In N. Ritter & H. van der Hulst (eds, 2024) The Oxford handbook of vowel harmony. Oxford University Press, pp. 486-497

Chapter 38

Vowel harmony in language acquisition

Heather Goad & Avery Ozburn

38.1 Introduction

Vowel harmony (VH) is widely attested across languages, yet not much is known about how it is acquired. Our goal in this chapter is to draw attention to what has been observed in the acquisition of VH by first (L1) and second (L2) language learners and to where further study is required.

We might conjecture that the acquisition of VH is challenging. At the segmental level, learners must determine the set of triggers and targets and, if neutral vowels are present, their status as transparent or opaque. At the interface with morphology, they must determine whether VH is root-controlled or dominant/recessive, whether it is uni- or bidirectional, and the domain in which it applies. Surprisingly, we will see that, from what is known to date, VH is straightforwardly acquired (Dasinger 1997).

The first step in the acquisition of VH involves detecting agreement among non-adjacent vowels. We thus begin with work that explores whether vowel agreement is used as a cue for word segmentation by pre-verbal infants. We then present what is known about children's acquisition of VH in languages displaying back, round, height, and ATR harmonies. Next, we discuss emergent VH in children learning languages without harmony, which we expect to be attested if vowel agreement is articulatorily advantageous. Finally, we turn to the VH grammars built by adult L2 learners, where we find the same types of constraints that hold of native speaker grammars.

38.2 Word segmentation

A body of literature has experimentally shown that infants use vowel agreement to segment words. However, differences are observed in the age at which infants become aware of such dependencies and in the preferences (measured via looking times) that they display. Studies on Turkish by van Kampen et al. (2008) and Hohenberger et al. (2016) found that 6-month-olds are sensitive to harmonic stimuli. Hohenberger et al.'s study also included 10-month-olds. Both age groups detected harmonic stimuli, but their preferences were different: the 6-month-olds preferred harmonic stimuli, suggesting that infants at this age may be predisposed to detect harmonic forms in their attempt to segment speech into words; the 10-month-olds preferred disharmonic stimuli, suggesting that these forms stood out as different from the word shapes they had been exposed to.

Gonzalez-Gomez et al.'s (2019) results on Hungarian 10-month-olds contrast with those of Hohenberger et al. on Turkish 10-month-olds. Gonzalez-Gomez et al. tested 10- and 13-month-olds. The older infants preferred disharmonic stimuli, like the Turkish 10-month-olds, but the younger infants showed no such preference. Gonzalez-Gomez et al. suggest that the contrast between Hungarian and Turkish at 10 months may stem from differences in the proportion of harmonic words in child-directed speech: only 71% of Hungarian words respect VH whereas 87% of Turkish words do, due to the presence of neutral vowels in Hungarian (Ketrez 2014).

They acknowledge, though, that this cannot be the only factor, as Mintz et al. (2018) show that, after familiarization, English-exposed 7-months-olds can also use vowel agreement for segmentation, even though harmony is absent from the adult grammar.

Considering all results together, the Turkish and English findings on 6- and 7-month-olds suggest that, regardless of the presence or absence of VH in the target language, prelinguistic infants may be biased to detect harmonic forms, as this facilitates word segmentation. Later in development, however, children's ability to use VH as a cue for segmentation depends on the grammar they have built, which will be impacted by the lexical properties of the language of exposure. Consistent with this, the 13-month-old Hungarian children in Gonzalez-Gomez et al. were at the age when word learning is central and, thus, they were attracted by forms that violate the VH constraints they had internalized. Coupled with differences in the proportion of harmonic forms in child-directed speech, this could also explain the 10-month-old Turkish results: although three months younger, infants at this age were similarly sensitive to non-conforming data, based on the more regular lexical properties found in their native language. Returning to Gonzalez-Gomez et al., this study also included 13-month-old French-learning children; not surprisingly, these older children showed no sensitivity to harmonic forms, as they had not been exposed to a language with VH.

38.3 First language acquisition

As alluded to, children's VH productions have been observed to be largely error free. We will see that this holds regardless of the type of harmony operative in the target language.

We begin with Hungarian and Finnish, where acquisition of VH has been examined in some detail. Both languages display back harmony; Hungarian also displays round harmony (see Chapter 67 this volume for an overview of VH in Uralic).

38.3.1 Back and round harmony in Hungarian

The Hungarian vowel inventory is /iː, i, yː, y, uː, u, eː, ɛ, øː, ø, oː, o, aː, ɔ/, orthographically represented as *í, i, ű, ü, ú, u, é, e, ő, ö, ó, o, á, a*.[1] In back harmony, most suffixes agree with the root-final vowel, except when that vowel is neutral (front unrounded). Roots cannot contain non-neutral front vowels and back vowels, loanwords aside. Round harmony is more limited. Roots are not harmonic for rounding. Round harmony compels the front variants of some non-high suffixes to agree in rounding with the root-final vowel. Other suffixes do not alternate in rounding, despite alternating in backness. See Törkenczy (2011) for an overview of Hungarian harmony.

Turning to acquisition, we first revisit Gonzalez-Gomez et al. (2019), which showed that Hungarian-learning 13-month-olds have some understanding of VH. The stimuli employed were novel words with no evidence of morphological complexity. This experiment, thus, does not indicate whether VH is productive at this age. To assess this, we must examine whether children can segment words into morphemes and recognize that suffixes vary in shape determined by the vowels in the root they attach to.

[1] Many works consulted transcribe children's examples orthographically. Because we cannot be certain exactly what was produced in these circumstances, all examples employ the transcription system of the original sources.

The first question is explored in Ladányi et al. (2020). 15-month-old children were exposed to novel nouns followed by the inessive suffix (*ban~ben*). Children used their understanding of this suffix to segment morphologically complex words. However, the study did not contain a single task with both front and back allomorphs, nor did it test how children respond to disharmony; we thus do not know if they understand what underlies the *ban~ben* alternation.

Several studies examine children's production of affixes (MacWhinney 1975; Pléh et al. 1997; Gábor and Lukács 2012). They do not systematically examine harmony, but they comment that children's productions are largely error free. Using spontaneous data from five children aged 1;5-2;9, Pléh et al.'s (1997) analysis of case marking in locative constructions finds no VH errors in inessive or superessive (*n~on~en~ön*) constructions, and only two errors in adessive (*nál~nél*) constructions. One involved inappropriate agreement with a non-adjacent (initial) vowel (**Bélus-nél*), perhaps because initial vowels are stressed in Hungarian. Another involved inappropriate agreement with a neutral vowel (**Moncsi-től* 'Moncsi-ABL'). In MacWhinney's (1975) examination of plural in 25 children (aged 2;1-3;8) using a wug test, he observed only "sporadic errors" in VH (MacWhinney 1975: 76). There was only one back harmony error in the corpus: *gvin-ok* (plural of novel form) instead of *gvin-ek*, where the base has a neutral vowel. Round harmony was more challenging, with errors involving underapplication from base to plural in real and novel forms; see (1).[2]

(1) Underapplication of round harmony (MacWhinney 1975):

a. Existing words:			b. Novel words:	
Target:	Child:		Target:	Child:
bör-ök	*bör-ek*	'leather-PL'	*vör-ök*	*vör-ek*
tükr-ök	*tükör-ek*	'mirror-PL'	*fükör-ök*	*fükör-ek*

Gósy (1989a,b) examined the acquisition of VH in spontaneous production. She reports that children do not make errors, aside from a handful in "early speech" (Gósy 1989a: 50). To support her claim that VH is productive, she asserts that children's novel productions ("erroneously or playfully derived word forms"; Gósy 1989a: 50) respect harmony; see (2).

(2) Novel productions (Gósy 1989a,b):

	Target:	Child:	
a.	*cipőcskéje*	*cipőjécskéje*	'his/her little shoe'
	itt van	*itvan-ka*	'it is here-DIM'
b.	*nadrágja*	*nadrágája*	'his/her trousers'
	piskóta	*pakká*	'sponge-cake'

The forms in (2a) contain a vowel that is harmonic in related forms (e.g., *cipő-je* 'his/her shoe', *István-ka* (hypocoristic); examples from Péter Siptár (p.c.)), suggesting that the child's productions, although morphologically incorrect, are phonologically licit. The forms in (2b), involving epenthesis and truncation, are likewise phonologically well-formed. However, all errored productions in Gósy (1989a,b) involve outputs where the erroneous vowel is identical to

[2] The root meaning 'leather' is *bőr*; *bör* is an error in the source. Additionally, although novel words were designed to parallel real words, it appears that MacWhinney tested *vör-ök* (not *vőr-ök*) and *fükör-ök* (not *fükr-ök*).

an adjacent vowel. Thus, although these vowels may result from application of VH (i.e., spreading of one feature), they resemble total vowel agreement, a process we discuss below that is commonly attested for learners of languages both with and without VH.

More compelling support for VH as productive comes from overapplication, where learners erroneously apply harmony when conditions for its application are not met in the target grammar. Gósy (1989a,b) finds that 3-year-old children overapply VH to the first singular present conditional indefinite suffix, which has no back vowel variant in the adult grammar; see (3). While there are non-standard dialects that harmonize this suffix, Gósy (1989b) implies that such forms were not in the input to which the children under study were exposed.

(3) Overgeneralization of back harmony (Gósy 1989b):

Target:	Child:	
alud-nék	*alud-nák*	'I would sleep'
vol-nék	*vol-nák*	'I would be'

38.3.2 Back harmony in Finnish

The Finnish vowel inventory is /i, y, u, e, ø, o, æ, ɑ/, plus their long counterparts, orthographically represented as *i, y, u, e, ö, o, ä, a*. All vowels occur in root-initial position. Vowels within a word agree for front/back such that /y, ø, æ/ and /u, o, ɑ/ generally do not co-occur. /i, e/ are neutral. For an overview of Finnish harmony, see Ringen and Heinämäki (1999).

Turning to acquisition, violations of VH are rare. In elicited productions from 196 children aged 2;6, Leiwo et al. (2006) found that only 2.1%-3.1% violated harmony, when the most target-like production of a word was selected for analysis. Even when all productions were considered, only 3.4%-3.6% violated harmony. Children had difficulties with [y, ø, æ], which were typically substituted by their back counterparts; see (4a). Earlier studies observe the same substitutions, especially when these vowels occur in non-initial (unstressed) position (Toivainen 1997; Leiwo et al. 2000). Toivainen (1997), for example, reports that the back harmonic form of the question particle, *ko~kö*, is sometimes used by children in front harmonic words; see (4b).

(4) Substitution:

a. Monomorphemic words (Leiwo et al. 2006):

Target:	Child:	
pöytä	[poutæ]	'table'
pyörä	[pierɑ]	'bike'

b. Suffixed words (Toivainen 1997):

Target:	Child:	
hyriseekö nyt	*hyliteeko nyt*	'is it humming now?' (vacuum cleaner)

The pattern in (4) stems in part from late acquisition of [y, ø], the last vowels to be acquired by Finnish-speaking children (Itkonen 1977; Iivonen 1993). It may also be driven by the input: [y, ø, æ] are the least frequent vowels in adult Finnish, with [y, ø] rarely occurring in non-initial position (Pääkkönen 1990; Nahkola 1998). Indeed, Leiwo et al. (2000) suggest that the development of VH involves a competition between satisfying harmony and avoiding front harmonic vowels in non-initial position.

Finally, Finnish children aged 2;6 seem to understand that /i, e/ are neutral. Leiwo et al. (2006) found no overapplication of harmony in words where /i, e/ are followed by back vowels; see (5). However, overapplication in such words would yield the disfavored [y, æ].[3]

(5) No overapplication from neutral vowels (Leiwo et al. 2006):

Target:	Child:	
lintu	*lintu* (**lintü*)	'bird'
kissa	*kissa* (**kissä*)	'cat'

38.3.3 Back and round harmony in Turkish

The Turkish vowel inventory is /i, e, y, ø, ɯ, ɑ, u, o/, orthographically represented as *i, e, ü, ö, ı, a, u, o*. All vowels occur in root-initial position. In back harmony, the front/back quality of following vowels is generally determined by this initial vowel. Round harmony is more restricted: only high vowels agree with immediately preceding vowels. See Kabak (2011) for a recent overview of Turkish harmony and Chapter 59 this volume for harmony in Turkic languages more generally.

Turning to acquisition, we begin with children's understanding of Turkish morphology, a precursor to mastering harmonic alternations. Ekmekçi (1979) and Aksu-Koç and Slobin (1985) remark that young children's productions are relatively complex: there is some productive use of morphology by 1;3 and most nominal and verbal inflection is acquired by 2;0.

Concerning harmony, Ekmekçi (1979) and Aksu-Koç and Slobin (1985) find that children's productions are mostly error free. Some overgeneralization was observed in Ekmekçi. The examples in (6a) show that disharmonic roots were regularized, with subsequent overapplication of VH to suffixes. In (6b), the copula was misanalyzed as a suffix, which then incorrectly harmonized with the preceding root. Ekmekçi states that this construction is grammatical in rural dialects, but not in the dialect this child was exposed to.

(6) a. Regularization of disharmonic roots (Ekmekçi 1979):

Target	Child:		
taksi-ye	*taksı-ya*	'taxi-DAT'	(1;9)
abi-ye	*abı-ya*	'elder boy-DAT'	(1;3)

b. Misanalysis of copula as suffix (Ekmekçi 1979):

Target:			Child:
Biri	*büyük*	*imis*	*Biri büyük-müs*
one-POSSESSED	big	be-REPORTED.TENSE	

Altan (2009) probed acquisition of VH in 48 children aged 2-6. In production, 2-year-olds showed that they grasped VH by appropriately inflecting novel nouns for plural and by misanalyzing *saat*, which unexpectedly takes front vowel allomorphs, as regular (*saat-ler* →

[3] In earlier work, Leiwo et al. (2000) report a handful of examples where children treat neutral vowels as harmonic. In all examples provided, neutral vowels follow back vowels and either undergo harmony (e.g., *nalle* → *nalla* 'teddy bear') or trigger regressive harmony (e.g., *sateenvarjo* → *tätenvaljo* 'umbrella').

saat-lar ‘clock/watch-PL’). In judgment and repetition, overregularization was similarly observed for irregular roots, but not for suffixes that unexpectedly fail to alternate (*koşar-ken → koşar-ken, *koşar-kan* ‘while running’).

38.3.4 Height harmony in Brazilian Portuguese

Brazilian Portuguese (henceforth Portuguese) contains seven (oral) vowels in stressed position: /i, u, e, o, ɛ, ɔ, a/ (Câmara Jr. 1970). Height contrasts are neutralized in unstressed positions, including via regressive harmony: /e, o/ variably raise to high before /i, u/. Some factors conditioning the variation are that harmony is more likely to apply when the trigger is stressed and in the root, and when trigger and target are in adjacent syllables (see Bisol 1989; Schwindt 1997; Chapter 69 this volume for an overview of VH in Romance; and Chapter 6 this volume for an overview of height harmony).

Two studies examine acquisition of height harmony using longitudinally-collected production data: Bohn (2013) on one child, L, aged 1;4-2;3 and Ferreira-Gonçalves and Brum-de-Paula (2012) on five children aged 1;4-3;0. For forms providing an appropriate context for harmony, we might expect underapplication in children’s productions, given that height harmony applies variably in adult Portuguese. Bohn reports only two cases (out of 128) where L does not produce a harmonized output when the adult grammar would. Ferreira-Gonçalves and Brum-de-Paula report that children’s application of VH is 59.6% (285 suitable contexts), which increases to 74.2% (206 suitable contexts) when forms with affixes are excluded. Although application rates for adults are not provided, the authors mention that the proportions are similar.

To determine whether children’s harmonic outputs reflect productive VH, we first consider contexts where the conditions for height harmony are met, but where its application is disfavored for adults. Bohn (2013) observes that L produced a handful of harmonic outputs like this: cases where harmony applies over /a/ (7a), the trigger is an unstressed vowel (7b), or the source of harmony is the diminutive suffix (7c).

(7) Disfavored contexts for height harmony (Bohn 2013):

	Target:	Child:		
a.	[ʒelaʧína]	[ilat^{h}í]	‘jelly’	(2;00.28)
b.	[pɾesizár]	[pisizá]	‘to need’	(1;11.09)
	[pɾokuɾáɾ]	[pukulá]	‘come back’	(2;00.07)
c.	[beʒíɲu]	[biʒíɲu]	‘little kiss’	(2;01.04)

Ferreira-Gonçalves and Brum-de-Paula (2012) similarly report that the children in their study applied harmony long distance 16.5% of the time; harmony involved triggers in unstressed syllables 23.9% of the time; and the trigger was in a stressed suffix 5.1% of the time.

Returning to (7), we may be tempted to conclude that examples like these indicate that L has a productive rule of height harmony. This, though, may be premature. In all examples that Bohn provides except for one ([pɾokuɾáɾ]), harmony targets /e/. In later work, Bohn and Santos (2018) observe that pretonic /e/ is the last vowel acquired by L, not being target-like until 2;7. Thus, we cannot be certain that the forms in (7) reflect feature sharing (true VH) as opposed to substitution of /e/ by [i]. Ferreira-Gonçalves and Brum-de-Paula do not discuss acquisition of pretonic vowels, but they report that /e/ was disproportionately targeted in children’s harmony.

Turning to overapplication, Bohn (2013) observes 40 such tokens. Some errors involve directionality where the stressed vowel is targeted and lowered (8a); others involve assimilation in both place and height (8b). All of the errors provided yield outputs where trigger and target vowels are identical.[4]

(8) Overapplication of height harmony (Bohn 2013):

	Target:	Child:		
a.	[pɔ́ɾta]	[páta]	'door'	(1;07.05)
	[vówta]	[váta]	'come back'	(1;10.25)
b.	[segúɾa]	[sugúla]	'hold'	(2;00.28)
	[boníto]	[biníto]	'beautiful'	(1;11.16)/(2;01.25)

Total vowel agreement is also found in overapplication errors in Ferreira-Gonçalves and Brum-de-Paula (2018). Not all examples, though, have this profile. Some involve errors in directionality (9a); in others, lower mid vowels are erroneously targeted (9b). There is no mention of how widespread such errors were.

(9) Overapplication of height harmony (Ferreira-Gonçalves and Brum-de-Paula 2018):

	Target:	Child:		
a.	[pikolɛ́]	[pikulɛ]	'popsicle'	(child M, 2;4)
b.	[bɔlíɲa]	[bulíɲa]	'ball'	(child M, 2;8)

Finally, we address acquisition of the variability associated with height harmony. Ferreira-Gonçalves and Brum-de-Paula (2018) compare the productions of one child, E, and her caregiver. They observe that, of the lexical items produced as harmonic by E, 66.7% were present in the caregiver's productions. Of these 66.7%, 50% were always produced by the caregiver as harmonized, 20% were never harmonized, and 30% were variably harmonized. For E, however, only one form in the entire sample was produced variably. The authors imply that harmonic forms were preferred, suggesting that harmony is facilitative for children.

38.3.5 ATR harmony in Ghanaian languages

Niger-Congo languages commonly display ATR harmony, where vowels agree for tongue root position (see Chapter 51 this volume for an overview). In the two languages under focus, Asante Akan (Kwa) and Safaliba (Gur), both spoken in Ghana, [+ATR] /i, u, e, o/ alternate with [-ATR] /ɪ, ʊ, ɛ, ɔ/. Regarding low vowels, /a/ in Akan has a [+ATR] counterpart [æ̱] when it occurs before high [+ATR] vowels (Stewart 1983); /ɑ/ in Safaliba raises to [e] in suffixes and, for some speakers, has a [+ATR] counterpart [ə] in roots (Schaefer 2009).

We discuss two studies that touch on the acquisition of ATR harmony, Amoako (2020) on Akan and Bodua-Mango (2015) on Safaliba. Amoako (2020) examined segmental and prosodic development in 3- to 5-year-old Akan-speaking children. She finds regularization of disharmonic roots, which she suggests may indicate that ATR harmony is acquired relatively early; see (10).

[4] The one exception is /boníto/ → [bonú] 'beautiful' (1;11.16), but in this case, the output also undergoes truncation. [ú] could involve fusion of /í/ and /o/, thus, no true application of VH.

(10) Regularization in Akan (Amoako 2020):

Target:	Child:	
[àbɛ̀tsí]	[ábɛ̀tì]	‘shoulder’
[èdᵘìá]	[ɛ̀dᵘìą̀]	‘tree’
[àpɔ̃̀ntɕɪɛ̀nɪ̃̀]	[àpʰɔ̃̀ntɕlɛ̀nɪ̨̀]	‘frog’

However, Amoako observes that [-ATR] vowels are acquired earlier than their [+ATR] counterparts and that repairs typically involved substitution of [-ATR] for their [+ATR] correspondents. Notably, Casali (Chapter 15 this volume) provides arguments that [-ATR] is unmarked. Thus, we cannot be certain that regularization of the forms in (10) truly reflects harmony, rather than substitution.

Bodua-Mango (2015) studied phonological development in six 3-year-old children acquiring Safaliba. Her focus was acquisition of individual segments. She found, though, that all vowels were target-like by age three and “were harmonized according to the ATR groups [+ATR] and [-ATR]” (Bodua-Mango 2015: 68).

38.4 Spontaneous emergence of VH

If vowel agreement is articulatorily advantageous because it reduces the number of gestural changes required to produce a word (Archangeli and Pulleyblank 1994; Gafos 1999),[5] we would expect spontaneous creation of VH in children learning languages without this process. Consider, for example, front rounded vowels in French. We might expect a developmental stage where the front rounded gesture of these vowels is anticipated by a preceding vowel, yielding, for example, [ʃyflœʁ] for target [ʃuflœʁ] ‘cauliflower’, because VH might facilitate production of [œ]. Spontaneous VH along these lines has not, to our knowledge, been observed for children learning their first language (Drachman 1978; Goad 2001; Berg 2008).

What has been attested is spontaneous total vowel agreement (TVA). The data in (11) from Hebrew-speaking SR demonstrate TVA when it was most productive (1;05.15-1;05.21) (Cohen 2012; for systematic TVA in English, see Ross 1937; Stemberger 1993).

(11) Total vowel agreement in Hebrew: SR (Cohen 2012):

Target:	Child:	
[sevivón]	[vivím]	‘spinning top’
[bakbúk]	[bubúk]	‘bottle’
[ódpam]	[ʔápam]	‘again’

TVA is also found for learners of languages with VH (e.g., see (7)-(8) from Portuguese). Fee (1991) reports forms like *bugyi* → [biji] ‘panties’ and *uborka* → [obojkɔ] ‘cucumber’ for Hungarian-speaking TA at 1;6-1;10 (data from Gósy 1978). She hypothesizes that TVA is independent of true harmony in Hungarian, consistent with this process being present in learners of languages both with and without VH.

As we agree with Fee’s assessment (Goad 2001), we must question why children display TVA. The process does not necessarily arise from gaps in their vowel inventories. Hungarian-

[5] Consistent with this, harmony is not impacted by aphasia, even though the morphology that hosts it can be (see Chapter 39 this volume).

speaking TA, for instance, had acquired *u* by the time this vowel was targeted. Rather, at early stages, TVA arises when children have difficulty navigating the segmental complexity of longer strings but strive to be faithful to the syllable count.

Since TVA yields a copy of an adjacent vowel, it is easily detected. It is possible that emergent VH is also attested, but that it has gone unnoticed. That is, children's errors in vowel production involving a single feature may be covert (Munson et al. 2010). To illustrate, if for target [u] in [ʃuflœʁ], French-learning children produced a vowel closer to [ʉ] than to [y] (ʃʉflœʁ]), this could reflect spontaneous VH, yet the error could go undetected by adults whose transcriptions are filtered through their mature perceptual systems (i.e., they identify [ʉ] as [u], not as [y]).

It could also be that emergent VH is not commonly attested for learners of some languages, because the shape of the language conspires against it. Consider, for example, English, where approximately 70% of words that learners are exposed to are monosyllabic (Marslen-Wilson 1993). The point when emergent VH could be facilitative for English may occur before widespread production of multisyllabic words.

The only study we have found that reports emergent VH in children is Sorenson Duncan et al. (2009), on the L2 English productions of Child 1. Child 1's L1 was Hindi, which lacks VH. At the time of testing, Child 1 was 5;7 with 5 months exposure to English. He repaired initial clusters via epenthesis. The epenthetic vowel surfaced as [ɪ/ɛ] when the following vowel was front (12a) and as [ə] when the following vowel was back (12b):

(12) Front/back harmony in child L2 English: Child 1 (Sorenson Duncan et al. 2009):

a.	[pɪleɪ]	'play'	b.	[bəlɑg]	'block'
	[tɛɹeinz]	'trains'		[bəlok]	'broke'

Child 1's VH pattern was detectable to the naked ear (Sorenson Duncan p.c.). Why then should emergent VH not be detectable among L1 learners? We might conjecture that the difference is because, by age 5;7, Child 1's productions were no longer constrained by articulatory immaturity, only by his previously-acquired L1. Hindi, though, permits CəLI strings (L=liquid, I=front vowel) (e.g., [pəliːtaː] 'match', [təriː] 'curry'), which makes this explanation suspect. We suggest instead that harmonic epenthetic vowels may have been in the English input to which Child 1 was exposed. If Child 1 was in an ESL classroom for immigrant children, he was likely exposed to "teacher talk", which aims to provide comprehensible input (Gass and Madden 1985). The characteristic prosody it involves may facilitate detection of marked structures, yet hinder establishment of target-like representations. Epenthetic vowels could, for example, be present in teacher talk to ensure that learners from L1s without complex onsets and/or without liquid contrasts detect both segments in the cluster. If the epenthesized schwa is lengthened somewhat, it will be produced more peripherally, yielding an [ɛ/ɪ]-like vowel before front vowels.

38.5 Second language acquisition

We turn finally to acquisition of VH by adults whose L1 lacks harmony. We have uncovered three studies, which show that harmony is early acquired and respects the same constraints that hold of native speaker systems. This is consistent with the literature on artificial grammar

learning, which finds that participants in experiments can learn VH after limited exposure (see Chapter 39 this volume).

Pitkänen et al. (2010; cited in McLaughlin et al. 2010) probe the acquisition of Finnish harmony by English-speaking learners using event-related potentials (ERPs). Participants performed a lexical decision task containing common Finnish words, orthographically well-formed non-words, and orthographically ill-formed non-words that violate VH. For native Finnish speakers, violations of VH elicited a P600, a positive-going component which peaks at approximately 600 milliseconds after stimulus presentation and signals a grammatical anomaly. After eight months of study, English-speaking learners displayed the same neurocognitive response. The authors attribute their success to the regularity of VH in Finnish, combined with the language's transparent orthography.

Altan (2012) also observes early success in the acquisition of VH in Turkish. Classroom instructed learners from English, French, Italian, or Spanish backgrounds made few errors, regardless of proficiency level. Some learners overgeneralized harmony to non-alternating suffixes, consistent with acquisition of a productive rule.

Özçelik and Sprouse (2017) examined learners' understanding of non-canonical VH in Turkish. Recall that in canonical VH, non-high suffixes agree in backness with the preceding root-final vowel. Laterals also participate in canonical harmony: a light allophone appears in front harmonic words (e.g., [iʎ-e] 'city-DAT') and a dark allophone in back harmonic words (e.g., [kɯɬ-ɑ] 'hair-DAT'). Non-canonical VH is observed in loanwords containing laterals: [ʎ] appears after back vowels and the suffix vowel agrees with the lateral, not with the preceding vowel (e.g., [roʎ-e] 'role-DAT'). Özçelik and Sprouse propose that laterals in loanwords are prespecified for [-back]. Vowel-to-vowel spread of [-back] is thus blocked by the No Crossing Constraint (NCC). They show that classroom-instructed learners understand that the NCC regulates harmony: learners prefer outputs like [roʎ-e] over [roʎ-ɑ] despite underdetermination in the input (suitable loanwords are largely absent from classroom input) and potentially misleading instruction (only canonical VH is taught).

38.6 Conclusion

The studies reviewed reveal early acquisition of VH by child and adult learners, with spontaneous and experimentally elicited data being largely error free. The few errors observed typically involve overapplication, not underapplication, indicating that VH is productive for learners. Surprisingly, no underapplication was found in Portuguese, even though harmonic forms are variably present in the input. Underapplication was observed with round harmony in Hungarian. This may be because roots are not harmonic for rounding. Since children use harmony as a cue for segmentation at early stages of word production, harmonic roots may be an important element for facilitating acquisition of VH; children then bootstrap from fixed vowel agreement patterns in roots to segment affixes that alternate in vowel quality. This is consistent with the finding that, in Hungarian and Turkish, acquisition of morphology and application of VH in affixes seem to happen simultaneously.

Because VH is acquired early, a significant challenge involved teasing apart gaps in the acquisition of vowel contrasts from the (non)application of VH. We saw that gaps in children's inventories may overestimate the productivity of VH. For example, we may interpret raising of /e/ preceding /i/ in Portuguese as feature agreement when it may instead reflect substitution of /e/ by earlier acquired [i]. Similarly, regularization of disharmonic roots in Akan may appear to

show early understanding of ATR harmony, or it may instead reflect the finding that [-ATR] vowels commonly substitute for their [+ATR] counterparts. We also saw that gaps in children's inventories may underestimate the productivity of VH. Underapplication of back harmony in front harmonic words in Finnish may only be apparent and may instead reflect substitution due to difficulty with the late-acquired [y, ø, æ].

One finding is that VH is beneficial for both segmentation and production. English-exposed infants use vowel agreement for word segmentation, even though harmony is absent from the target grammar, suggesting that infants are predisposed to detect harmonic forms in continuous speech. It remains to be determined whether this bias is specific to language or reflects more general organizing principles related, for example, to acoustic symmetry (cf. Mintz et al. 2018). VH is also facilitative in production: it minimizes the number of gestural changes required to produce a word. Because of this, one surprising finding is the absence of spontaneous VH in learners of languages without harmony. We have suggested that emergent VH may be attested, but undetected in early productions. Exploring this further requires acoustic analysis of early multisyllabic words, perhaps coupled with ultrasound, as there are many articulatory gestures that can produce the same acoustic outcome (e.g., Kelso et al. 1984).

Finally, our chapter did not include height harmony in Bantu languages, as our examination of the literature did not uncover any studies. Bantu forms an important link between what we know about the acquisition of Hungarian, Finnish, and Turkish on one hand and Portuguese on the other; it shares the agglutinative profile with the former languages and the feature implicated in harmony with the latter.

Acknowledgements

Many thanks to Gunnar Hannson, Yvan Rose, Péter Siptár, an anonymous reviewer, and the editors for comments; as well as Liisa Duncan, Natália Guzzo, Alexandra O'Neil, Öner Özçelik, and Marci Soskuthy for help with some of the languages. This research was supported by SSHRC and FRQSC.

References

Aksu-Koç, Ayhan A. & Dan I. Slobin. 1985. The acquisition of Turkish. In Dan I. Slobin (ed.), *Cross-linguistic study of language acquisition*, vol. 1: 839-878. Hillsdale, NJ: Erlbaum.

Altan, Aslı. 2009. Türkçe'de ünlü uyumunun edinimi [Acquisition of vowel harmony in Turkish]. In S. Nalan Büyükkantarcıoğlu & Emine Yarar (eds.), *35. yıl Yazıları [35th anniversary articles]*, 9-26. Istanbul: Multilingual Yabancı Dil Yayınları.

Altan, Aslı. 2012. Türkçe öğrenen yabancıların ünlü uyumu konusunda yaptıkları hatalar ve genellemeler [Mistakes and generalizations made by foreigners learning Turkish vowel harmony]. In V. Doğan Günay, Özden Fidan, Betül Çetin & Funda Yıldız (eds.), *III. Uluslararası Türkçenin Eğitimi-Öğretimi Kurultayı Bildirileri [III. Proceedings of the International Turkish Language Education-Teaching Congress]*, 35-47. İzmir: Dokuz Eylül Üniversitesi Yayınları.

Amoako, Wendy Kwakye. 2020. Assessing phonological development among Akan-speaking children. MA thesis: University of British Columbia.

Archangeli, Diana & Doug Pulleyblank. 1994. *Grounded phonology.* Cambridge, MA: MIT Press.

Berg, Thomas. 2008. On the complementary nature of consonant and vowel harmony in child and adult language. *Word* 59(3): 241-256.

Bisol, Leda. 1989. Vowel harmony: A variable rule in Brazilian Portuguese. *Language Variation and Change* 1: 185-198.

Bodua-Mango, Ruth Karehina. 2015. The phonology of a three year old Safaliba-speaking child. MPhil thesis: University of Ghana.

Bohn, Graziela Pigatto. 2013. A case study in the acquisition of vowel harmony in Brazilian Portuguese. Poster presented at the 21st Manchester Phonology Meeting, Manchester, UK, May.

Bohn, Graziela Pigatto & Raquel Santana Santos. 2018. A aquição das vogais pretônicas em português brasiliero [The acquisition of pretonic vowels in Brazilian Portuguese]. *Alfa [Alpha]* 62(1): 195-226.

Câmara Jr., Joaquim Mattoso. 1970. *Estrutura da língua portuguesa [Structure of the Portuguese language].* Petrópolis: Editora Vozes.

Cohen, Evan Gary. 2012. Two paths – one goal – vowel harmony in the acquisition of Hebrew. Paper presented at the 28th annual conference of the Israel Association for Theoretical Linguistics (IATL), Tel Aviv University, October.

Dasinger, Lisa. 1997. Issues in the acquisition of Estonian, Finnish, and Hungarian: A crosslinguistic comparison. In Dan I. Slobin (ed.), *The crosslinguistic study of language acquisition*, vol. 4: 1-86. Mahwah, NJ: Lawrence Erlbaum.

Drachman, Gabarell. 1978. Child language and language change: A conjecture and some refutations. In Jacek Fisiak (ed.), *Recent developments in historical phonology*, 123-144. The Hague: Mouton.

Ekmekçi, Özden. 1979. *Acquisition of Turkish: A longitudinal study on the early language development of a Turkish child.* PhD dissertation: University of Texas at Austin.

Fee, E. Jane. 1991. *Underspecification, parameters, and the acquisition of vowels.* PhD dissertation: University of British Columbia.

Ferreira-Gonçalves, Giovana & Mirian Rose Brum-de-Paula. 2012. Aquisição da linguagem e harmonia vocálica [Language acquisition and vowel harmony]. *Letras de Hoje [Current Language Studies]* 47(3): 333-341.

Gábor, Bálint and Ágnes Lukács. 2012. Early morphological productivity in Hungarian: Evidence from sentence repetition and elicited production. *Journal of Child Language* 39: 411-442.

Gafos, Adamantios. 1999. *The articulatory basis of locality in phonology*. New York: Garland.

Gass, Susan M. & Carolyn G. Madden. 1985. (eds.) *Input in second language acquisition*. Rowley, MA: Newbury House.

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

Gonzalez-Gomez, Nayeli, Silvana Schmandt, Judit Fazekas, Thierry Nazzi & Judit Gervain. 2019. Infants' sensitivity to nonadjacent vowel dependencies: The case of vowel harmony in Hungarian. *Journal of Experimental Child Psychology* 178: 170-183.

Gósy, Mária. 1978. Szavak és toldalékok hangalaki jellemzői a gyermeknyelvben [Phonetic properties of stems and suffixes in child language]. *Magyar Fonetikai Füzetek [Hungarian Phonetics Booklets]* 2: 90-99.

Gósy, Mária. 1989a. Vowel harmony in children's speech. *Mitteilungen der Societas Uralo-Altaica [Communications of the Uralic-Altaic Society]* 8: 49-54. Hamburg: Herausgegeben von W. Veenker.

Gósy, Mária. 1989b. Vowel harmony: Interrelations of speech production, speech perception, and the phonological rules. *Acta Linguistica Hungarica* 39: 93-118.

Hohenberger, Annette, Aslı Altan, Utku Kaya, Özgün Köksal Tuncer & Enes Avcu. 2016. Sensitivity of Turkish infants to vowel harmony: Preference shift from familiarity to novelty. In Belma Haznedar & F. Nihan Ketrez (eds.), *The acquisition of Turkish in childhood*, 29-56. Amsterdam: John Benjamins.

Iivonen, Antti. 1993. Paradigmaattisia ja syntagmaattisia näkökohtia lapsen foneettisfonologisesta kehityksestä [Paradigmatic and syntagmatic aspects of a child's phonetic-phonological development]. In Antti Iivonen, Anneli Lieko & Pirjo Korpilahti (eds.), *Lapsen normaali ja poikkeava kielen kehitys [A child's normal and abnormal language development]*, 34-77. Suomalaisen Kirjallisuuden Seuran Toimituksia 583. Helsinki: Suomalaisen Kirjallisuuden Seura.

Itkonen, Terho. 1977. Huomioita lapsen äänteistön kehityksestä [Comments on the development of the child's phonetic system]. *Virittäjä [Tuner]* 81(3): 279-308.

Kabak, Barış. 2011. Turkish vowel harmony. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 2831-2954. Oxford: Wiley-Blackwell.

Kampen, Anja van, Güliz Parmaksız, Ruben van de Vijver & Barbara Höhle. 2008. Metrical and statistical cues for word segmentation: The use of vowel harmony and word stress as cues to word boundaries by 6- and 9-month-old Turkish learners. In Anna Gavarró & M. João Freitas (eds.), *Language acquisition and development: Proceedings of GALA 2007*, 313-324. Newcastle upon Tyne: Cambridge Scholars.

Kelso, J. Scott, Betty Tuller, E. Vatikiotis-Bateson & Carol A. Fowler. 1984. Functionally specific articulatory cooperation following jaw perturbations during speech: Evidence for coordinative structures. *Journal of Experimental Psychology: Human Perception and Performance* 10(6): 79-106.

Ketrez, F. Nihan. 2014. Harmonic cues in speech segmentation: A cross-linguistic corpus study on child-directed speech. *Journal of Child Language* 41: 439-461.

Ladányi, Enikő, Ágnes M. Kovács & Judit Gervain. 2020. How 15-month-old infants process morphologically complex forms in an agglutinative language? *Infancy* 25(2): 190-204.

Leiwo, Matti, Pirjo Kulju & Katsura Aoyama. 2006. The acquisition of Finnish vowel harmony. In Mickael Suominen, Antti Arppe, Anu Airola & Orvokki Heinämäki (eds.), *A man of measure: Festschrift in the honour of Fred Karlsson on his 60th birthday*. Special issue of *SKY Journal of Linguistics* 19: 149-161. Turku: The Linguistic Association of Finland.

Leiwo, Matti, Pirjo Turunen, Jouko Koivisto & Päivi Korhonen. 2000. Kielenomaksumisen vokaaliharmonioista ja suomen vokaaliharmoniasta [Language proficiency in vowel harmonies and Finnish vowel harmony]. *Virittäjä [Tuner]* 104(3): 442-449.

MacWhinney, Brian. 1975. Rules, rote, and analogy in morphological formations by Hungarian children. *Journal of Child Language* 2: 65-77.

Marslen-Wilson, William D. 1993. Issues of process and representation. In Gerry T. M. Altmann & Richard Shillcock (eds.), *Cognitive models of speech processing: Psycholinguistic and computational perspectives*, 187-210. Cambridge, MA: MIT Press.

McLaughlin, Judith, Darren Tanner, Ilona Pitkänen, Cheryl Frenck-Mestre, Kayo Inoue, Geoffrey Valentine & Lee Osterhout. 2010. Brain potentials reveal discrete stages of L2 grammatical learning. *Language Learning* 60(Suppl.2): 123-150.

Mintz, Toben *H.,* Rachel L. Walker, Ashlee Welday & Celeste Kidd. 2018. Infants' sensitivity to vowel harmony and its role in segmenting speech. *Cognition* 171: 95-107.

Munson, Ben, Jan Edwards, Sarah K. Schellinger, Mary E. Beckman & 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.

Nahkola, Kari. 1998. Paaministeri paatti tanaan [The Minister of Railways took a nap]. *Virittäjä [Tuner]* 102(2): 224-232.

Özçelik, Öner & Rex Sprouse. 2017. Emergent knowledge of a universal phonological principle in the L2 acquisition of vowel harmony in Turkish: A 'four'-fold poverty of the stimulus in L2 acquisition. *Second Language Research* 33: 179-206.

Pääkkönen, Matti. 1990. *Grafeemit ja konteksti: Tilastotietoja suomen yleiskielen kirjaimistosta [Graphemes and context: Statistical data on the graphology of standard Finnish].* Helsinki: Suomalaisen Kirjallisuuden Seura.

Pitkänen, Ilona, Darren Tanner, Judith McLaughlin & Lee Osterhout. 2010. Use it or lose it: Second language attrition in the brain looks like acquisition in reverse. Unpublished manuscript, University of Washington.

Pléh, Csaba, Zsuzsanna Vinkler and László Kálmán. 1997. Early morphology of spatial expressions in Hungarian children: A CHILDES study. *Acta Linguistica Hungarica* 44(1-2): 249-260.

Ringen, Catherine O. & Orvokki Heinämäki. 1999. Variation in Finnish vowel harmony: An OT account. *Natural Language & Linguistic Theory* 17: 303-337.

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

Schaefer, Paul Alan. 2009. *Narrative storyline marking in Safaliba: Determining the meaning and discourse function of a typologically-suspect pronoun set.* PhD dissertation: University of Texas at Arlington.

Schwindt, Luiz Carlos. 1997. A harmonia vocálica em dialetos do sul do país: uma análise variacionista [Vowel harmony in dialects in the south of the country: A variationist analysis]. *Graphos: Revista da Pós-Graduação em Letras [Graphos: Post-Graduate Journal in Language Studies]* 1(2): 55-65.

Sorenson Duncan, Tamara, Anne-Michelle Tessier & Johanne Paradis. 2009. Preferences for vowel epenthesis and child ESL cluster reduction. Poster presented at Child Phonology Conference, Austin, Texas.

Stemberger, Joseph P. 1993. Glottal transparency. *Phonology* 10: 107-138.

Stewart, John M. 1983. Akan vowel harmony: The word structure conditions and the floating vowels. *Studies in African Linguistics* 14(2): 111-139.

Toivainen, Jorma. 1997. Kysymysliitteen vokaalisointuun mukautumattomuus Oulun aluekielessä [Incompatibility of the question particle with the vowel in the regional language of Oulu]. *Virittäjä [Tuner]* 101(3): 438-440.

Törkenczy, Miklós. 2011. Hungarian vowel harmony. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 2963-2990. Oxford: Wiley-Blackwell.