (Goad and Buckley 2006), although both adult languages contain several CV words.

Given the variability observed across children, we must question whether the CV stage is genuine. Perhaps for some learners, CV outputs are limited to a handful of words only (see Ota 2003). This is not, however, the case for Mollie. Holmes (1927) provides a complete list of single-word utterances produced by Mollie on one day at age 18 months, from which the examples in (10) are drawn. There were 46 words, of which 25 were produced as monosyllabic. Of these, 18 (72%) were CV in shape!

5 Epenthesis, which would yield bisyllabic feet/words, is not robustly attested in development (Demuth et al. 2006), but it does occur regularly in some children's grammars (e.g. Padmint: [ˈtɔpɔ] 'top', [ˈbihi] 'beach' (Ross 1937)).

Perhaps for some children, the transcriptions are too broad to reflect what was actually produced, that forms transcribed as CV were actually produced as CVV. Consider again Mollie. It could be that Mollie's outputs in (10a) with tense vowels are not subminimal, that Holmes intended, for example, [kou] or [koː] for 'coat'. This seems unlikely: concerning [kou], the word 'no' is transcribed by Holmes as [nou], suggesting that [ko] indeed contains a monophthong; concerning [koː], Holmes transcribes the difference between short, half-long and long segments, as seen in the alternative pronunciations for some words in (10), suggesting that he is particularly sensitive to differences in length.

We infer that the CV stage is genuine for at least some children, including Mollie. We turn, then, to a formal analysis of this stage. We begin by supplementing the ranking in (9) for the minimal word stage with undominated NOCODA and NOLONGVOWEL, which prohibit syllables from having codas and long vowels respectively; see (11). With this ranking, we incorrectly predict some type of CVCV output to be selected as optimal.[6]

(11)

/ðæt/	FTBIN	NOCODA	NOLONGV	DEP	MAX
a. $[(\text{dæt})_{\text{Ft}}]_{\text{PWd}}$		*!			
b. $[(\text{dæː})_{\text{Ft}}]_{\text{PWd}}$			*!	*	*
c. $[(\text{dæ})_{\text{Ft}}]_{\text{PWd}}$	*!				*
☹ d. $[(\text{dædæ})_{\text{Ft}}]_{\text{PWd}}$				*	

Clearly, with FTBIN undominated, the subminimal output in (11c) will never surface. If we introduce ALL-SYLL-LEFT, which requires the left edge of every syllable to be aligned with the left edge of the PWd, and rank it above FTBIN, as in (12), the subminimal form will be selected. As long as ALL-SYLL-LEFT is demoted below FTBIN at the minimal word stage, binary outputs will correctly be selected as optimal at that stage.

(12)

/ðæt/	ALL-SYLL-LEFT	NOCODA	NOLONGV	FTBIN	DEP	MAX
a. $[(\text{dæt})_{\text{Ft}}]_{\text{PWd}}$		*!				
b. $[(\text{dæː})_{\text{Ft}}]_{\text{PWd}}$			*!		*	*
☞ c. $[(\text{dæ})_{\text{Ft}}]_{\text{PWd}}$				*!		*
d. $[(\text{dædæ})_{\text{Ft}}]_{\text{PWd}}$	*!				*	

However, although ALL-SYLL-LEFT capitalises on the fact that alignment constraints can take any prosodic constituents as arguments, it receives no cross-linguistic support.[7] We must therefore reject the analysis in (12).

A second possibility is that CV outputs are not footed at this developmental stage. This would appear to violate PARSE-σ, which we saw in (9) is undominated at the minimal word stage.

---

6 NOCODA is undominated in (11) because the larger dataset in Holmes (1927) suggests that the CVC outputs in (10) reflect the next developmental stage.

7 Mandarin is often raised as a language that may appear to motivate ALL-SYLL-LEFT. However, although many Mandarin words are monosyllabic, this arises not from ALL-SYLL-LEFT but from the fact that morphemes are predominantly monosyllabic and Chinese languages have limited bound morphology (Yip 1992). Concerning the shapes of prosodic words, which ALL-SYLL-LEFT refers to, there is no pressure toward monosyllabic PWds in Mandarin. Indeed, less than 30% of Mandarin words are monosyllabic and most newly introduced words are bisyllabic (Duanmu 2007).

However, if there were simply no foot projection in the grammar at the CV stage (Fikkert 1994; Demuth and Fee 1995; Demuth 1995; Goad 1996), then FTBIN and PARSE-σ would be vacuously satisfied. Consider (13); with DEP ranked over MAX in Mollie's grammar, the CV output is selected as optimal for monosyllabic inputs.

(13)

/ðæt/	FTBIN	PARSE-σ	NOCODA	NOLONG V	DEP	MAX
a. [dæt]$_{PWd}$			*!			
b. [dæː]$_{PWd}$				*!	*	*
☞ c. [dæ]$_{PWd}$						*
d. [dædæ]$_{PWd}$					*!	

Evidence for this analysis comes from Holmes's (1927:221) comment on Mollie's two syllable words at 18 months: "Each of these syllables received an *equal* stress". With no foot projection, equal prominence on both syllables is exactly what is expected. Equal prominence could also arise from Mollie not knowing whether feet are left- or right-headed (simultaneous satisfaction of FOOTSHAPE(TROCH) and FOOTSHAPE(IAMB)). However, if bisyllabic forms with equal prominence are truly footed, then FTBIN, along with these two constraints, would predict monosyllabic forms to be realized as bisyllabic with equal prominence, counter to what was observed in (10).

Under the approach outlined here, absence of a foot projection is what defines the CV stage. Assuming that this constituent can be projected in the course of acquisition based on positive evidence (greater prominence associated with stressed syllables), does this mean that children's early grammars are deviant? Yes, unless it can be shown that there are adult languages that are footless. Although it is standardly accepted that all languages contain the foot (Selkirk 1996:189-190), McCarthy and Prince (1995:323) mention the possibility of footless languages, and the literature on some languages contains analyses of prosodic phenomena assuming no foot (e.g. Jun and Fougeron 2000 on French; Özçelik 2009 on Turkish).[8] Clearly, more work is required, but if the foot proves to be universally present in adult grammars and if the CV stage is genuine, we must accept the possibility that early grammars do not contain exactly the same toolkit as adult grammars: behaviour that cannot be captured solely through constraint ranking may require that children begin acquisition with an impoverished set of (prosodic) primitives.

3.2 Children's grammars may contain more than adult grammars

Consider now the other side of the coin. If children have access to the same toolkit as adults, their grammars should contain *no more* than adult grammars: only constraints present in end-state systems should be evidenced in development; there should be no child-specific constraints or child-specific interpretation of constraints. Some processes in children's grammars, notably consonant harmony (CH), challenge this view. In this case, vocal tract immaturity may be responsible: it impacts the shape of an otherwise adult-like phonological system yielding non-adult-like behaviour. The question is how to formally express this, given that, in some ways, CH looks like ordinary phonology.

---

8 If French is truly footless, we should not expect learners of this language to evidence the foot. This, however, is contrary to what has been observed (Vihman et al. 1998; Goad and Buckley 2006; Demuth and Tremblay 2008; Goad and Prévost 2010).

In CH, consonants at a distance agree in primary place features (Vihman 1978; see Levelt 2011 for a review). Representative examples from Amahl's regressive coronal-to-dorsal harmony at age 2.60 (years.days) are in (14) (Smith 1973) ([ġ]=voiceless unaspirated lenis).

(14) Coronal-to-dorsal CH:

Target:	Amahl:	
[daːk]	[ġaːk]	'dark'
[sneik]	[ŋeⁱk]	'snake'
[sɔk]	[ġɔk]	'sock'
[lɛgəu]	[ġɛguː]	'Lego'

Across children, this type of harmony is most widely attested: (i) coronals are the optimal targets (Spencer 1986; Stemberger and Stoel-Gammon 1991; Bernhardt and Stemberger 1998); (ii) right-to-left directionality is preferred (Menn 1971; Smith 1973; Vihman 1978, Stoel-Gammon 1996); (iii) velars are better triggers than labials (Smith 1973; Pater 1997). All of these observations also define adult assimilation (Pater and Werle 2003): (i) coronals are prime targets in assimilation (Paradis and Prunet 1991); (ii) right-to-left directionality is preferred: local place assimilation between consonants targets codas from following onsets (Jun 1995) and long-distance adult CH is typically regressive (Hansson 2001); (iii) in some languages, notably Korean, velars trigger place assimilation targeting labials (Jun 1995).

Before turning to the formal challenges that child CH presents, we briefly address whether it involves "real" phonology. As Levelt (2011) points out, systematic child CH may be less widely attested than the literature implies: it is clearly not always productive, and may for some children represent a speech error rather than rule-governed behaviour. The speech error account cannot, however, always hold: Gormley's (2003) articulatory and acoustic examination of CH reveals fully harmonic forms, which would be unexpected if harmony were the result of poor motor planning like speech errors (see also Vihman 1978). Further, Amahl's forms in (14) reflect a fully productive process: of the 25 coronal-dorsal targets at age 2.60, 100% undergo CH; over the three month period from 2.60-2.152, 95/113 (84%) of coronal-dorsal targets undergo CH; and during the last stage when the process is productive, three months later (2.233-2.242), 21/38 (55%) of suitable targets still undergo CH. Clearly, CH represents productive rule-governed behaviour for some children.

We now address the formal challenges that arise from this conclusion. CH of the type exhibited in children's grammars is not attested in end-state grammars (Vihman 1978), an observation confirmed by recent surveys of adult CH (Hansson 2001; Rose and Walker 2004). Although consonant-to-consonant assimilation for primary place features is widespread in adult languages, it is limited to string-adjacent consonants. Long-distance patterns only hold for secondary place features, for example, in Barbareño Chumash, where apical and laminal sibilants assimilate right-to-left within a word (Beeler 1970): [kiš̱kín] 'I save it, store it up', [kis̱kínus̱] 'I saved it for him'; [kas̱únan] 'I command', [kaʔalaš̱únaš̱] 'he's the boss'.

Two general approaches to child CH have been proposed. On one hand are analyses that involve the same formal mechanisms available to adult grammars. Most of these predict that CH should be freely attested in adult languages (Smith 1973; Stemberger and Stoel-Gammon 1991; Rose 2000; Goad 2001); others predict more restricted CH, either limiting it to languages with a particular profile (McDonough and Myers 1991) or to languages under emergence of the unmarked scenarios (Goad 1997). As all of these proposals assume that learners have access to the same toolkit as adults, they cannot confine CH to development. On the other hand are proposals that assume that some formal change takes place in children's grammars, which accounts for the discontinuity observed as concerns CH (Menn 1978; Pater 1997; Pater and Werle 2003; see also Fikkert and Levelt 2008). We focus principally on Pater (1997).

As mentioned, in some ways, CH resembles ordinary phonology, notably in the preference for coronal targets and velar triggers. Pater proposes that this follows from a fixed ranking of faithfulness constraints: FAITH(DOR) >> FAITH(LAB) >> FAITH(COR) (see also Goad 1997). Harmony arises from a child-specific constraint, REPEAT, which requires successive consonants to agree in primary place (cf. Menn 1978). REPEAT is proposed to be induced by the child in response to the articulatory pressures that arise from the developing phonological system (cf. Hayes 1999). Kiparsky and Menn (1977), Vihman (1978), Fikkert and Levelt (2008) and Becker and Tessier (2011) point out that CH is an emergent process, which may indicate that a child-induced constraint like REPEAT is along the right lines.[9]

REPEAT can be interranked with 'regular' constraints and demoted through the course of acquisition like other markedness constraints. These properties are illustrated in the tableaux below for Trevor. At Stage 1, both coronal- and labial-initial forms assimilate to following velars, driven by the ranking of REPEAT above FAITH(LAB) and FAITH(COR); see (15).

(15) Stage 1:

/dɔg/ 'dog'	FAITH(DOR)	REPEAT	FAITH(LAB)	FAITH(COR)
a. [dɔg]		*!		
☞ b. [gɔg]				*
c. [dɔd]	*!			

/bæk/ 'back'	FAITH(DOR)	REPEAT	FAITH(LAB)	FAITH(COR)
a. [bæk]		*!		
☞ b. [gæk]			*	
c. [bæp]	*!			

At Stage 2, only coronal-initial forms continue to undergo CH. With REPEAT demoted below FAITH(LAB), 'back' is now faithfully rendered as [bæk]:

(16) Stage 2:

/dɔg/ 'dog'	FAITH(DOR)	FAITH(LAB)	REPEAT	FAITH(COR)
a. [dɔg]			*!	
☞ b. [gɔg]				*
c. [dɔd]	*!			

[9] If CH is the child's response to articulatory pressures, we must question why REPEAT is not induced at the earliest stage. Perhaps these pressures arise only at the point when the child must contend with a rapidly expanding lexicon (cf. Vihman 1978:328).

/bæk/ 'back'	FAITH(DOR)	FAITH(LAB)	REPEAT	FAITH(COR)
☞ a. [bæk]			*	
b. [gæk]		*!		
c. [bæb]	*!			

What is appealing about this approach is that it isolates the child-specific part of CH by means of REPEAT, allowing other aspects of the process to be handled through independently-needed constraints.[10] The merits of this approach, however, are also its downfall: we must ensure that CH effects are not inadvertently predicted to occur in adult grammars. Demotion of REPEAT to the bottom of the constraint hierarchy may appear to be ideal, as the child-adult asymmetry would be reduced to a difference in ranking. Demotion, however, cannot guarantee that REPEAT will not rear its head in emergence of the unmarked scenarios. Instead, REPEAT must be purged from the grammar. This approach to CH must therefore accept the position that children begin with a richer toolkit than that available to adult grammars.[11]

4 Rogue substitutions: Is children's divergent behaviour always grammar-driven?

We have hitherto discussed cases of divergence between developing and end-state grammars that may require that children begin acquisition with a set of primitives and constraints that are not identical to those manipulated by adult systems. On one hand, accounting for the CV stage may require that children's grammars contain less than adult grammars, specifically, without the full set of prosodic constituents available to adults. On the other hand, explaining consonant harmony may require that children's grammars contain more than adult grammars, constraints that are confined solely to development. In this section, we examine types of divergent behaviour that, on closer examination, appear to be amenable to formal explanation using the same primitives and constraints that define adult grammars.

We consider that some rogue substitutions may arise from physiological constraints: for anatomical reasons, children simply miss the adult target. Others may reflect covert contrasts where, because of poor gestural timing, learners' productions are misinterpreted by adult transcribers. Others may arise from children misperceiving target material. And others may indicate that learners have adopted an analysis of the ambient data that is different from that assumed by the linguist. As we will see, all four possibilities potentially lead to explanations for rogue behaviour; and, consequently, children's grammars may not, in the end, stray too far from what is formally observed in adult systems.

---

[10] Pater and Werle (2003) propose that REPEAT be replaced by AGREE, an independently-motivated constraint responsible for assimilation in adult grammars (Lombardi 1999; Baković 2000). What distinguishes consonant-to-consonant assimilation in child and adult systems is that AGREE has wider scope in the former: it is not limited to applying between string-adjacent segments. The discussion in the text focuses on REPEAT, although the same issues arise for wide scope AGREE.

[11] Child-specific constraints can conceivably be purged from the grammar once the articulatory limitations which compelled their creation are overcome (Hayes 1999; McAllister Byun 2011). The problem remains nonetheless: children's grammars are drawing on different formal resources than adult grammars.

4.1 Velar fronting

We begin with velar fronting (VF), where velars surface as coronal across-the-board or, surprisingly, it first seems, in prosodically-strong positions (Ingram 1974; Chiat 1983; Stoel-Gammon 1996; Morrisette et al. 2003; Inkelas and Rose 2007). The examples in (17a) show that English-speaking E restricted VF to word-initial onsets and word-medial onsets in stressed syllables; velars in medial unstressed onsets and in codas were realised faithfully (17b) (Inkelas and Rose 2007).

(17) E's positional VF:

a. Prosodically-strong positions:

[tʰʌp]	'cup'	(1;09.23)
[tʌnˈdʌktə]	'conductor'	(2;01.21)
[ˈhɛksəˌdɔn]	'hexagon'	(2;02.22)

b. Prosodically-weak positions:

[ˈbejgu]	'bagel'	(1;09.23)
[ˈɑktəgɑn]	'octagon'	(2;01.05)
[bʊkʰ]	'book'	(1;07.22)

Inkelas and Rose propose that anatomical constraints and grammatical considerations together account for this child-specific process, including its restriction for children like E to prosodically-strong positions (see also McAllister Byun 2012). Physiological constraints on young children's vocal anatomy, including a relatively bigger tongue size and shorter palate, result in velars being articulated in a more anterior position than for adults. The restriction to prosodically-strong positions comes from the greater gestural amplitude exhibited in these positions which disproportionately affects velars, resulting in their being realised with greater palatal contact (Fougeron and Keating 1996; Fougeron 1999 on adult languages).

Although Inkelas and Rose do not provide a formal analysis of VF, they propose that physiological constraints distinguishing the child's vocal tract from that of the adult are sufficient to restrict this process to developing grammars. That is, velar-fronting children are only "cosmetically unfaithful" to target velars (Rose 2009:340).

If VF can be reduced to physiological considerations, no child-adult asymmetry must be formally expressed by the grammar. We conclude, then, that some types of child-specific behaviour, like VF, may be amenable to explanations outside the grammar while others, like CH, require a grammar-internal explanation.[12]

4.2 Glide substitution

We consider now the robustly-observed process of glide substitution for target liquids. Representative data from English-speaking Jake (age 2;1) are in (18) (Bleile 1991). Jake produced no liquids at all: onset liquids were realised as glides, in both clusters (18a) and singletons (18b); coda liquids were deleted or vocalised.

[12] Although see Qu (2011), who provides a unified grammar-driven account of both processes tied to the development of place features.

(18) Glide substitution: Jake:

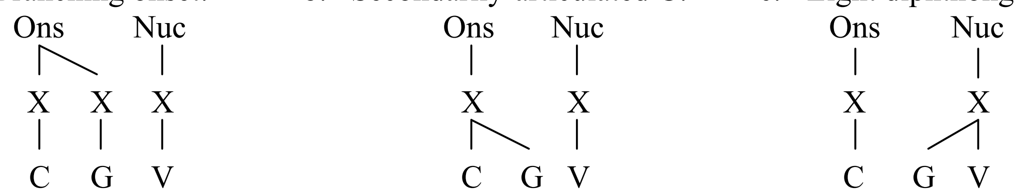
a.	[fwɛnz]	'friends'	b.	[wɛd]	'red'
	[fwɔg]	'frog'		[wum]	'room'
	[pwiz]	'please'		[waɪt]	'light'
	[twækʊ]	'tractor'		[woʊsɪn]	'lotion'
	[stwɔbnwiz]	'strawberries'			
	[kwaɪ]	'cry'			
	[kwoʊz]	'close'			

We refer to the point in development, where glides consistently substitute for liquids in clusters, as the "CG stage". At this stage, derived CG clusters are typically assumed to be represented as branching onsets (Fikkert 1994; Barlow 1997; Jongstra 2003). However, adult grammars where the only branching onsets are CG in shape are unattested: CG onsets are only permitted in languages that also allow CL (consonant+liquid) onsets (Clements 1990). Although there are end-state grammars that lack liquids, for example Blackfoot (Algonquian: southern Alberta and northwestern Montana; see Frantz 2009), in contrast to Jake, languages of this type do not permit branching onsets, consistent with Clements's (1990) implicational universal. Jake's grammar at the CG stage thus appears to be a rogue grammar. Further, glide substitution contrasts sharply with G's treatment of left-edge clusters discussed earlier: sonority-driven onset selection had clear adult parallels (section 2.1). Given both of these observations, we pursue other explanations for glide substitution: misanalysis and covert contrast.[13]

4.2.1 Misanalysis

As mentioned, in languages with branching onsets, CG onsets (19a) are only allowed if the language also allows CL (Clements 1990). In languages where clusters are CG in shape only, distributional evidence –available to the learner– reveals that the glide represents a secondary articulation (19b) (e.g. Clements 1986 on Luganda) or forms part of a light diphthong (19c) (e.g. Lee 1998 on Korean).

(19) a. Branching onset: b. Secondarily-articulated C: c. Light diphthong:



[13] Misperception is not considered. Although there are children who misperceive liquids as glides (Aungst and Frick 1964; Monnin and Huntington 1974; McReynolds et al. 1975; Strange and Broen 1980), this does not offer a solution to the CG stage. If developing grammars are possible grammars, we would expect children who misperceive CL as CG to: (i) repair the putative CG cluster through deletion of the glide until the perceptual problem is overcome and the child realises that what s/he thought were CG strings are in fact CL; (ii) select words for production that lack CG clusters ("selection and avoidance"; see Schwartz and Leonard 1982); or (iii) assign an analysis other than branching onset to putative CG strings. Clearly, neither (i) nor (ii) is the solution taken by children like Jake who produce CL clusters as CG. We consider (iii) in the text.

We must therefore consider whether (19b) or (19c) could be motivated for derived CG clusters in acquisition (Goad 2006; Kehoe et al. 2008). Below, we focus on distributional constraints present in derived CGV strings in Jake's grammar, assessing them against the possibilities in (19).

We first consider place constraints holding between C and G. Place constraints are observed when CG is syllabified as a branching onset (19a) or as a secondarily-articulated consonant (19b): branching onsets typically forbid place identity between C and G (*[pw]), parallel to what is observed with CL (*[tl]); place constraints are often observed for secondarily-articulated consonants such that labialised labials, labialised coronals and palatalised dorsals are dispreferred (Maddieson 1984; Ladefoged and Maddieson 1996). Light diphthongs, by contrast, do not enter into place constraints between C and G, because the two segments are in different constituents (e.g. French [pwa] 'pea'). Jake's grammar does not display place constraints for derived CG strings: the data in (18a) show that he freely permits labial obstruents to be followed by [w]. This supports the light diphthong analysis in (19c).

Turning to sonority, constraints hold between C and G when G is syllabified inside a branching onset (19a) or as a secondarily-articulated consonant (19b): in the former case, C is virtually always an obstruent; in the latter, C prefers to be a stop (Maddieson 1984). Fewer constraints hold when a constituent boundary interrupts C and G, in the light diphthong analysis (19c) (e.g. French [nwaʁ] 'black'). Given that CL clusters must be obstruent-initial in English, it would be surprising to find children producing derived CG clusters with initial sonorants. However, Jake does produce one such cluster in [stwɔbnwiz] 'strawberries'. Although this is consistent only with the light diphthong analysis (19c), we do not know how representative this form is of his grammar overall. We thus cannot definitively rule out (19a) on sonority grounds. The presence of fricatives in CG clusters in [fwɛnz] and [fwɔg], however, eliminates (19b). We might not expect children learning Germanic languages to constrain CG outputs to those that are stop-initial only, in support of (19b), but there are children in the CG stage who have this profile: English-speaking Kylie (Bleile 1991) and Dutch-speaking Elke (Fikkert 1994) reduce all fricative+liquid clusters to the fricative, rather than allowing these to surface as fricative+glide; this is consistent with a secondary articulation analysis for these children. For Jake, though, sonority constraints support either (19a) or (19c).

Considering finally place constraints holding between G and the following vowel, constraints are observed when G and V are internal to the same constituent, as in (19c). Jake has no GV restrictions, supporting any analysis other than (19c). Again, we might not expect to find such constraints, given that none hold in the target LV strings. There are learners, however, who do observe constraints on GV place: Kylie permits [w] in derived CG strings to be followed by a front vowel only.

Taking the distributional evidence altogether, we can see that no single analysis emerges as definitive for Jake; the only option we can eliminate is (19b). This problem does not hold solely for Jake (Goad 2006), suggesting that misanalysis of derived CG as something other than branching onset is not a likely solution for the rogue CG stage.

4.2.2 Covert contrast

In view of this, we take a different tack and consider the possibility that some processes in acquisition, including glide substitution, are not genuine. Rather, children are producing a covert liquid-glide contrast (Kornfeld 1976; Scobbie 1998), but the contrast is not perceptible to adult transcribers. This would arise because of poor gestural timing: the cues used by children to express the liquid-glide contrast are not sufficient for linguists to perceive these classes of segments as different. If instrumental analysis were to reveal that putative glides in derived CG clusters in fact have liquid properties, this would avoid the unwanted conclusion that children's grammars formally diverge from what is possible adult behaviour.

For some children, we might expect poor gestural timing to hold for all onset liquids; for others, the problem may be confined to clusters, where the child must quickly transition from the gestures involved in the closure to those required for the following liquid. As seen earlier, in Jake's grammar, glide substitution applies across-the-board. Dutch-speaking Catootje and Elke, however, produce singleton onset liquids as target-like during the CG stage (Fikkert 1994). To the extent possible, then, we must examine the results on covert contrast for both contexts.

Spectrographic studies show that for English-speaking children judged to be substituters, productions of derived [w] and target [w] are measurably different, in both singleton contexts (Klein 1971; Menyuk 1971; Dalston 1972; Hawkins 1973; Chaney 1978) and clusters (Kornfeld 1971; Menyuk 1971; Hawkins 1973; Chaney 1978). Klein (1971), for example, found that F2 origin is higher for derived [w] than for target [w], indicating the presence of [r]-like qualities in the former. Chaney (1978) observed that, in some contexts, children had different F2 frequency and/or F2 transition rates for target [w] and [w] substitutes (for [r] and [l]), although no child judged to be a substituter did this reliably. UIltrasound imaging, which has more recently become available, has also revealed physical evidence of covert contrast (Richtsmeier 2007). Analysis involving two-dimensional tongue postures of two children's productions of initial [r] and [w] targets, both of which were consistently transcribed as [w], reveals different tongue shapes.

The possibility that children are representing the [r]-[w] contrast covertly is also supported by perceptual studies. Goehl and Golden (1972, cited in Kornfeld and Goehl 1974) observe that English-speaking children whose productions are judged to involve substitution of [w] for [r] can perceive these same productions of derived [w] as distinct from their productions of target [w]. Similar results are reported in Bryan's (2009) study on the perception and production of the English [r]-[w] contrast and the French [ʁ]-[w] and [ʁ]-[j] contrasts. Some English learners whose productions of target [r] were transcribed as [w] could perceive the [r]-[w] contrast. Acoustic analysis of these learners' outputs revealed a difference between their productions of derived and target [w]: derived [w] had lower F3 values than target [w]. Similarly, some French children whose outputs for target [ʁ] were transcribed as [w] or [j] could perceive the difference between [ʁ] and [w] and between [ʁ] and [j]. Acoustic analysis revealed differences in F2 and F3 for these children's derived and target glides.

Not all researchers who have phonetically compared derived and target [w] among English learners have found evidence of distinct articulations (Locke and Kutz 1975; Kuehn and Tomblin 1977; see also Menyuk and Anderson 1969; Hoffman et al. 1983). Importantly, though, we have no information on how the children in these studies produced branching onsets. If the children reduced branching onsets to singletons, then neutralisation of the liquid-glide contrast would not yield a rogue grammar but, rather, a grammar like that found in Blackfoot.

Clearly, more research must be undertaken, but the evidence thus far available suggests that the explanation for the CG stage in acquisition may lie in covert contrast: if all children who seemingly produce a glide in CL targets in fact show evidence of producing liquids covertly, this would be significant.

Before concluding this section, we briefly return to Jake's data in (18) where liquids are uniformly transcribed as glides. As Smit (1993) points out, it is difficult to accurately transcribe substitutions for English [r]. In view of this, we must question whether the glides in Jake's outputs are genuine or whether the data are transcribed too broadly to reflect any evidence of covert contrast. For this child, we will never know. What we expect, though, is that if adult misanalysis of children's liquids as glides is due to poor gestural coordination, significant variation should be observed in children's production of glides, some of which should be reflected in narrowly transcribed data. That this variation may indeed be observed for some learners is revealed by the range of outputs observed for Richard, who went through an extended CG stage. Examining his 88 CG outputs for CL targets at 2;5 uncovers significant variation in the way the glide was phonetically transcribed. Although no instrumental data are available, the transcriptions reveal liquid properties much of the time (e.g. labio-rhotic glide: [dr̯aiṿ] 'drive') (see Goad 2006).

We have concluded that the most promising avenue to pursue for the rogue CG stage is that the transcribed glides in children's CG outputs are not truly glides but, instead, are covertly produced liquids misanalysed by transcribers due to children's poor gestural coordination. If vocal tract immaturity is responsible for the misanalysis, then this would be a case, like VF, where rogue behaviour can be reduced entirely to physiological constraints and no child-adult asymmetry would need to be formally expressed by the grammar.

4.3 Velar substitution

Another possible source of explanation for rogue behaviour is children's misperception of adult forms. In this section, we examine velar substitution in Amahl's outputs (Smith 1973) from this perspective. From age 2.60-2.333, Amahl produced strident fricatives as stops. The examples in (20a) exhibit this for words of the shape under focus. From age 2.60-3.282, target [t,d,nt,nd,n] in medial position before dark *l* surfaced as velar. See (20b).

(20)	a. Stopping:				b. Velar substitution:			
		[pʌdəl]	'puzzle'	(2.207-2.215)		[pʌgəl]	'puddle'	(2.247-2.256)
		[paːtəl]	'parcel'	(2.317-2.333)		[bɔġul]	'bottle'	(2.207-2.215)
		[witəl]	'whistle'	(2.233-2.242)		[kɛŋəl]	'kennel'	(3.159-3.206)

Words of certain types are protected from undergoing velar substitution: those with derived coronal stops, (20a), and those with target [st], even though [s] is deleted from clusters during much of the relevant period; see (21).

(21)	Target [st]:		
	[nɔtil]	'nostril'	(2.207-2.215)
	[pitəl]	'pistol'	(2.247-2.256)

We return to these "exceptions" shortly. We first consider whether velar substitution like (20b) can be motivated for adult grammars. We begin with the following assumptions. One, given that laterals are velarised in English rhymes, we assume that the process in (20b) involves place assimilation: coronals acquire velarity from [ɫ]. Two, we assume that the process applies between an onset consonant and following nuclear trigger (syllabic [ɫ]); that is, it applies locally rather than long-distance, which we have already seen is not attested for primary place in adult grammars. Given these assumptions, a rule-based formulation of this process would be: /t,d,n/→[k,g,ŋ]/__[ɫ̩]. Let us now address whether adult grammars contain such processes. Although place sharing between onset and nuclear consonants is attested, these assimilations seem to be restricted to cases where the nucleus acquires place from the preceding onset rather than the other way around (e.g. Gronings Dutch: *lachen*→[laχŋ̍] 'to laugh' (Humbert 1997)). While we do commonly observe cases where vowels spread place features to a preceding consonant, they never seem to affect a change in primary place; rather they involve the addition of secondary place (Ní Chiosáin and Padgett 1993) (e.g. Fante Akan: /abɛ/→[ab^{j}ɛ], *[adɛ] 'palm' (Clements 1984)). It appears, thus, that assimilations like /t,d,n/→[k,g,ŋ]/__[ɫ̩] are not attested in adult grammars. For the string of segments under focus, we should rather expect to derive [t^{ɣ},d^{ɣ},n^{ɣ}].

Must we then conclude that Amahl's grammar is a rogue grammar? Not if an alternative explanation holds. Following Macken (1980), we suggest that the explanation lies in perception: the forms in (20b) reflect perceptual miscoding rather than the operation of a rule or set of constraints. The discussion below largely follows Macken.

Smith (1973) proposes that mismatches between adult surface representations and children's outputs are generally due to constraints on production. Macken (1980) challenges this view for the data in (20b) beginning with the chain shift in (20a-b): 'puddle'→[pʌgəl] while 'puzzle'→[pʌdəl]. Although formal accounts of chain shifts have been provided (involving rule ordering (Smith 1973) or judicious use of constraints (Dinnsen et al. 2001; Jesney 2007)), it remains mysterious why a production difficulty should yield [pʌgəl] for 'puddle' when intervocalic [d] is perfectly well-formed in [pʌdəl] from 'puzzle'.

The perceptual account makes specific predictions, which Macken shows are supported. (i) Underapplication: Perceptual encoding problems should not be attested across-the-board; they should not be observed in contexts where perceptual confusion would not arise. This is supported: intervocalic dorsal is found in the 'puddle'-type words in (20b) but not in the 'pistol'-type words in (21).[14] (ii) Overapplication: When the perceptual-encoding problem is overcome, the correction should overapply to some words which were appropriately stored with underlying velars, until such words are heard again. This is supported, as the examples in (22a) show. Those in (22b) are consistent with this, although there are no productions for these words before age 3.286-3.355.

(22)	a.	'pickle(s)'	[pikəl]	(3.45-3.70)	'circle'	[səːkəl]	(3.45-3.70)
			[pitəl]	(3.286-3.355)		[səːtəl]	(3.286-3.355)
	b.	'winkle'	[wintəl]	(3.286-3.355)			
		'Trugel'	[ˈtruːdrɛl]	(3.286-3.355)			

In sum, the perceptual account of velar substitution yields dividends of two types. One, the chain shift (20), underapplication (21) and overapplication (22) patterns are no longer surprising. Two, we avoid the unwanted conclusion that Amahl has a rogue grammar. The latter problem

[14] Presumably, [st] is not misperceived before [ɫ] because [s] has robust internal cues for place (Wright 2004), which ensures its perceptibility even in non-optimal contexts (before stops) (Goad 2011).

does not arise under a perceptual account: medial velars in ‘puddle’-type words are not derived; they are stored as such.

In sum, the rogue substitutions examined in this and the preceding sections have been explained by probing how perceptual and motor development interface with the acquisition of an adult-like grammar.

5 Unexpected complexity

We consider one remaining type of mismatch between children’s and adults’ grammars, cases where children’s outputs are not puzzling from the perspective of adult typology but where they seem to involve complexity beyond what is attested in the target grammar and, thus, complexity in the absence of positive evidence. If learners are on a trajectory from unmarked outputs to outputs that more faithfully reflect the adult grammar, markedness considerations should be responsible for shaping intermediate grammars. Accordingly, we must carefully examine cases of unexpected complexity at these intermediate stages.

We consider, here, unexpected syllable complexity in Mollie’s grammar (Holmes 1927). At Stage 1, Mollie’s bisyllabic forms are CVCV in shape; see (23a) (age indicated in parentheses). At Stage 2, a different pattern emerges: the first syllable is heavy, regardless of its target weight, (23b). The forms in (23b.i), in particular, require explanation.

(23) Bisyllabic targets: Mollie:

a. Stage 1:

[nænæ]	‘dinner’ (18)
[bɪbi]	‘bib’ (18)
[dædæ]	‘dadda’ (18),(20)

b. Stage 2:

i.	[tʌnni]/[tʌnˑti]	‘tummy’ (22)	ii.	[wæŋˑki]	‘hanky’ (22)
	[bɪbbi]	‘bib’ (23)		[pɛnˑtə]	‘pencil’ (22)
	[dɑddi]	‘dolly’ (22)		[kwʌnˑtri]	‘country’ (23)

As mentioned in section 3.1, Holmes observes that Mollie has equal stress on both syllables in her bisyllabic words at 18 months, revealing a lack of understanding of English stress and possibly the absence of foot structure. This pattern is only made in reference to Mollie’s outputs at 18 months, suggesting that the Stage 2 words have the target stressed–unstressed profile. In view of this, foot well-formedness may be responsible for the pattern in (23b): if, by this point, Mollie understands that English builds moraic trochees and that final syllables in nouns are extrametrical, the first syllable must be augmented to respect foot binarity (Goad 2001). The adult analysis of ‘tummy’-type words with light penults either violates FTBIN, (tʌ)$_{Ft}$<mi>, or the extrametricality requirement (NONFINALITY), (tʌmi)$_{Ft}$. If Mollie’s Stage 2 grammar must respect both of these constraints, the first syllable must be rendered heavy, as shown in (24).

(24)

/tʌmi/	FTBIN	NONFINALITY	FAITH
a. (tʌni)$_{Ft}$		*!	
b. (tʌ)$_{Ft}$<ni>	*!		
☞ c. (tʌn)$_{Ft}$<ni>			*

Under this analysis, the forms in (23b.i), that seemingly involve complexity beyond what is attested in the target grammar, do not imply a more complex grammar, which would have been built in the absence of positive evidence. Rather, the added complexity stems from Mollie needing to satisfy requirements imposed by the English grammar which conflict in CVCV words.

In sum, competing demands on the grammar can lead to unexpected behaviour. Whether this type of approach can account for other cases of unexpected complexity we leave to future research.

6 Conclusion

We began this chapter with some predictions that arise from Optimality Theory in the context of a theory of acquisition. The foundation of the latter was that children's grammars are possible grammars. Because all constraints in OT, along with the primitives, structures and operations they refer to, are present in the grammar of every language, it followed that children's grammars should manipulate all and only the constraints that adult systems do. We provided support for this from sonority-driven onset selection in English and the development of branching onsets in Québec French.

We turned next to examine several types of divergent behaviour, where children's grammars seem to depart from what is expected from adult behaviour. One type, which we discussed at the end of the chapter, included cases of unexpected complexity in children's grammars, unexpected because the particular patterns observed arise in the absence of positive evidence. The case under examination, augmentation of stressed light syllables in Mollie's grammar, was argued to be due to the child needing to satisfy competing requirements imposed by the target grammar.

Explanations for the other types of unexpected behaviour required that we look beyond the target grammar. One type seemed amenable to formal explanation using the same primitives and constraints that define adult grammars. Specifically, the patterns observed could be explained by examining how perceptual and motor development interface with an adult-like phonological grammar. Velar substitution in Amahl's grammar was shown to be likely due to misperception of intervocalic alveolar stops before dark *l*. Velar fronting and glide substitution were proposed to arise from vocal tract immaturity. In the latter case, poor gestural timing resulted in the cues being used by the child to express a contrast not being sufficient for the transcriber to perceive the sounds involved in the contrast as different.

The final type of unexpected behaviour included the CV stage and consonant harmony, two phenomena that suggest that children's grammars do not manipulate exactly the same toolkit as adult grammars: the CV stage seemed to require that children begin acquisition without the full set of prosodic constituents available to adults; consonant harmony seemed to require that early grammars contain constraints that cannot be motivated for adult grammars.

This paper has focused entirely on unusual patterns that are present in early grammars. In the literature, significantly less attention has been paid to processes that are commonly attested in adult grammars, yet absent from development. A striking comparison here is types of place harmony (Drachman 1978). As we have seen, consonant harmony, where consonants at a distance agree for primary place, is commonly attested in children's grammars yet absent from adult grammars. Vowel harmony, where vowels at a distance agree for place, is common in adult grammars yet seemingly absent from the grammars of children learning languages without this process. Spontaneous creation of vowel harmony would not be surprising, because, like consonant harmony, it is articulatorily advantageous in reducing the number of gestural changes required to produce a word. In view of this, does the absence of vowel harmony suggest that children's grammars lack the mechanisms required to formally represent this process (see Goad 2001)? Perhaps, although any explanation for the absence of vowel harmony must, at the same time, permit the presence of the seemingly-similar consonant harmony.

We have tried to come to some understanding of processes that unexpectedly occur in children's grammars. We leave exploration of the unexpected absence of cross-linguistically common patterns from early grammars to future research.

Author's Address
Heather Goad
Department of Linguistics
McGill University
1085 Dr-Penfield
Montréal (Qué)
Canada H3A 1A7
heather.goad@mcgill.ca

Acknowledgements
Thanks to an anonymous reviewer and Joe Pater for helpful comments on an earlier version of this paper. Many of the ideas contained in this paper were presented at the Boston University Conference on Language Development, Universität Hamburg, Rutgers University, Université de Montréal, Université Paris 8 and Memorial University of Newfoundland. Thanks to the audiences for questions and comments. This research was supported by grants from SSHRC and FQRSC.

REFERENCES

Aungst, Lester and James V. Frick (1964), Auditory discrimination ability and consistency of articulation of /r/. *Journal of Speech and Hearing Disorders* 29:76-85.

Baković, Eric (2000), *Harmony, Dominance and Control.* Unpublished Ph.D. thesis. Dept. of Linguistics. Rutgers University. New Brunswick, NJ.

Barlow, Jessica (1997), *A Constraint-based Account of Syllable Onsets: Evidence from Developing Systems.* Unpublished Ph.D. thesis. Dept. of Linguistics. Indiana University.

Becker, Michael and Anne-Michelle Tessier (2011), Trajectories of faithfulness in child-specific phonology. *Phonology* 28:163-196.

Beeler, M. S. (1970), Sibilant harmony in Chumash. *International Journal of American Linguistics* 36:14-17.

Bernhardt, Barbara H. and Joseph P. Stemberger (1998), *Handbook of Phonological Development: From the Perspective of Constraint-based Nonlinear Phonology.* Academic Press. San Diego.

Bleile, Ken (1991), *Child Phonology: A Book of Exercises for Students.* San Diego: Singular Publishing.

Boersma, Paul and Bruce Hayes (2001), Empirical tests of the Gradual Learning Algorithm. *Linguistic Inquiry* 32:45-86.

Brown, Cynthia and John Matthews (1997), The role of feature geometry in the development of phonetic contrasts. In S. J. Hannahs and Martha Young-Scholten (eds.), *Focus on Phonological Acquisition.* Benjamins. Amsterdam. 67-112.

Bryan, Michelle (2009), An exploration of r-sound mispronunciations during speech development of English- and French-speaking children. Unpublished B.A. honours thesis. Dept. of Psychology. University of Calgary. Calgary, Canada.

Buckley, Eugene (2003), Children's unnatural phonology. In *Proceedings of the Twenty-Ninth Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on Phonetic Sources of Phonological Patterns: Synchronic and Diachronic Explanations.* Berkeley Linguistics Society. Berkeley, CA. 523-534.

Chaney, Carolyn F. (1978), *Production and Identification of /j, w, r, l/ in Normal and Articulation Impaired Children.* Unpublished Ph.D. thesis. Health Sciences: Speech Pathology, School of Education. Boston University. Boston, MA.

Chiat, Shulamuth (1983), Why *Mikey*'s right and *my key*'s wrong: The significance of stress and word boundaries in a child's output system. *Cognition* 14:275-300.

Clements, George N. (1984), Vowel harmony in Akan: A consideration of Stewart's word structure conditions. *Studies in African Linguistics* 15:321-337.

Clements, George N. (1986), Compensatory lengthening and consonant gemination in Luganda. In Leo Wetzels and Engin Sezer (eds.), *Studies in Compensatory Lengthening.* Foris. Dordrecht. 37-77.

Clements, George N. (1990), The role of the sonority cycle in core syllabification. In John Kingston and Mary E. Beckman (eds.), *Papers in Laboratory Phonology I: Between the Grammar of Physics and Speech*. Cambridge University Press. Cambridge. 283-333.

Dalston, Rodger M. (1972), *A Spectrographic Analysis of the Spectral and Temporal Acoustic Characteristics of English Semivowels Spoken by Three-year-old Children and Adults.* Ph.D. thesis. Northwestern University. Evanston, Illinois.

Demuth, Katherine (1995), Markedness and the development of prosodic structure. In Jill Beckman (ed.), *Proceedings of the North East Linguistic Society 25. Volume 2: Papers from the Workshops on Language Acquisition & Language Change.* GLSA. University of Massachusetts, Amherst. 13-25.

Demuth, Katherine, Jennifer Culbertson and Jennifer Alter (2006), Word-minimality, epenthesis and coda licensing in the early acquisition of English. *Language and Speech* 49:137-174.

Demuth, Katherine and E. Jane Fee (1995), Minimal words in early phonological development. Unpublished MS.

Demuth, Katherine and Annie Tremblay (2008), Prosodically-conditioned variability in children's production of French determiners. *Journal of Child Language* 35:99-127.

Dinnsen, Daniel A., Kathleen M. O'Connor, and Judith A. Gierut (2001), The puzzle-puddle-pickle problem and the Duke-of-York gambit in acquisition. *Journal of Linguistics* 37:503-525.

Drachman, Gaberell (1978), Child language and language change: A conjecture and some refutations. In Jacek Fisiak (ed.,) *Recent Developments in Historical Phonology.* Mouton. The Hague. 123-144.

Duanmu, San (2007), *The Phonology of Standard Chinese.* 2nd edition. Oxford University Press. Oxford.

Edwards, Mary Louise (1974), Perception and production in child phonology: The testing of four hypotheses. *Journal of Child Language* 1:205-219.

Fikkert, Paula (1994), *On the Acquisition of Prosodic Structure.* HIL Dissertations. The Hague.

Fikkert, Paula (2010), Developing representations and the emergence of phonology: Evidence from perception and production. In Cécile Fougeron, Barbara Kühnert, Mariapaola D'Imperio, and Nathalie Vallée (eds.), *Laboratory Phonology 10.* De Gruyter. Berlin. 227-260.

Fikkert, Paula and Clara C. Levelt (2008), How does Place fall into place? The lexicon and emergent cosntraints in children's developing phonological grammar. In Peter Avery, B. Elan Dresher, and Keren Rice (eds.), *Contrast in Phonology: Theory, Perception, Acquisition.* Mouton de Gruyter. Berlin. 231-268.

Fougeron, Cécile (1999), Prosodically conditioned articulatory variation: A review. *UCLA Working Papers in Phonetics* 97:1-73.

Fougeron, Cécile and Patricia A. Keating (1996), Articulatory strengthening in prosodic domain-initial position. *UCLA Working Papers in Phonetics* 92:61-87.

Frantz, Donald G. (2009), *Blackfoot Grammar*. 2nd edition. University of Toronto Press. Toronto.

Garnica, Olga K. (1973), The development of phonemic speech perception. In Timothy E. Moore (ed.), *Cognitive Development and the Acquisition of Language.* Academic Press. New York. 215-222.

Gierut, Judith (1999), Syllable onsets: Clusters and adjuncts in acquisition. *Journal of Speech Language and Hearing Research* 42:708-726.

Gnanadesikan, Amalia (1995), Markedness and faithfulness constraints in child phonology. Published 2004 in René Kager, Joe Pater, and Wim Zonneveld (eds.), *Constraints in Phonological Acquisition*. Cambridge University Press. Cambridge. 73-108.

Goad, Heather (1996), Codas, word minimality, and empty-headed syllables. In Eve Clark (ed.), *Proceedings of the 28th Annual Child Language Research Forum.* Center for the Study of Language and Information. Stanford. 113-122.

Goad, Heather (1997), Consonant harmony in child language: An optimality-theoretic account. In S. J. Hannahs and Martha Young-Scholten (eds.), *Focus on Phonological Acquisition*. Benjamins. Amsterdam. 113-142.

Goad, Heather (2001), Assimilation phenomena and initial constraint ranking in early grammars. In Anna H.-J. Do, Laura Domínguez, and Aimee Johansen (eds.), *Proceedings of the 25th Annual Boston University Conference on Language Development.* Cascadilla Press. Somerville, MA. 307-318.

Goad, Heather (2006), Are children's grammars rogue grammars? Glide substitution in branching onsets. *Recherches linguistiques de Vincennes* 35:103-132.

Goad, Heather (2011), The representation of sC clusters. In Marc van Oostendorp, Colin Ewen, Elizabeth Hume, and Keren Rice (eds.), *The Blackwell Companion to Phonology.* Wiley-Blackwell. Oxford. 898-923.

Goad, Heather and Meaghen Buckley (2006), Prosodic structure in child French: Evidence for the foot. *Catalan Journal of Linguistics* 5:109-142. Special issue on the Acquisition of Romance Languages.

Goad, Heather and Adèle-Elise Prévost (2010), A test case for markedness: The acquisition of Québec French stress. Unpublished MS.

Goad, Heather and Yvan Rose (2004), Input elaboration, head faithfulness and evidence for representation in the acquisition of left-edge clusters in West Germanic. In René Kager, Joe

Pater, and Wim Zonneveld (eds.), *Constraints in Phonological Acquisition.* Cambridge University Press. Cambridge. 109-157.

Goehl, Henry and S. Golden (1972), A psycholinguistic account of why children do not detect their own errors. Unpublished MS.

Gormley, Andrea (2003), The production of consonant harmony in child speech. Unpublished M.A. thesis. Dept. of Linguistics. University of British Columbia. Vancouver, Canada.

Hale, Mark and Charles Reiss (1998), Formal and empirical arguments concerning phonological acquisition. *Linguistic Inquiry* 29:656-683.

Hansson, Gunnar Ó. (2001), *Theoretical and Typological Issues in Consonant Harmony*. Unpublished Ph.D. thesis. Dept. of Linguistics. University of California Berkeley. Berkeley, CA.

Harris, John (1997), Licensing inheritance: An integrated theory of neutralisation. *Phonology* 14:315-370.

Hawkins, Sarah (1973), Temporal coordination of consonants in the speech of children: Preliminary data. *Journal of Phonetics* 1:181-217.

Hayes, Bruce (1999), Phonetically-driven phonology: The role of Optimality Theory and inductive grounding. In Michael Darnell, Edith Moravcsik, Frederick J. Newmeyer, Michael Noonan, and Kathleen Wheatley (eds.), *Functionalism and Formalism in Linguistics, Volume I: General Papers*. Benjamins. Amsterdam. 243-285.

Hoffman, Paul R., Sheila Stager, and Raymond G. Daniloff (1983), Perception and production of misarticulated /r/. *Journal of Speech and Hearing Disorders* 48:210-215.

Holmes, Urban T. (1927), The phonology of an English-speaking child. *American Speech* 2:219-225.

Humbert, Helga (1997), On the asymmetrical nature of nasal obstruent relations. In Kiyomi Kusumoto (ed.), *Proceedings of the North East Linguistic Society 27.* GLSA. University of Massachusetts, Amherst. 219-233.

Ingram, David (1974), Fronting in child phonology. *Journal of Child Language* 1:233-241.

Ingram, David (1978), The role of the syllable in phonological development. In Alan Bell and Joan B. Hooper (eds.), *Syllables and Segments.* North-Holland. Amsterdam. 143-155.

Inkelas, Sharon and Yvan Rose (2007), Positional neutralization: A case study from child language. *Language* 83:707-736.

Jakobson, Roman (1941), *Child Language, Aphasia, and Phonological Universals*. Mouton. The Hague. Translated (1968), by Allan R. Keiler.

Jesney, Karen (2007), Child chain shifts as faithfulness to input prominence. In Alyona Belikova, Luisa Meroni, and Mari Umeda (eds.), *Proceedings of the 2nd Conference on Generative Approaches to Language Acquisition–North America (GALANA 2)*. Cascadilla. Somerville, MA. pp. 188-199.

Jesney, Karen and Anne-Michelle Tessier (2011), Biases in Harmonic Grammar: The road to restrictive learning. *Natural Language & Linguistic Theory* 29:251-290.

Jongstra, Wenckje (2003), Variable and stable clusters: Variation in the realisation of consonant clusters. *Canadian Journal of Linguistics* 48:265-288.

Jun, Jongho (1995), *Perceptual and Articulatory Factors in Place Assimilation: An Optimality Theory Approach.* Unpublished Ph.D. thesis. Dept. of Linguistics. UCLA. Los Angeles, CA.

Jun, Sun-Ah and Cécile Fougeron (2000), A phonological model of French intonation. In Antonis Botinis (ed.), *Intonation: Analysis, Modelling and Technology.* Kluwer. Dordrecht. 209-242.

Kehoe, Margaret, Geraldine Hilaire-Debove, Katherine Demuth, and Conxita Lleó (2008), The structure of branching onsets and rising diphthongs: Evidence from the acquisition of French and Spanish. *Language Acquisition* 15:5-57.
Kehoe, Margaret and Carol Stoel-Gammon (1997), The acquisition of prosodic structure: An investigation of current accounts of children's prosodic development. *Language* 73:113-144.
Kiparsky, Paul and Lise Menn (1977), On the acquisition of phonology. In John Macnamara (ed.) *Language Learning and Thought*. Academic Press. New York. 47-78.
Klein, Robert P. (1971), Acoustic analysis of the acquisition of acceptable "r" in American English. *Child Development* 42:543-550.
Kornfeld, Judith R. (1971), What initial clusters tell us about the child's speech code. *Quarterly Progress Report*, *MIT Research Laboratory of Electronics* 101:218-221.
Kornfeld, Judith R. (1976), Implications of studying reduced consonant clusters in normal and abnormal child speech. In Robin N. Campbell and Philip T. Smith (eds.), *Recent Advances in the Psychology of Language: Formal and Experimental Approaches.* New York: Plenum Press. 413-423.
Kornfeld, Judith R. and Henry Goehl (1974), A new twist to an old observation: Kids know more than they say. In Anthony Bruck, Robert A. Fox, and Michael W. La Galy (eds.), *Papers from the Tenth Annual Meeting of the Chicago Linguistic Society, Parasession on Natural Phonology.* Chicago Linguistic Society. Chicago. 210-219.
Kuehn, David P. and J. Bruce Tomblin (1977), A cineradiographic investigation of children's w/r substitutions. *Journal of Speech and Hearing Disorders* 42:462-473.
Ladefoged, Peter and Ian Maddieson (1996), *The Sounds of the World's Languages.* Blackwell. Oxford.
Lee, Duck-Young (1998), *Korean Phonology: A Principle-based Approach.* LINCOM Europa. München.
Levelt, Clara C. (2011), Consonant harmony in child language. In Marc van Oostendorp, Colin Ewen, Elizabeth Hume, and Keren Rice (eds.), *The Blackwell Companion to Phonology.* Wiley-Blackwell. Oxford. 1691-1716.
Levelt, Clara C., Niels O. Schiller and Willem J. Levelt (2000), The acquisition of syllable types. *Language Acquisition* 8:237-264.
Levelt, Clara C. and Ruben van de Vijver (2004), Syllable types in cross-linguistic and developmental grammars. In René Kager, Joe Pater and Wim Zonneveld (eds.), *Constraints in Phonological Acquisition.* Cambridge University Press. Cambridge. 204-218.
Locke, John L. (1993), *The Child's Path to Spoken Language.* Harvard University Press. Cambridge, MA.
Locke, John L. and Kathryn J. Kutz (1975), Memory for speech and speech for memory. *Journal of Speech and Hearing Disorders* 18:176-191.
Lombardi, Linda (1999), Positional faithfulness and voicing assimilation in Optimality Theory. *Natural Language & Linguistic Theory* 17:267-302.
Macken, Marlys (1980), The child's lexical representation: The 'puzzle-puddle-pickle' evidence. *Journal of Linguistics* 16:1-17.
Macken, Marlys and David Barton (1980), The acquisition of the voicing contrast in English: a study of voice onset time in word-initial stop consonants. *Journal of Child Language* 7:41-74.
Maddieson, Ian (1984), *Patterns of Sounds.* Cambridge University Press. Cambridge.

McAllister Byun, Tara (2011), A gestural account of a child-specific neutralisation in strong position. *Phonology* 28: 371-412.

McAllister Byun, Tara (2012), Positional velar fronting: An updated articulatory account. *Journal of Child Language* 39:1043-1076.

McCarthy, John J. and Alan S. Prince (1994), The emergence of the unmarked: Optimality in prosodic morphology. In Mercè Gonzàlez (ed.), *Proceedings of the North East Linguistics Society* 24. GLSA. Amherst, MA. 333-379.

McCarthy, John J. and Alan S. Prince (1995), Prosodic morphology. In John Goldsmith (ed.), *The Handbook of Phonological Theory.* Blackwell. Oxford. 318-366.

McDonough, Joyce and Scott Myers (1991), Consonant harmony and planar segregation in child language. Unpublished MS.

McReynolds, Leija V., Joan Kohn, and Gail C. Williams (1975), Articulatory-defective children's discrimination of their production errors. *Journal of Speech and Hearing Disorders* 40:327-338.

Menn, Lise (1971), Phonotactic rules in beginning speech. *Lingua* 26:225-251.

Menn, Lise (1978), Phonological units in beginning speech. In Alan Bell and Joan B. Hooper (eds.), *Syllables and Segments*. North Holland. Amsterdam. 315-334.

Menyuk, Paula (1971), Clusters as single underlying consonants: Evidence from children's productions. Paper presented at the International Congress of Phonetic Sciences, Montreal, August.

Menyuk, Paula and Suzan Anderson (1969), Children's identification and reproduction of /w/, /r/ and /l/. *Journal of Speech and Hearing Disorders* 12:39-52.

Monnin, Lorraine M. and Dorothy A. Huntington (1974), Relationship of articulatory deficits to speech-sounds identification. *Journal of Speech and Hearing Research* 17:352-366.

Morrisette, Michele L., Daniel A. Dinnsen, and Judith A. Gierut (2003), Markedness and context effects in the acquisition of place features. *Canadian Journal of Linguistics* 48:329-355.

Munson, Benjamin, Jan Edwards, Sarah K. Schellinger, Mary E. Beckman and Marie K. Meyer (2010), Deconstructing phonetic transcription: Covert contrast, perceptual bias, and an extraterrestrial view of *Vox Humana*. *Clinical Linguistics and Phonetics* 24:245-260.

Ní Chiosáin, Máire and Jaye Padgett (1993), On the nature of consonant-vowel interaction. Presented at HILP, Leiden University.

Ohala, Diane (1999), The influence of sonority on children's cluster reductions. *Journal of Communication Disorders* 32:397-422.

Ota, Mits (2003), *The Development of Prosodic Structure in Early Words.* Benjamins. Amsterdam.

Özçelik, Öner (2009), Exceptions in stress assignment: Feet in input. Paper presented at NELS 40, MIT, November.

Paradis, Carole and Jean-François Prunet, eds. (1991), *The Special Status of Coronals: Internal and External Evidence*. Academic Press. San Diego.

Pater, Joe (1997), Minimal violation and phonological development. *Language Acquisition* 6:201-253.

Pater, Joe (2004), Bridging the gap between receptive and productive development with minimally violable constraints. In René Kager, Joe Pater, and Wim Zonneveld (eds.), *Constraints in Phonological Acquisition*. Cambridge University Press. Cambridge. 219-244.

Pater, Joe and Adam Werle (2003), Direction of assimilation in child consonant harmony. *Canadian Journal of Linguistics* 48:385-408.

Pinker, Steven (1984), *Language Learnability and Language Development.* Harvard University Press. Cambridge, MA.

Prince, Alan and Paul Smolensky (1993), *Optimality Theory: Constraint Interaction in Generative Grammar.* Published 2004 by Blackwell. Oxford.

Qu, Chen (2011), Development of place contrast system in early L1 grammar. *Western Conference of Linguistics (WECOL).* Simon Fraser University. Vancouver, Canada. November.

Richtsmeier, Peter T. (2007), An articulatory analysis of gliding. Paper presented at Ultrafest IV, New York, Sept. Retrieved from http://web.ics.purdue.edu/~prichtsm/professional/pres.html.

Rose, Sharon and Rachel Walker (2004), A typology of consonant agreement as correspondence. *Language* 80:475-531.

Rose, Yvan (2000), *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology.* Unpublished Ph.D. thesis. Dept. of Linguistics. McGill University. Montreal, Canada.

Rose, Yvan (2009), Internal and external influences on child language productions. In François Pellegrino, Egidio Marsico, Ioana Chitoran and Christophe Coupé (eds.), *Approaches to Phonological Complexity.* Mouton de Gruyter. Berlin. 329-351.

Ross, Alan S.C. (1937), An example of vowel-harmony in a young child. *Modern Language Notes,* November, pp. 508-509.

Salidis, Joanna and Jacqueline S. Johnson (1997), The production of minimal words: A longitudinal case study of phonological development. *Language Acquisition* 6:1-36.

Schwartz, Richard G. and Laurence B. Leonard (1982), Do children pick and choose? An examination of phonological selection and avoidance. *Journal of Child Language* 9:319-336.

Scobbie, James M. (1998), Interactions between the acquisition of phonetics and phonology. In M. Catherine Gruber, Derrick Higgins, Kenneth S. Olson and Tamra Wysocki (eds.), *Proceedings from the Panels of the Chicago Linguistic Society's Thirty-fourth Meeting. Volume 34-2*. Chicago Linguistic Society. Chicago. 343-358.

Selkirk, Elisabeth (1996), The prosodic structure of function words. In James Morgan and Katherine Demuth (eds.), *Signal to Syntax: Bootstrapping from Speech to Grammar*. Lawrence Erlbaum. Mahwah, NJ. 187-213.

Shvachkin, N. Kh. (1948), The development of phonemic speech perception in early childhood. Reprinted (1973), in Charles A. Ferguson and Dan I. Slobin (eds.), *Studies of Child Language Development.* Holt, Rinehart and Winston. New York. 91-127.

Smit, Ann B. (1993), Phonologic error distributions in the Iowa-Nebraska Articulation Norms Project: Consonant singletons. *Journal of Speech and Hearing Research* 36:533-547.

Smith, Neil V. (1973), *The Acquisition of Phonology: A Case Study*. Cambridge University Press. Cambridge.

Smolensky, Paul (1996), On the comprehension/production dilemma in child language. *Linguistic Inquiry* 27:720-731.

Spencer, Andrew (1986), Towards a theory of phonological development. *Lingua* 68:3-38.

Stampe, David (1969), The acquisition of phonetic representation. In Robert I. Binnick, Alice Davison, Georgia M. Green and Jerry L. Morgan (eds.), *Papers from the Fifth Regional Meeting of the Chicago Linguistic Society.* Chicago Linguistic Society. Chicago. 443-454.

Stemberger, Joseph and Carol Stoel-Gammon (1991), The underspecification of coronals: Evidence from language acquisition and performance errors. In Carole Paradis and Jean-François Prunet (eds.), *The Special Status of Coronals: Internal and External Evidence.* Academic Press. San Diego. 181-199.

Stoel-Gammon, Carol (1996), On the acquisition of velars in English. In Barbara H. Bernhardt, John Gilbert and David Ingram (eds.), *Proceedings of the UBC International Conference on Phonological Acquisition.* Cascadilla Press. Somerville, MA. 201-214.

Stoel-Gammon, Carol and Judith A. Cooper (1984), Patterns of early lexical and phonological development. *Journal of Child Language* 11:247-271.

Strange, Winifred and Patricia A. Broen (1980), Perception and production of approximant consonants by 3-year-olds: A first study. In Grace H. Yeni-Komshian, James F. Kavanagh and Charles A. Ferguson (eds.), *Child Phonology, 2: Perception*. Academic Press. New York. 117-154.

Tesar, Bruce and Paul Smolensky (1993), The learnability of Optimality Theory: An algorithm and some basic complexity results. Unpublished MS. ROA-2, Rutgers Optimality Archive. Retrieved from http://ruccs.rutgers.edu/roa.html.

Vihman, Marilyn (1978), Consonant harmony: Its scope and function in child language. In Joseph Greenberg (ed.), *Universals of Human Language*. Stanford University Press. Stanford. 281-334.

Vihman, Marilyn (1996), *Phonological Development: The Origins of Language in the Child.* Blackwell. Oxford.

Vihman, Marilyn, Rory DePaolis, and Barbara Davis (1998), Is there a "trochaic bias" in early word learning? Evidence from infant production in English and French. *Child Development* 69:935-949.

Wexler, Kenneth and Peter Culicover (1980), *Formal Principles of Language Acquisition.* MIT Press. Cambridge, MA.

White, Lydia (1982), *Grammatical Theory and Language Acquisition.* Dordrecht: Foris.

Whitney, William Dwight (1889), *Sanskrit Grammar.* Harvard University Press. Cambridge, MA.

Wright, Richard (2004), A review of perceptual cues and cue robustness. In Bruce Hayes, Robert Kirchner and Donca Steriade (eds.), *Phonetically Based Phonology*. Cambridge University Press. Cambridge. 34-57.

Yip, Moira (1992), Prosodic morphology in four Chinese dialects. *Journal of East Asian Linguistics* 1:1-35.