COALESCENCE IN CHILD GREEK: A REPAIR STRATEGY AS A PRECURSOR TO CLUSTER ACQUISITION[*]

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1. Introduction

Numerous studies have focused on the acquisition of rising sonority clusters in child speech. Previous studies report that children tend to simplify clusters. The prevalent strategy is that of reduction to the least sonorous consonant ((1a), e.g. Gnanadesikan 2004, Gerlach 2010 for English, Grijzenhout and Joppen-Hellwig 1998, Schaefer and Fox-Boyer 2017 for German, Kappa 2002, Tzakosta 2007, Ploumidi 2022 for Greek, Fikkert 1994 for Dutch, Cucinelli 2020 for Italian, Łukaszewicz 2007 for Polish, Freitas 2003 for European Portuguese, Bloch 2011 for Hebrew, Buja 2015 for Romanian, Morales-Front 2006, Vivar and Lleó 2020 for varieties of Spanish). Reduction to the most sonorous consonant ((1b), van der Pas 2004 for Dutch, Bloch 2011 for Hebrew, Ploumidi in press a for Greek) and coalescence ((1c), Gnanadesikan 2004 for English, Ramalho and Freitas 2018 for European Portuguese, Kappa 2004, Coutsougera 2007, Tzakosta 2009 for Greek, Łukaszewicz 2007 for Polish, Ben-David 2001, Bloch 2011 for Hebrew) apply less frequently.

(1)		Target	Output	Gloss	Child	Age	
	a.	prɛzɛnt	pɛzɛnt	gift	Ola	4	(Polish: Łukaszewicz 2007)
	b.	trɛɪn	lɛɪn	train	Saar	1;11	(Dutch: van der Pas 2004)
	c.	$k_1l_2$ips	$t_{1,2}$its	clip	RM	2;05	(Hebrew: Bloch 2011)

The great majority of studies explore the application of reduction to the least sonorous cluster member in isolation, and only seldom the application of the rest repair strategies is thoroughly discussed (e.g. see Kappa 2004 for the parallel application of reduction and coalescence in obstruent-obstruent clusters in child Greek). Also, only seldom the parallel realization of faithful and unfaithful forms is considered (e.g. Freitas 2003 for European Portuguese, Tzakosta and Kappa 2008, Ploumidi 2022 for Greek).

Interesting empirically and/or theoretically as the previous studies are, this case study explores the acquisition of rising sonority clusters in Greek while focusing on the variability of the emergent patterns and repair strategies throughout acquisition. By

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considering the child's system as a whole, it is claimed that variation abides by phonological principles and that the child's system represents rising sonority clusters as head-dependent sequences. The data reveal that heads have primacy over dependents since, before clusters being produced, the child realizes the head and/or a coalesced segment that preserves some features of the head. The core claim is that grammars acquire early the hierarchical organization of structures and build their outputs on the basis of heads. Finally, the emergence of coalescence a phase before clusters being realized indicates that this strategy serves as a precursor to cluster acquisition.

This paper is organized as follows: Section 2 provides information for the participant of this study and describes the methodology. Section 3 describes the emergent patterns. Section 4 offers an Optimality Theoretic account (Prince and Smolensky 1993) using floating constraints (Reynolds 1994). Section 5 concludes.

2. Methodology

The data are drawn from a longitudinal study of a monolingual typically developing Greek-acquiring child (age range: 2;01.24-3;04.11). The child was recorded twice a week by a linguist, the author of this study, who visited the child in 20-30-minute-long sessions. We focus on data obtained from spontaneous speech and a picture-naming task. The stimuli were designed to elicit all segments, prosodic structures and stress patterns in Greek. A recorder, Marantz PMD661MKII, was used during the sessions. The speech samples were transcribed into the International Phonetic Alphabet. The participation of the child in this study took place upon the explicit informed and signed parental consent, according to the regulations of the Ethics Committee of the University of Crete.

3. The acquisition of rising sonority clusters

This subsection sheds light on the acquisition of rising sonority clusters in Greek. To begin with, despite that previous studies have pointed out that children's productions display a great degree of variability (e.g. Taelman and Gillis 2002, Tzakosta 2004 for Greek), several studies suggest that phonological acquisition proceeds in terms of a sequence of stages and that each stage displays uniformity in production (e.g. Ingram 1989, Demuth 1995, Demuth and Fee 1995, Adam 2002, Greenlee 1974, Rose 2000). For example, Rose (2000) claims that the acquisition of clusters in French proceeds in terms of three stages. In the first stage, cluster reduction occurs. In the second stage, clusters are faithfully produced in stressed syllables and they are reduced in unstressed syllables. In the third stage, clusters emerge in all positions.

Here, we argue that cluster acquisition proceeds in a phase-like progression rather than in a stage-like progression (see also Tzakosta 2004 for phases in child speech). To begin with, the claim about the phase-like acquisition progression stems from the close investigation of the child's sufficiently rich longitudinal data corpus, which provides strong evidence regarding the preferences, requirements and characteristics of the grammar and well documents the occurrence and the extent of variation in the child's speech throughout acquisition. Recall that the child was followed for more than a year

and was recorded twice a week in 20-45-minute-long sessions. Also, recall that the major goal of the methodological design was to elicit all phonological structures of Greek by means of a picture-naming task and of recording the child's spontaneous speech.

In this study, a phase in cluster acquisition is defined on the basis of the qualitative characteristics of the developing grammar and variation. It is argued that the preferences, requirements and characteristics of the child's grammar are strongly linked with the occurrence and the degree of variation in the produced forms. Special emphasis is placed on the variability of the realization patterns and on the cluster simplification strategies. On the one hand, it is argued that the emergent patterns constitute a reflection of the preferences, requirements and characteristics of the grammar; on the other, it is claimed that the strategies are the means by which the preferences and requirements of the grammar are satisfied. For example, a grammar may display a clear preference for simple onsets at some point in development. This preference may be met by means of only a strategy, e.g. reduction, or by means of several strategies, e.g. reduction and coalescence.

Variation does not emerge in the child's speech randomly; rather, variation, regardless of whether it is limited or extensive, abide by the qualitative characteristics of the developing grammar. Hence, variation serves as a cue for the identification of phonological characteristics, preferences and requirements of developing grammars at certain points in acquisition. Also, variation serves as a cue for the investigation of the gradual changes occurring in a developing grammar throughout the acquisition. A glance at the data reveals that the speech of the child in the present study displays considerable variation throughout the course of cluster acquisition. Nevertheless, the degree of variation changes as the developing grammar gradually approximates the target system. Specifically, variation tends to be limited at the earliest and the latest periods of development, namely few patterns emerge and provide evidence for the state of the developing grammar. For instance, C_1C_2 forms may emerge as C_1 or C_2 at the earliest periods. Also, variation tends to be extensive at the intermediate periods of development, for example C_1C_2 forms may emerge as C_1C_2, C_1, C_2 and $C_{1,2}$ in parallel.

It is argued that a phase in cluster acquisition cannot be defined on the basis of strict chronological boundaries and/or the child's age. The literature shows that grammars differ in the developmental pace, e.g. a grammar may converge to the target system faster or slower than another (see e.g. Ragheb and Davis 2014, Ploumidi 2022 for child Greek). As a result, a child may reach a phase earlier than another child. In other words, the emergence of a phase is linked to the developmental pace of the child's grammar. Secondly, the emergence and the suppression of a phase cannot be predicted based on the characteristics of the child's speech, for instance a phase may last longer than another.

It is proposed that a grammar gradually reaches the final phase. The convergence to the target system involves the progression from the realization of unmarked forms to more marked and target-like forms (see also the studies of Smith 1973, Gnanadesikan 2004, Levelt et al. 1999/2000 Levelt and van de Vijver 2004, Rose 2000, Adam 2002, see also Tzakosta and Kappa 2008 for Greek). It is suggested that the progression requires the transition from one phase to another. The transition involves the emergence of (a) pattern(s) not available before, which is/are attributed to the application of (a) repair mechanism(s) not used before. Accordingly, the transition to another phase may involve

the suppression of a pattern and the avoidance of a strategy. Moreover, the transition across phases may involve increase or decrease in the frequency of occurrence of a pattern and, thus, increase or decrease in the frequency of use of a strategy. Put simply, the transition from one phase to another involves inter-phase variation, i.e. variable and overlapping patterns and strategies are observed.

In this study, it is not assumed that there is a sequence of phases which are considered as obligatory for all children. Children are not expected to pass through the same phases not only quantitatively but also qualitatively. Inter-child variation with respect to phases in cluster acquisition is expected and is explained in terms of the (non-)availability of patterns and strategies. For instance, a child may reach a phase in which vowel epenthesis is well-attested (e.g. Freitas 2003 for European Portuguese) whereas another child may acquire the target language without exhibiting vowel epenthesis at all.

3.1 Data

The data show that cluster acquisition involves the gradual progression from the realization of unmarked forms to more marked and target-like forms. We explore the application of repair strategies, with a special focus on the emergence and the role of coalescence in the child's speech. It will be proposed that the child's data reflect four distinct phases of cluster acquisition. A phase may be characterized by limited or extensive variation. Limited variation is observed during PHASE 1 and PHASE 4. Extensive variation is observed in the intermediate phases, i.e. during PHASE 2 and PHASE 3.

3.1.1 Phase 1: Cluster reduction

In PHASE 1, the child's grammar shows preference for simple ones. The emergence of rising sonority clusters is prohibited, i.e. target branching onsets surface as simple onsets. Cluster reduction reflects the only means to prevent the realization of clusters. Reduction results in the production of the leftmost cluster member, i.e. the obstruent, and the deletion of the rightmost one, i.e. the sonorant ((2), see also references in section 1).

(2)		Target	Output	Gloss	Age
	a.	oˈbre.la	ˈbe.ʌa	umbrella	2;02.04
	b.	kre.ˈva.ti	ce.ˈka.ci	bed	2;02.04
	c.	ˈble	ˈbe	blue	2;02.04
	d.	ˈpra.si.no	ˈpa	green	2;02.07
	e.	xri.ˈstu.ɟe.na	çi.ˈsti.nis	Christmas	2;02.07

Interestingly, there are few data that show that the child selects the sonorant instead of the obstruent (3). In all these data, it seems that the selection of the sonorant reflects a marginal preference of the child's grammar for the target adjacent coronal segments, i.e. the consonant and the vowel, to be adjacent in the output.

(3)		Target	Output	Gloss	Age
	a.	ɣli.ˈko	li.ˈko	sweet	2;02.07
	b.	ˈti.ɣris	ˈti.lis	tiger	2;02.07
	c.	so.ko.ˈfre.ta	ko.ˈle.ta	waffer	2;03.06
	d.	ˈble	ˈle	blue	2;03.09
	e.	ˈvri.si	ˈli.si	tap	2;03.16

To summarize, in PHASE 1 the preference for simple onsets is met by means of reduction. In this phase, variation is limited with respect to the available patterns, namely the prevalent pattern is that of the preservation of the leftmost cluster member and the marginal is that of the preservation of the rightmost cluster member.

3.1.2 Phase 2: Cluster reduction and coalescence

In PHASE 2, the child's grammar continues exhibiting preference for simple onsets. This preference is reflected on the child's patterns, namely C_1C_2 forms emerge as C_1 or $C_{1,2}$, and is satisfied by the parallel use of reduction and coalescence. Thus, the transition from PHASE 1 to PHASE 2 involves the emergence of an additional pattern attributed to the emergence of an additional strategy, that of coalescence. Put simply, intra-phase variation with respect to the emergent patterns and strategies is observed.

Firstly, regarding the application of reduction, rising sonority clusters are reduced to the leftmost consonant, i.e. the child selects the obstruent rather than the sonorant (4). Note that instances of reduction to the rightmost consonant do not appear in this phase.

(4)		Target	Output	Gloss	Age
	a.	ˈble	ˈbe	blue	2;03.23
	b.	ka.ˈre.kla	ka.ˈʎe.ka	chair	2;03.26
	c.	ˈxro.ma	ˈxo.ma	color	2;04.09
	d.	ˈma.vro	ˈma.vo	black	2;05.14
	e.	ˈfra.u.la	ˈfa.u.a	strawberry	2;06.15

Regarding coalescence, the members of the target cluster are merged into a consonant, i.e. the output segment shares features of the two original consonants (/C_1C_2/ → [$C_{1,2}$]). The selection of the features that comprise the coalesced segment reveals a solid pattern. Specifically, the voicing and manner features are taken from the leftmost cluster member and the place feature is taken from the rightmost cluster member (5).

(5)		Target	Output	Gloss	Age
	a.	vi.ˈvli.o	ma.ˈði.o	book	2;04.06
	b.	ˈble	ˈde	blue	2;05.03
	c.	ɣli.ˈka.ci	ˈða.ci	sweet	2;05.16
	d.	ˈci.klo	ˈci.to	circle	2;07.16

It is argued that the emergence of coalescence in the child's forms provides evidence that segments are hierarchically organized in the child's phonological lexicon (see also Kappa (2004) for coalescence in obstruent-obstruent clusters in child Greek). Cluster members are organized under their root node (see Figure 1a). Coalescence results in a segment that combines features of the two input nodes (Figure 1b).

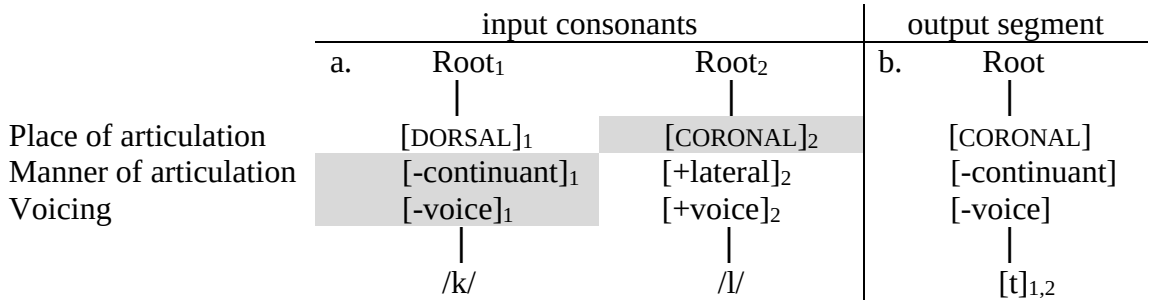

Figure 1. Coalescence.

The emergence of coalescence indicates that the grammar strives to achieve the realization of more faithful to the target forms. The coalesced segment, since it shares features of the two original consonants, is 'close' enough to the target branching onset. It is suggested that the child's grammar reconciles the prohibition on clusters with the emergence of coalescence, which results in the production of a segment that displays partial faithfulness to the target consonants. Thus, coalescence serves as a precursor to cluster acquisition. This strategy emerges a stage before clusters being faithfully realized, as it will be shown in subsection 3.3. Consequently, coalescence can be viewed as a means that facilitates the gradual transition from simple to branching onsets.

3.1.3 Phase 3: Cluster reduction, coalescence and faithful realizations

The emergence of faithful cluster realizations signals the transition from PHASE 2 to PHASE 3. The latter phase displays extensive intra-phase variation since simplified and faithful productions co-occur (6). In this phase, cluster simplification takes the shape of reduction and coalescence and results in simple onsets (see also PHASE 2 for the parallel use of these strategies). Interestingly, few instances of reduction to the rightmost cluster member appear in this phase (6d, f) and are explained as regressions to a previous phase, i.e. PHASE 1 (see the data in (3), see e.g. Tzakosta 2004 for regressions).

(6)

	Target	Output	Gloss	Age
a.	ˈma.vro	ˈfa.vo	black	2;08.08
b.	ˈkle.i	ˈkle	cry	2;08.08
c.	vi.ˈvli.o	me.ˈvli.o	book	2;09.06
d.	ˈti.ɣris	ˈti.lis	tiger	2;09.06
e.	ˈxro.ma	ˈxo.ma	color	2;09.19
f.	vi.ˈvli.o	e.ˈli.o	book	2;10.03
g.	ˈpra.si.no	ˈta.si.no	green	2;10.03

h.	a.e.ro.ˈpla.no	a.o.ˈpla.no	airplane	3;00.09

Interestingly, intra-word variation also appears. Specifically, the same word may exhibit variable patterns, due to the application of reduction, coalescence and faithful realization. Instances of intra-word variation occur even during the same session (7).

(7)		Target	Output	Gloss	Age
	a.	ˈble	ˈbe ~ ˈde ~ ˈble	blue	2;08.08
	b.	mi.ˈkro	ma.ˈko ~ mi.ˈto ~ mi.ˈkro	small	3;02.09

To sum up, the preference of the child's grammar for the realization of simplified and faithfully produced forms results in intra-phase variation.

3.1.4 Phase 4: Faithful realizations

In PHASE 4, the child's grammar exhibits a clear preference for faithful cluster realizations. In this phase, faithful realizations occur in an across-the-board fashion (8).

(8)		Target	Output	Gloss	Age
	a.	mi.ˈkres	mi.ˈkle	small	3;03.14
	b.	ka.ˈre.kla	ka.ˈre.kla	chair	3;03.14
	c.	ˈfra.u.les	ˈfla.u.les	strawberries	3;03.14
	d.	a.e.ro.ˈpla.no	a.lo.ˈpla.no	airplane	3;03.28

A few instances of coalescence and reduction appear in the child's speech (9). Nevertheless, they are explained as instances of regression to previous phases.

(9)		Target	Output	Gloss	Age
	a.	kre.ˈva.ti	te.ˈva.ti	bed	3;02.29
	b.	ˈblu.za	ˈbu.ða	blouse	3;04,11
	c.	ˈti.ɣris	ˈti.jis	tiger	3;04.11

To summarize, in this phase, the child is considered to have reached the final state of the target system. In the next section, we turn to the analysis.

4. Theoretical framework and analysis

4.1 Preliminaries

This study assumes that segments are hierarchically organized into prosodic constituents (Kaye et al. 1990) and that constituency and heads are fundamental concepts (e.g. Cairns and Feinstein 1982, Anderson and Ewen 1987, Halle and Vergnaud 1987, Dresher and van der Hulst 1993, 1998, Kaye et al. 1990, also see Kappa 1995 for Greek). It is assumed that rising sonority clusters are branching onsets, in which the leftmost

consonant is the head and the rightmost consonant is the dependent, as can be seen in Figure 2 (e.g. Goad and Rose 2004, Rose 2000, Ploumidi in press b).

Figure 2. The representation of rising sonority clusters.

Several studies argue that developing grammars display considerable knowledge of structure. For instance, previous studies show that grammars tend to force the retention of heads in the outputs (Slobin 1973, Dresher and van der Hulst 1993, 1998, Spencer 1986, Halle and Vergnaud 1987, Jongstra 2003, Goad and Rose 2004, Rose 2000, Revithiadou and Tzakosta 2004a, b, Tzakosta and van de Weijer 2006, Ploumidi in press b). Also, it is suggested that clusters are acquired on the basis of headedness and constituency (see also Goad and Rose 2004, Rose 2000, Jongstra 2003, Ploumidi in press b for Greek).

This study, presupposing that the child's input is identical to the adult's output (e.g. Gnanadesikan 2004, Smith 1973, Adam 2002, Chambles 2006, Tzakosta 2004), gives further evidence that grammars have access to the hierarchical organization of clusters and proposes that rising sonority clusters are represented as head-dependent sequences. The child of this study shows a clear preference for the retention of the head of the cluster in the outputs. Before head-dependent sequences become stable in the child's speech (PHASE 4), reduction (PHASES 1-3) and coalescence (PHASES 2-3) prevent the production of clusters. On the one hand, reduction results in the realization of the leftmost consonant which is the head of the cluster (e.g. /pl/ → [p]); on the other, coalescence results in a segment that combines features of the original consonants (e.g. /pl/ → [t]). Recall that the child takes the features of manner and voicing from the head. It is argued that the preservation of features from the leftmost consonant reflects a pattern that is consistent with the retention of the head of the cluster (see also Goad and Rose 2004: 150). It is suggested that the preference for the realization of the head shows that the child knows that the head as an obligatory constituent of the input (branching) onset should be in correspondence between the input and the output form. The next subsection, based on the above claims, offers an Optimality Theoretic account using floating constraints.

4.2 Theoretical framework and analysis

This study provides an account of intra-child, intra-phase and inter-phase variation during cluster acquisition using the tools of Optimality Theory (Prince and Smolensky 1993). Fully and non-fully developed systems are analyzed by the same set of universal and violable constraints. Markedness constraints militate against the realization of marked forms, e,g. clusters, and faithfulness constraints require input-output identity, e.g. they permit the emergence of clusters. In Optimality Theory, it is assumed that languages and speakers have available a single grammar which consists of strictly ranked constraints. The relative ranking of constraints has consequences for the selection of the optimal output, i.e. the candidate that best satisfies the hierarchy is selected as optimal. Thus,

intra-language and intra-speaker variation is not permitted. The theoretical explanation of the differences between systems requires the consideration of the differences in constraint rankings. Hence, inter-language and inter-speaker variation is permitted.

Having said that, let us focus on phonological acquisition. Recall that several studies propose that acquisition proceeds in terms of a sequence of stages, each one reflecting uniformity in the produced forms (see section 3). The occurrence of uniformity in production at each stage is explained in terms of a hierarchy of strictly ranked constraints. The transition from one stage to another is modeled in terms of constraint rerankings, which involve constraint demotion (e.g. Tesar and Smolensky 2000, Adam 2002), promotion (Gnanadesikan 2004, Ben-David 2001) or both demotion and promotion (e.g. Boersma 1997, Tzakosta 2004), and result in hierarchies of ranked constraints. The main issue with the hierarchies of strict domination is that they do not allow the occurrence of intra-stage variation and the emergence of regressions to previous stages of acquisition. The occurrence of inter-stage variation is modeled in terms of constraint reranking, which also results in strictly ranked constraints.

However, the data used in this study show that variation characterizes the child's forms throughout the course of cluster acquisition. Variation emerges in the shape of intra-phase and inter-phase variation. Also, variation in the child's speech takes the shape of regression to earlier phases. To account for the occurrence of variable and overlapping patterns and strategies, we assume that the child has available a single grammar, in which one or more constraints are allowed to float within a certain range among other strictly ranked constraints (e.g. Reynolds 1994 for floating constraints). Thus, the child's grammar does not correspond to a hierarchy of strict domination, e.g. as shown in Figure 3, F_1 is the floating constraint, landing in one of four positions marked with a '•'. The constraints M_1 and M_2 outrank the constraint F_1.

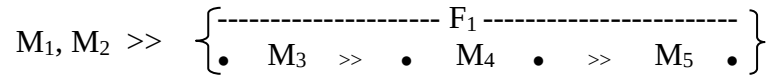

Figure 3. A floating constraint within a grammar.

We argue that intra-phase variation is attributed to the operation of floating constraints within the child's grammar. Specifically, one or more constraints are allowed to float within a fixed floating range in the hierarchy among other categorically ranked constraints at a particular phase and/or phases of cluster acquisition. Inter-phase variation is a consequence of constraint reranking(s) and/or of changes in the available range of the floating constraint. In this study, the following set of constraints is adopted (10).

(10) Relevant markedness and faithfulness constraints

a. Markedness constraints		b. Faithfulness constraints	
*COMPLEX:	No clusters	MAX_{HEAD}	The head of the cluster is preserved
		MAX:	No segment deletion
		UNIFORMITY:	No coalescence

It is proposed that the constraint hierarchy in (11) corresponds to PHASE 1.

(11) Constraint hierarchy for PHASE 1

*COMPLEX >> MAX_{HEAD} >> UNIFORMITY >> MAX

This hierarchy models the preference for the realization of simple onsets. It shows that clusters are reduced to the leftmost consonant, i.e. the head. The constraint *COMPLEX is undominated and blocks the realization of clusters. This constraint does not show preference for the retention of the leftmost or the rightmost consonant. The retention of the leftmost consonant implies that a faithfulness constraint specifically referring to the head of the branching onset is highly ranked throughout PHASE 1. The constraint MAX_{HEAD} protects the head of the cluster[1]. In this phase, the presence of segment deletion and the absence of coalescence is explained by the domination of UNIFORMITY over MAX.

PHASE 2 corresponds to the hierarchy in (12). This hierarchy models the preference for simple onsets and the variability of the emergent patterns (recall that branching onsets emerge as C_1 due to reduction or $C_{1,2}$ due to coalescence). The transition from PHASE 1 to PHASE 2 is explained without presupposing that constraint reranking has taken place. On the contrary, the emergence of PHASE 2 is explained by using a floating constraint, which allows the emergence of intra-phase variation. Intra-phase variation occurs since the constraints which are relevant for reduction and coalescence, i.e. MAX and UNIFORMITY, are not strictly ranked with respect to each other. It is argued that MAX and not UNIFORMITY is the floating constraint in PHASE 2. In this study, in line with the theoretical assumption that constraint promotion can only refers to faithfulness constraints (e.g. Gnanadesikan 2004, Ben-David 2001), it is proposed that a floating faithfulness constraint is allowed to float towards the top of the hierarchy.

(12) Constraint hierarchy for PHASE 2

*COMPLEX >> MAX_{HEAD} >> { ●--------- MAX ---------● / UNIFORMITY }

In PHASE 2, *COMPLEX banns the emergence of consonant sequences in onsets. The production of the leftmost consonant (e.g. /pl/ → [p]) and the emergence of a segment that combines features from the target cluster members (e.g. /pl/ → [t]) constitute patterns that are consistent with the preference for the retention of the head. The highly ranked constraint MAX_{HEAD} ensures that the head, or at least some features of the head surface in

[1] In subsection 3.1.1. it was shown that few instances of reduction to the rightmost consonant were observed in the child's utterances (see the examples in (3)). It was proposed that these instances were driven by a marginal grammatical preference for the retention of the input sequence of coronal segments in the output. In other words, these realizations are not considered as 'genuine' instances of divergence from the head-based reduction pattern. It seems that these realizations emerge due to a floating faithfulness constraint specifically referring to input-output adjacency relations, e.g. CONTIGUITY (see e.g. van der Pas 2004 for child Dutch, Ploumidi 2022 in press a for child Greek). However, solid claims cannot be made based on few data.

the child's forms. Reduction is driven by the domination of UNIFORMITY over MAX. Coalescence is driven by the domination of MAX over UNIFORMITY. Since coalescence does not result in segment deletion, the realization of a segment that combines features of the two original consonants satisfies MAX and violates UNIFORMITY.

The emergence of coalescence in the child's speech indicates that the developing grammar continuously recruits additional ways to converge to the target system. The grammar reconciles the prohibition on clusters with the application of a strategy that results in the realization of more faithful to the target forms. Put differently, the coalesced segment combines features of both cluster members and is 'close' enough to the target consonants. The fact that coalescence emerges a stage before clusters surface in the child's speech indicates that this strategy serves as a precursor to cluster acquisition.

The transition from PHASE 2 to PHASE 3 corresponds to the hierarchy in (13). The proposed hierarchy reveals that the child exhibits considerable variation in the produced forms, given that target-like and non-target-like cluster realizations co-occur.

(13) Constraint hierarchy for PHASE 3

$$\text{MAX}_{\text{HEAD}} \gg \left\{ \begin{array}{c} \text{MAX} \\ \text{UNIFORMITY} \\ *\text{COMPLEX} \end{array} \right\}$$

The transition from PHASE 2 to PHASE 3 is signaled by the demotion of *COMPLEX below MAX_{HEAD}. It is suggested that the floating range of the floating constraint MAX has been extended. Put simply, the floating range of MAX is wider in PHASE 3 than in PHASE 2. Also, it is proposed that, in this phase, not only MAX but also *COMPLEX are floating constraints. Recall that a faithfulness floating constraint is allowed to float towards the highest stratum of the hierarchy and note that a markedness floating constraint is allowed to float towards the lowest stratum of the hierarchy. The relative ranking of these constraints with respect to each other and with respect to UNIFORMITY results in faithful cluster realization, head-based reduction or coalescence. Specifically, if MAX and UNIFORMITY outrank *COMPLEX, faithful realizations occur. Accordingly, the domination of *COMPLEX over UNIFORMITY and the domination of UNIFORMITY over MAX results in the head-based reduction pattern. Finally, if *COMPLEX is ranked higher than MAX and UNIFORMITY is ranked lower than MAX, coalescence occurs. Consequently, the parallel production of simplified and target-like forms requires continuous movements of floating constraints across the hierarchy.

PHASE 4 corresponds to the final state of the target system (14).

(14) Constraint hierarchy for PHASE 4

MAX_{HEAD}, UNIFORMITY , MAX >> *COMPLEX

The hierarchy in (14) shows that all faithfulness constraints dominate the markedness constraint *COMPLEX. The faithful cluster productions provide clear evidence that UNIFORMITY and MAX have been promoted to the highest stratum of the hierarchy and that *COMPLEX has been demoted to the lowest stratum. In this phase, the constraints

seem to be categorically ranked. However, the instances of regression to previous phases (see the examples in (9)) indicate that constraints may be able to 'reactivate' their floating range. Nevertheless, since this issue is out of the scope of this study, we do not provide a thorough account of regressions. This issue is left for future research.

5. Conclusions

This longitudinal data-based case study explored the acquisition of rising sonority clusters in Greek. The study proposes that cluster acquisition proceeds in terms of distinct phases, each one accompanied by specific phonological characteristics, requirements, preferences and variation. The child's patterns at a given phase constitute a reflection of the qualitative characteristics of the child's grammar. Accordingly, the application of one or more strategy of simplification at a given phase results in the satisfaction of the characteristics of the child's grammar. Thus, it is suggested that the definition of a phase in cluster acquisition requires the consideration of the qualitative characteristics of the grammar, the patterns and the strategies used. Consequently, strict chronological boundaries or the child's age are not considered as useful in the definition of a phase given that grammars may differ with respect to each other in the developmental pace.

The data used in the present study provide evidence for four phases of cluster acquisition. In PHASE 1, the preference for simple onsets is satisfied by the application of cluster reduction, which results in the retention of the leftmost consonant and the deletion of the rightmost consonant. Rarely are clusters reduced to the rightmost consonant. In PHASE 2, the preference for simple onsets is satisfied by the parallel use of reduction and coalescence. The former strategy results in the retention of the leftmost consonant and the latter strategy results in a segment that combines features of the two target consonants. In PHASE 3, the grammar shows preference for simple and branching onsets. The preference for simple onsets is satisfied by means of reduction and coalescence and the preference for branching onsets is satisfied by the emergence of both cluster members. In PHASE 4, the child's grammar exhibits preference for the realization of branching onsets and, thus, clusters are faithfully produced. Regressions to earlier phases were, also, well-attested.

A core claim of the present study is that the emergence of coalescence indicates that the developing grammar continuously seeks additional patterns and strategies to gradually approximate the adult grammar. The child's grammar reconciles the prohibition against the realization of clusters with the emergence of a pattern that results in more faithful to the target forms. Recall that the coalesced segment combines the manner and the voicing features of the leftmost cluster member and the place feature of the rightmost cluster member. It is argued that coalescence emerges in a phase which shows 'genuine' preference for simple onsets. Also, since the very first cluster realizations occur in PHASE 3, it is claimed that coalescence is considered as a precursor to cluster acquisition.

The data demonstrated that variation characterizes the child's speech. Nevertheless, regardless of the type and the degree of variation at a particular phase or across phases, the grammar abides by phonological principles. The child's grammar has access to the hierarchical organization of clusters, namely rising sonority clusters consist of the head, i.e. the leftmost consonant, and the dependent, i.e. the rightmost consonant, and gives

primacy to heads rather than to dependents at least in the earliest phases of acquisition. The analysis showed that, across all phases of cluster acquisition and regardless of the degree of intra-phase variation, the grammar exhibits a clear preference for the retention of the head or of some features of the head of the cluster in the produced forms.

The analysis showed that the child's consistency in realizing the head of the cluster is driven by the constraint MAX_{HEAD}, which is highly ranked throughout acquisition. The relevant ranking of the rest markedness and faithfulness constraints determines the realization pattern, i.e. reduction, coalescence, faithful production. The analysis, also, demonstrated that variation results from the operation of floating constraints and from rerankings. The occurrence of intra-phase variation is explained in terms of the operation of one (e.g. PHASE 2) or more floating constraints (e.g. PHASE 3) which float within a certain range in the hierarchy among other (ranked) constraints. The range of a floating constraint may change in the course of acquisition, e.g. the range of MAX was wider in PHASE 3 than in PHASE 2. Regarding the occurrence of inter-phase variation, it results from rerankings and/or from the operation of floating constraints. Moreover, this study showed that regressions to previous phases are well-attessted. It seems that a floating constraint is able to 'reactivate' its range at a subsequent phase. Nevertheless, since the issue of regressions deserves special focus, it is left for future research.

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