A Grammar Inclusion Hypothesis of child language variation

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This paper examines variation in language development based on production data from three Greek-speaking children. Variation suggests that children employ more than one grammar during the acquisition process. This naturally raises the question of how 'unwanted' grammars gradually give way to the one that relates to the adult/target grammar. To account for variation, we implement *partial ordering* (Anttila 1997a, 1997b) to Tzakosta's (2004) *Multiple Parallel Grammars* model of language development. More specifically, we propose that, in the intermediate stage of acquisition, constraint permutation of the initial *Markedness » Faithfulness* ranking leads to grammar explosion. We view the resulting grammars as partial orders that contain sets of totally ranked grammars (subgrammars). The pivotal claim is that only those subgrammars that are typologically closer to the target one will eventually survive. This is stated as the *Grammar Inclusion Hypothesis*. The theoretical gain of the proposed model is that it provides a principled basis to define developmental paths and also to distinguish between *smart* and *non-smart* paths. The latter are partial orders that do not contain the target grammar as a total order and hence are doomed to extinction. The former, on the other hand, are partial orders that contain at least one total order that relates to the target grammar and, crucially, connect the running state of acquisition with the end state of language development. Our hypothesis finds empirical support by both inter-child and intra-child language acquisition data.

Keywords: language acquisition, partial ordering, multiple parallel grammars, smart and non-smart paths

1. Introduction

Research on language acquisition was originally restricted to the description of child data, the discussion of the emergent production patterns and the formulation

Journal of Greek Linguistics 7 (2006), 49–70.
ISSN 1566–5844 / E-ISSN 1569–9856

of linguistic generalizations in the form of phonological rules (Smith 1973, Stampe 1973). Only in the early 1990s, there was a shift of attention to the process of acquisition per se and, specifically, to how exactly children reach the final stage of the ambient language given the impoverished status of their initial grammar (Demuth & Fee 1995, Fikkert 1994, Vihman 1996). In particular, most research questions aimed at providing an explanation regarding the order of acquisition and, especially, the particular paths young language learners take during the acquisition process.

Studies on language development are primarily couched within the *Principles and Parameters* (PP) framework (Chomsky 1981) and *Optimality Theory* (OT, Prince & Smolensky 1993, McCarthy & Prince 1993a, 1993b). According to Chomsky (1981), *Universal Grammar* (UG) consists of a finite set of parameters, not yet set on specific values. Depending on the system being acquired, each child has to appropriately adjust these parameters. More precisely, s/he has to determine the parameter setting of the target language and tune the parameters accordingly. The question posed by Dresher (1999a, 1999b) is how the learner knows which parts of the input are relevant to each parameter, given that the latter are by definition abstract structures. Dresher's (1999a, 1999b) and Dresher & Kaye's (1990) answer to this question is that the learner needs to associate each parameter with specific *triggers* or *cues*. That is, the learner must always be in search of positive evidence (see also: Lasnik & Uriagereka 2002, Legate & Yang 2002, Pulleyblank & Turkel 1998, Sampson 2002). For instance, in a language where CVC syllables are permitted, the learner needs to be exposed to such structures in order to set the syllable coda parameter (i.e. syllables must have codas) to the value 'on'. If exposure to such structures does not take place, it is likely that the learner will acquire the wrong grammar, i.e. one that lacks CVC syllables. Such a grammar potentially corresponds to an actual grammar of some language but, crucially, not to the grammar of the specific language being acquired. In other words, parameters must be intrinsically ordered as the learner progressively moves from less complex structures to more complex ones. Fikkert (1994) argued that this is exactly the case in the acquisition of syllable structure and stress in Dutch. On the basis of production data from twelve children, she shows that, at the beginning, children set some parameters so that they produce simple words in terms of the number and the complexity of syllables. As the acquisition process proceeds, however, they gradually re-set the parameters towards producing more complex syllable structures. Language development, therefore, is considered to be a gradual parameter (re-)setting process. It should be emphasized that in the PP framework the child acquires *one* grammar, which, at each stage of language acquisition, becomes more elaborate — via parameter re-setting — and thus typologically closer to the adult grammar.

Tesar and Smolensky (1993, 1998a, 1998b, 2000) advance a similar idea which is, however, cast within the constraint-based framework of OT. More specifically, they propose a learning algorithm that is based on *constraint demotion*.[1] To explain, a grammar is considered to be a set of universal and violable constraints that are ranked with respect to each other. Languages differ in how they prioritize and appropriately order these constraints. Consequently, acquiring a language is tantamount to figuring out the particular ranking of the target language.[2] Tesar and Smolensky (2000) provide solid argumentation that children start from the simplest possible grammar, namely one where all markedness constraints outrank faithfulness constraints. In the course of acquisition, they refine and improve this grammar by gradually demoting markedness constraints, as dictated by the data they are exposed to. The process of demotion is completed only when they reach a certain stage where the constraint ordering of their grammar is identical to the one of the adult grammar.

The above proposals as well as other models of language development (Smith 1973, Drachman 1973a, 1973b) assume a linear model of acquisition in the sense that the child's language system progresses step-by-step and in a homogeneous fashion without regressions to earlier developmental states and without showing any variation in production. In fact, such proposals do not leave much leeway to variation outside transitional stages, i.e. turning points for parameter re-setting. However, Revithiadou and Tzakosta (2004a, 2004b) and Tzakosta (2004), based on longitudinal production data from Greek, observed extensive inter- and intra-child variation that is, crucially, not restricted to transitional developmental stages only, but rather spreads throughout the language acquisition process (cf. Drachman 1975 for relevant discussion). On the basis of these findings, they propose that each child makes use of a set of *multiple parallel grammars* (MPG), which are responsible for the rising of variable output productions for a given input string during the same developmental phase.

According to the MPG, elaborately developed in Tzakosta 2004, learning is completed in three developmental phases: the initial phase, the intermediate phase and the final phase. The shape of the grammar in polar phases is quite stable. More specifically, in the initial state, markedness constraints outrank faithfulness constraints and, consequently, unmarked structures prevail in child speech. In the final stage, on the other hand, faithfulness constraints occupy a rank in the constraint hierarchy yielding outputs that are typologically closer to the target forms. Multiple grammars emerge during the intermediate phase as a result of constraint permutation of the initial *Markedness* » *Faithfulness* grammar. Such grammars are activated in parallel, but become weaker and are eventually abandoned as acquisition proceeds and children reach the target grammar. Significantly, the grammars, which are typologically more distant to the target grammar, are abandoned first, whereas grammars with a stronger typological connection to the target grammar are more resistant to elimination.

Extending this non-linear model of acquisition, Kateri, Revithiadou and Varlokosta (2005) show that the grammars each child employs at a certain developmental phase are interconnected in the sense that one may entail the other. Because only a few and not all of these grammars are reinforced by positive evidence, the child maintains a web of grammars that progressively will lead her/him to the adult grammar. The main goal of this paper is to explore the nature of such developmental paths[3] and, moreover, to explain in a principled way how the child is driven from a set of multiple grammars to the target one. For this purpose, we propose a restricted version of the MPG that relies heavily on the *Grammar Inclusion Hypothesis* ('grammars that include other grammars') first proposed by Kateri, Revithiadou and Varlokosta (2005) and further elaborated here. More specifically, we exploit the inherent property of Optimality-Theoretic grammars, namely *partial ordering*, proposed by Anttila (1997a, 1997b, 2002 et seq.), and put forward the claim that the set of possible grammars employed by a child is the sum of total and/or partial orders of the relevant markedness and faithfulness constraints. Furthermore, we claim that the developmental path a child chooses to follow is simply a subset of these partial orders. Interestingly, this approach allows us to draw a distinction between *smart* and *non-smart* developmental paths. The former leads smoothly to the target grammar because they consist of grammars that include the target grammar. The latter, on the other hand, are paths that do not contain a grammar exhibiting typological links with the target one and, due to lack of positive reinforcement, they are inevitably driven to extinction.

The remainder of this paper is organized as follows: In Section 2, we describe the research methodology followed in data collection and encoding. In Section 3, we introduce Anttila's (1997a, 1997b, 2002 et seq.) theory of variation. We discuss the implementation of this model in acquisition in Section 4 and continue in Section 5 with exploring its ramifications for phonological development. In particular, we draw a distinction between smart and non-smart developmental paths, as these are revealed by inter- and intra-child variation data from Greek. In Section 6, we conclude this paper.

2. Methodology

The present survey is based on Tzakosta's (2004) Greek L1 acquisition database. In this paper, however, we confine our discussion and results to a group of three children, two girls and a boy — Ioanna (Io), Marilia (Ma) and *Baby-M* (BM). The children recruited for this study were raised in monolingual environments and range in age from 1;9.22 to 3;05.23 years. The observations and generalizations drawn in this paper have broader empirical coverage; however, limitations on space prevent us from including datasets from other children in our discussion.

Our survey relies both on controlled and spontaneous natural speech data. The former were elicited with the help of a semi-structured technique of picture naming, whereas the latter were collected through free interaction of the interviewer with the child. The data were recorded by a trained linguist who visited the children on a weekly basis in 25–45 minute-long sessions over a period of two years, depending on each child's recording period. An analogical recorder and a microphone were used for the recordings. The recorded speech samples were transcribed into IPA by two trained phoneticians and one of the authors, all native speakers of Greek. In the few cases that the transcribers could not reach full agreement on what was produced by the child, the data were omitted. In general, the transcription process was consistent with the criteria of reliability posited in Bennett-Kastor 1988. The data were organized in an Access Database (Leiden University/ULCL).

3. Anttila's Partial Ordering Theory of variation

As mentioned in the introductory part of this paper, young learners of Greek display variation in their production. In this section, we outline the basics of an OT-based theory of variation that will serve as the theoretical basis for the definition of developmental paths.

Anttila (1997a, 1997b, 2002 et seq.) exploits an intrinsic property of OT, namely *partial ordering* (PO), to account for variation in Finnish phonology and morphology. According to this theory, variation is the result of partial orders. More specifically, in a total order every constraint is fully ranked with respect to every other constraint; in a partial order, on the other hand, the ranking remains incomplete. The abstract example in (1), drawn from Anttila 1997b:24–26, helps us understand the distinction between total and partial orders.

Given the constraints A, B and C in (1a), the grammar A » B » C is a total order because every constraint occupies a position in a separate stratum. This grammar yields a single output for a given input form. Thus, it predicts no variation. By removing one of the rankings, for example B » C, we obtain the partial order A » B, C, which corresponds to the rankings given in (1b). Each of the unordered constraints is ranked below constraint A but, crucially, they are not ranked with respect to one another. The grammar in (1c) is thus a partially ordered grammar.

(1) *a partially ordered grammar*
 a. Constraints: A, B, C
 b. Rankings: A » B, A » C
 c. Grammar: A » B, C

Crucially, in (1c), the absence of ranking between B and C entails that, given one input form, the grammar generates two possible outputs and, consequently, predicts language variation. More specifically, it corresponds to the two totally ordered tableaux given in (2). T1 and T2 illustrate that the crucial ranking between constraints B and C provide different winning forms. More specifically, ranking B » C favors *cand2*, whereas ranking C » B appoints *cand1* as the winner.

(2) *totally ordered tableaux*

T1	A	B	C
a. *cand1*		*!	
☞ b. *cand2*			*

T2	A	C	B
☞ a. *cand1*			*
b. *cand2*		*!	

Let us examine how this model of variation accounts for variable pairs such as 'θ*elun* ~ 'θ*elune* "want-PRES.3PL" in Greek. The former output ends in a closed syllable suggesting that MAX-SEG and DEP-SEG are both ranked above the NOCODA constraint. The latter output, however, implies that a different ranking is also at play, one in which DEP-SEG is outranked by NOCODA. In the PO model, the observed pattern of variation is a reflection of the partial ordered grammar in (3a), which corresponds to two total orders in (3b–c):

(3) a. MAX-SEG » DEP-SEG, NOCODA
b. MAX-SEG » DEP-SEG » NOCODA
c. MAX-SEG » NOCODA » DEP-SEG

This partial order corresponds to two tableaux that appoint different candidates as winners: 'θ*elun* is the winner in T3 and 'θ*elune* is the winner in T4. Since the described partial grammar permits two rankings, it also permits two outputs and hence variation.

T3 /θelun/	MAX-SEG	DEP-SEG	NOCODA
☞ a. 'θelun			*
b. 'θelune		*!	

T4 /θelun/	MAX-SEG	NOCODA	DEP-SEG
a. 'θelun		*!	
☞ b. 'θelune			*

Subsequently, if a grammar is defined as a total order, in the case of variation we deal with multiple grammars (Anttila 1997b:29).[4] A partial grammar, in other words, consists of a set of total orders, e.g. Max-seg » Dep-seg » NoCoda and Max-seg » NoCoda » Dep-seg, each of which constitutes what is called here a *subgrammar* (cf. Waterson 1971, for relevant discussion on subgrammars in language acquisition). The addition of more rankings in a partially ordered grammar means that we generate proper subsets of this grammar. Anttila (2002:21) explains that "the resulting partial orders will each be increasingly specific and contain fewer and fewer total orders. The most specific partial order is one where every constraint is ranked with respect to every other constraint, which equals a single total order." Thus, by adding rankings between the constraints, we proceed to more specific grammars and hence to a complete disappearance of variation. In the next section, we move on to present an implementation of partial ordering to the MPG model of L1 acquisition.

4. Variation in L1 acquisition

4.1 Variable stress outputs

The diversity in the manifestation of stress in Greek will serve as a representative example of variation from L1 acquisition. It is well-established that stress can appear on any of the last three syllables of a word (Malikouti-Drachman & Drachman 1989, Drachman & Malikouti-Drachman 1999, Revithiadou 1999). Our focus here is on the so-called *metrically ambiguous* words, that is, trisyllabic or longer words that carry stress on a non-peripheral syllable. As shown in (4), for an input of the stress pattern W_1SW_2,[5] Marilia produces three different outputs: (1) W_1S (4a–b), (2) SW_2 (4c–d) and (3) the faithful W_1SW_2 (4e–f).

(4)	a.	/xti.ˈpa.o/	→	[di.ˈba]	"hit-pres.1sg"	(2;07.06)
	b.	/pu.ˈla.ca/	→	[pu.ˈla]	"bird-nom.pl"	(2;09.26)
	c.	/ma.ˈri.na/	→	[ˈli.na]	"Marina-nom.sg"	(2;07.06)
	d.	/ma.ˈri.na/	→	[ma.ˈli.na]	"Marina-nom.sg"	(2;07.06)
	e.	/ða.ˈska.la/	→	[ja.ˈka.la]	"teacher-nom.sg"	(2;07.22)
	f.	/ci.ˈri.a/	→	[ti.ˈri.a]	"lady-nom.sg"	(2;09.26)

Such observed patterns of variation led Tzakosta (2004) to the conclusion that children employ more than one grammar in parallel. These grammars are developed during the grammar explosion stage as the result of constraint permutation — via demotion — of the initial M » F ranking. To explain, in the transition from an initial stage to a more advanced one, different markedness constraints are demoted in parallel, thus generating a large pool of possible grammars. To give an abstract example, the permutation of just eleven constraints generates 39,916,800 grammars! This is an amazingly large number of grammars for a child to develop. More importantly, it is impossible for all of them to be empirically motivated. However, Tzakosta (2004) has shown that variation is not unconstrained, since in reality children make use of a remarkably confined set of grammars. The interested reader is referred to Tzakosta (2004) for the principles and constraints that hamper grammar explosion. In this paper, our focus is on exploring exactly how the child proceeds from a confined set of grammars to the one that corresponds to the target language. We illustrate this with inter-and intra-child data from the acquisition of stress.

4.2 Inter-child variation

The young learners of our study group make use of several grammars for stress. Here, we provide robust versions of the grammars activated by these children, although in reality they may employ more refined versions of these grammars. The following five grammars are observed: the Faithfulness Grammar, the Truncation Grammar, the Reverse Rhythm grammar, the Weak Syllable grammar and the Constructed Syllable grammar.

The Faithfulness[6] Grammar (Faith-G) corresponds to the target grammar that yields outputs faithful to the adult language. As illustrated by the examples in (5), the metrical and prosodic shapes of the adult forms are faithfully produced by the children.

(5)	a.	/ˈvle.po/	→	[ˈva.po]	"see-PRES.1SG"	(Me 1;9.22)
	b.	/ˈtsa.da/	→	[ˈɢa.da]	"bag-NOM.SG"	(Io 2;9.22)
	c.	/pe.ˈðja/	→	[pe.ˈða]	"child-NOM.PL"	(Io 2;9.22)
	d.	/ˈe.fi.je/	→	[ˈe.fi.je]	"go-PAST.3SG"	(Io 3;3.8)
	e.	/ðu.ˈʎes/	→	[ɣu.ˈjeç]	"job-NOM.PL"	(Ma 2;8.15)
	f.	/ˈfar.ma.ko/	→	[ˈfa.ma.ko]	"medicine-NOM.SG"	(Ma 2;07.28)

The Truncation Grammar (Trunc-G), on the other hand, is responsible for the manifestation of truncated, i.e. syncopated, outputs in child speech. The data in (6) demonstrate that, regardless of the stress pattern of the input word, child productions are maximally two syllables long. Interestingly, the output template is either trochaic or iambic depending on whether the stressed syllable groups with the preceding or with the following syllable of the input word.

(6)	a.	/ˈθa.la.sa/	→	[ˈθa.la]	"sea-NOM.SG"	(Me 2;10.23)
	b.	/lu.ˈlu.ðja/	→	[ˈlu.ja]	"flower-NOM.PL"	(Me 2;4.27)
	c.	/ˈbe.ni/	→	[ˈbe]	"enter-PRES.3SG"	(Me 2;2.5)
	d.	/ˈpra.si.no/	→	[ˈpa.ti]	"green-NOM.SG"	(Io 2;6)
	e.	/ˈxti.pi.sa/	→	[ˈti.pi]	"hit-PAST.1SG"	(Io 2;9.26)

	f.	/ka.'fe/	→	['fe]	"brown-NOM.SG"	(Io.: 3;2.13)
	g.	/'ka.to/	→	['ka]	"down"	(Ma 2;11.12)
	h.	/ma.'ri.na/	→	['li.na]	"Marina-NOM.SG"	(Ma 2;07.06)
	i.	/ka.'re.kla/	→	[ga.'re]	"chair-NOM.SG"	(Ma 3;03.14)
	j.	/for.ti.'ɣo/	→	[bu.'ko]	"lorry-NOM.SG"	(Ma 2;10.01)

Furthermore, the Reverse Rhythm Grammar (REVRHYTHM-G) strives towards unfaithful realizations of the metrical pattern of input forms. For example, disyllabic words of trochaic shape are realized as iambs (7a–c) and vice versa (7d–e). It is worth pointing out that in the speech of many children in Tzakosta's (2004) database words of the pattern W_1SW_2 are produced with reverse rhythm, namely SW_1W_2, e.g. /vu.'va.li/ → ['bu.ba.li] "buffalo-NOM.SG" (BM 1;7.14). This grammar is more likely to arise in the acquisition of Greek stress where trochaic forms coexist with iambic as well as metrically ambiguous ones than in more transparently trochaic systems such as English or Dutch.

(7)	a.	/'va.la.me/	→	[və.'la]	"put-PAST.1PL"	(BM 1;9.22)
	b.	/'sta.vro/	→	[va.'vo]	"Stavros-VOC.SG"	(BM 1;10.18)
	c.	/'ka.ʎa/	→	[ka.'la]	"Kalia-NOM.SG"	(Ma 2;08.15)
	d.	/kal.'tson/	→	['ka.to]	"tights-NOM.SG"	(Io 2;04.29)
	e.	/ra.fa.'il/	→	['a.li]	"Raphael-NOM.SG"	(Io 2;8.11)

The Weak Syllable Grammar (WEAKSYLL-G) and the Constructed Syllable Grammar (CONSTRSYLL-G) are more marginal than the others. The former strives towards preserving weak (unstressed) syllables, preferably those that lie at one of the word edges. Some representative examples are given in (8). As is obvious from examples such as (8d), for instance, markedness restrictions often apply to simplify the segmental composition of the produced form. Stress is predominantly trochaic in these productions.

(8)	a.	/'e.fi.ɣa/	→	['fi.ɣa]	"leave-PAST.1SG"	(Me 2;3.19)
	b.	/ka.tsa.'ri.ðes/	→	['ka.ja]	"cockroach-NOM.PL"	(Me 2;09.25)
	c.	/'e.ka.na/	→	['ka.na]	"do-PAST.1SG"	(Ma 3;1.2)
	d.	/pe.ta.'lu.ða/	→	['pa.ðəl]	"butterfly-NOM.SG"	(Io 3;03.15)
	e.	/'e.na/	→	['na]	"one"	(Io 2;11.10)

The CONSTRSYLL-G averts the emergence of complex structures and yields mainly monosyllabic outputs that consist of the most unmarked (i.e. underspecified) segments of the input form. To explain, such syllables are composed of the less marked segments in the word, but not necessarily the ones that occupy the head position. Some illustrative examples are provided in (9), where coronals, for example, are favored to velars, and stops are chosen over fricatives. In (9a), for instance, the syllable with the coronal voiceless stop /toː/ surfaces in preference to the stressed one or even, the other syllables in the word that contain a fricative or a sonorant. The stressed syllable is chosen to be pronounced only when it has a relatively unmarked segmental make-up compared to the remaining syllables of the word, as shown by examples such as (9b).

(9)	a.	/ti.ˈle.fo.no/	→	[ˈtoː]	"phone-NOM.SG"	(Io 2;08.11)
	b.	/ˈvle.po/	→	[ˈlep]	"see-PRES.1SG"	(Io 3;3.28)
	c.	/ku.ˈku.la/	→	[ˈla]	"hood-NOM.SG"	(Ma 2;8.7)
	d.	/ɟor.ti.ˈno/	→	[ˈti]	"festive-NOM.SG"	(Ma 2;11.12)

Table 1 presents all attested grammars in the speech of the three children under examination and their respective outputs for SW, WS, SW_1W_2, W_1SW_2 and W_1W_2S[7] input forms.

Table 1. Set of multiple grammars

	/SW/	/WS/	/SW_1W_2/	/W_1(W)SW_2/	/W_1W_2(W)S/
FAITH-G[8]	SW	WS	SW_1W_2	W_1SW_2	W_1W_2S
TRUNC-G	S	S	SW	SW	WS
REV RHYTHM-G	WS	SW	WS, WWS, WSW	SWW, WWS	SWW, WSW
WEAKSYLL-G	W	W	W_1,W_2, W_1W_2	W_1,W_2, W_1W_2	W_1,W_2, W_1W_2
CONSTR SYLL-G[9]	CV	CV	CV	CV	CV

The grammars listed in Table 1 can be either total or partial orders. Table 2 lays out the rankings for each grammar. However, before taking a closer look at these rankings, it is necessary to introduce the relevant constraints first. As mentioned above, in this paper we present robust grammars, therefore archetypical versions of the relevant constraints are employed. The constraint 'Fσ́' strives for faithfulness of the stressed syllable, whereas 'Fsize' is a faithfulness constraint that requires preservation of the original size of the target word. On the contrary, 'T' stands for constraints that favor truncation and, in general, produce reduced versions of the input word. T is satisfied when sizable chunks of the input word are trimmed off. 'W' is an abbreviated form of a markedness constraint that compels preservation of some weak syllable. 'M' yields the preservation of unmarked segments in the produced forms. 'Unmarkedness' primarily involves the selection of consonants lacking positive featural values over other consonants. M is active not only in the CONSTRSYLL-G, but also in all grammars that favor the production of unmarked forms. Crucially, however, in the CONSTRSYLL-G, it is highly ranked. Finally, the constraint '¬R' is a rhythmic constraint that reverses the rhythm-type of an input word in the output. It is satisfied when output rhythm does not match input rhythm, that is, when an input /SW/ is realized as [WS] in the output and vice versa.[10]

It is evident from Table 2 that only the Faith-G, which yields outputs identical to the target language, is a total order.[11] All other grammars are partial orders and hence yield variable outputs, the number of which is relative to the number of rankings permitted in each partially-ordered grammar. For example, the Trunc-G is a partial order that consists of six total orders, i.e. it corresponds to six tableaux. Each tableau derives a unique winner. It is possible that the winners of these tableaux converge. Thus, the system predicts at least two and at most six possible outputs for the Trunc-G.

Table 2. Totally and partially ordered grammars

Faith-G	Fσ́ Fsi » T W
Trunc-G	T, Fσ́, W » Fsi
WeakSyll-G	T, W » Fσ́, Fsi
RevRhythm-G	¬R, Fsi » Fσ́, T
ConstrSyll-G	T, M » Fσ́, Fsi

Interestingly, we found out that in our case studies there is a subset relation among the sets of grammars of the children examined. As illustrated in Table 3, *Baby-M*'s grammar inventory is a proper subset of Ioanna's grammar inventory. More specifically, *Baby-M* lacks the ConstrSyll-G that Ioanna has.

Table 3. Cross-child distribution of grammars

	BM	Ioanna
Faith-G	✓	✓
Trunc-G	✓	✓
WeakSyll-G	✓	✓
RevRhythm-G	✓	✓
ConstrSyll-G		✓

This observation extends beyond the specific pair of learners and, in general, characterizes the distribution of grammars across all children in Tzakosta's database: some grammars appear steadily in all children's speech whereas others do not. For instance, Faith-G and Trunc-G are among the most widespread ones. In contrast, the RevRhythm-G and the ConstrSyll-G are less common (Tzakosta 2004). In fact, they are attested primarily in Ioanna's speech. This is anticipated given that Ioanna was recorded for the longest period of time. Therefore, it is more likely that her speech displays a wider range of grammars including also those that are typologically more distant from the target grammar. The question that naturally arises at this point is why some grammars appear to have a broader empirical coverage than others. We know from previous studies that typologically simple and less marked grammars are favored by children (Gnanadesikan 2004). However, under this assumption, it comes as a surprise that that the Faith-G is also among the preferred grammars of the young learners of Greek. In order to answer this question, we must, first, have a careful look at the grammars at hand and, then, explore the nature of the rankings they consist of.

Table 4 demonstrates that Trunc-G is a partial order that consists of six total orders, two of which contain some aspect of the target grammar, namely Fσ́ » T » W » Fsize and Fσ́ » W » T » Fsize. In particular, in subgrammar-3 and subgrammar-4, Fσ́ is ranked above T and W, respectively. Crucially, this ranking partly identifies with the target grammar. In other words, Trunc-G subsumes some version of the target grammar, in the sense that the Fσ́, which requires the preservation of the stressed syllable, is ranked in the highest stratum of the constraint hierarchy.

Table 4. Trunc-Grammar: rankings and subgrammars

Trunc-G	T, Fσ́, W » Fsize
ranking-1/subgrammar-1	T » Fσ́ » W » Fsize
ranking-2/subgrammar-2	T » W » Fσ́ » Fsize
ranking-3/subgrammar-3	Fσ́ » T » W » Fsize
ranking-4/subgrammar-4	Fσ́ » W » T » Fsize
ranking-5/subgrammar-5	W » Fσ́ » T » Fsize
ranking-6/subgrammar-6	W » T » Fσ́ » Fsize

☒ **Target Grammar:**
Fσ́ Fsi » T W

Unlike the Trunc-G, the ConstrSyll-G is a partial order that consists of four total orders, which correspond to the four tableaux shown in Table 5. Strikingly, none of these orders identifies with the target grammar. This is because in all subgrammars both faithfulness constraints occupy a low rank in the constraint hierarchy.

Table 5. ConstrSyll-Grammar: rankings and subgrammars

ConstrSyll-G	T, M » Fσ́, Fsize
ranking-1/subgrammar-1	T » M » Fσ́ » Fsize
ranking-2/subgrammar-2	T » M » Fsize » Fσ́
ranking-3/subgrammar-3	M » T » Fσ́ » Fsize
ranking-4/subgrammar-4	M » T » Fsize » Fσ́

☒ **Target Grammar:**
Fσ́ Fsi » T M

Let us take a closer look at two representative total orders of the ConstrSyll-G. Tableau 5 (T5) exemplifies subgrammar-1 and tableau 6 (T6) exemplifies subgrammar-3. In both subgrammars, T or M occupies the highest stratum, whereas Fσ́ and Fsize occupy the lowest one. As a result, only truncated forms that crucially do not contain the stressed syllable qualify as optimal outputs. Under no ranking, does the stressed syllable have the chance to emerge, unless it so happens that it consists of the most unmarked segment in the word, e.g. /'vle.po/ → ['lep].

T5 /ti.'le.fo.no/	T	M	Fσ́	Fsize
a. ti.'le.fo.no	** !**	***		
b. ti.'le	** !	*		**
c. 'le	*	* !		**
☞ d. 'toː	*		*	***
e. 'fo	*	* !	*	***
f. 'no	*	* !	*	***

T6 /ti.'le.fo.no/	M	T	Fσ́	Fsize
a. ti.'le.fo.no	* !**	****		
b. ti.'le	* !	**		**
c. 'le	* !	*		**
☞ d. 'toː		*	*	***
e. 'fo	* !	*	*	***
f. 'no	* !	*	*	***

Turning now to the question concerning the somewhat unexpected predominance of Faith-G and, to some extent the Trunc-G, as opposed to the marginality of the WeakSyll-G, the RevRhythm-G and the ConstrSyll-G, we argue that this can receive a straightforward explanation in a model that views parallel grammars as partial orders. A comparative look among these parallel grammars reveals that partially ordered grammars subsuming total orders that contain the target grammar are more likely not only to emerge early in acquisition but also to adopt a slower pace of dying out than other grammars. We argue that this is because they share strong typological links with the target grammar. The results of inter-child variation are further supported by our findings regarding intra-child variation on which the next subsection focuses.

4.3 Intra-child variation

Table 6 shows the distribution of grammars in the language development of a single child. Ioanna will serve as a case study. Ioanna's grammar explosion state is divided into two periods on the basis of the grammars used. Interestingly, she uses only a subset of the original grammars in the second period of her language development. More specifically, in the transition from the first to the second period she abandons the ConstrSyll-G and the RevRhythm-G. It should be noted that the abandoned grammars do not subsume a single total ranking that corresponds to the adult/target language and, consequently, are of the type that cannot guarantee a smooth transition to the target grammar.

Table 6. Intra-child distribution of grammars

	Ioanna (period 1) 2;04,03–3;02.12	Ioanna (period 2) 3;02.13–3;06.26
Faith-G	1	✓
Trunc-G	✓	✓
WeakSyll-G	✓	✓
RevRhythm-G	✓	
ConstrSyll-G	✓	

5. The Grammar Inclusion Hypothesis

The examination of inter- and intra-child variation data revealed that partial orders that include the target grammar are attested in all children's speech, whereas partial orders that do not contain even a single total order relating to the target grammar are highly disfavored. The *Grammar Inclusion Hypothesis* stated in (10) provides a viable explanation to this disparity. A partial grammar of the former type constitutes a *smart developmental path* because it includes the target-language ranking and, eventually, is designed to lead to it. A partial grammar of the latter type, however, does not contain the target-language grammar and hence constitutes a *non-smart developmental path*. Undeniably, such a path delays the acquisition process because it is not typologically related to the target grammar. A non-smart path fails to connect the running state of acquisition with the end state of language development and hence it slowly but surely loses ground.

(10) Grammar Inclusion Hypothesis
Advanced grammars are partial orders which subsume total orders that are proper subsets of early grammars. A smart developmental path is one that subsumes subset total orders that contain the target (more faithful) grammar. (Kateri, Revithiadou & Varlokosta 2005:33)

The following abstract example helps us visualize the described system of relations. Any partially ordered grammar (Grammar-1) forms a possible developmental path since it subsumes more than one total order/subgrammar (Subgrammar-2 and Subgrammar-3). A developmental path is smart, if and only if it contains at least one total order that reflects the target grammar; otherwise the described web of (sub)grammars forms a non-smart path. The path depicted in (11) qualifies as smart because the partial order A » B, C contains Subgrammar-2, which corresponds to the target grammar.

(11) Grammar-1: A » B, C (partial order)

Subgrammar-2 Subgrammar-3 (total orders)
A » B » C A » C » B

where A » B » C is the target grammar
∴ G-1 ⊃ G-2, G-3 is a developmental path; it is
smart if SubG-2 or SubG-3 ≅ target grammar

Given that smart paths share some typological properties with the target grammar, it becomes clear why they are preferred by all children: they smoothly lead to the target grammar without the chance of obstructing phonological acquisition. Thus, smart paths lower the expectation for regression to earlier developmental stages. The question, however, that arises from the discussion so far is why 'non-smart' paths are adopted by children to begin with. The answer to this question lies on the nature of the subgrammars that comprise 'non-smart' paths. Such subgrammars are governed by UG principles such as sonority, ideal prosodic size (e.g. word binarity), and so on. In general, they reflect the unmarked properties of human language. Hence, they are expected to emerge during the initial and, naturally, the intermediate state of L1 acquisition as well. Moreover, non-smart paths may constitute real grammars or possible subgrammars of other languages of the world. Consequently, given the unifying character of UG, the grammars of some languages may be potential developmental grammars in other languages. Input frequency in the target language relates the actual data with these potential grammars and renders them smart or non-smart developmental paths. Extending this line of thought, we also predict grammars not typologically related to the target grammar will form impossible paths and hence never be used by children.

One may wonder how exactly non-smart paths get out of the picture. Do they succumb to the leveling forces of the other grammars? The most plausible scenario is that non-smart paths die out due to their poor typological relevance with the target grammar. Moreover, input frequency effects do not reinforce their maintenance either. In other words, non-smart paths are disposed of as soon as children realize, on the one hand, their minuscule typological identity or even profound disparity with the target grammar and, on the other hand, the absence of empirical evidence in their support. Our prediction is that the more non-smart paths are activated, the slower the process of acquisition is.

6. Summary and conclusions

In order to account for the patterns of variation observed in the speech of children acquiring Greek L1, we proposed a grammatical model that relies on the MPG theory of acquisition (Revithiadou & Tzakosta 2004a, 2004b, Tzakosta 2004) and, at the same time, incorporates the basic insights of Anttila's (1997a, 1997b, 2002) theory of phonological and morphological variation and, specifically, partial ordering.

The implementation of partial order to language acquisition has several advantages. First, it allows us to account for variation in child speech in terms of a grammar with incomplete constraint rankings. Subgrammars are taken to be not accidental constellations of constraint hierarchies but rather the sum of total orders a partially ordered grammar consists of. To put it simply, the less the missing rankings in a grammar, the fewer the total orders it subsumes, and hence the subgrammars. Second, partial ordering offers a principled basis, i.e. the Grammar Inclusion Hypothesis, for the definition of developmental paths. More specifically, it succeeds in drawing a distinction between smart paths that gradually lead to the target grammar and non-smart paths that possibly trigger regression and, inevitably, impede the acquisition process.

In the future, there is a need to explore further and test the predictive and explanatory power of the Grammar Inclusion Hypothesis. More specifically, the investigation should focus first on the theoretical and typological distinctions between paths that qualify as smart or not from the outset of phonological development, and, second, on how non-smart paths emerge and eventually decline.

Acknowledgements

We wish to thank an anonymous reviewer, the Editors of the *JGL*, as well as Michalis Georgiafentis and the audience of ICLaVE 3 (Meertens Institute, Amsterdam, 23–25 June 2005) for their insightful comments and valuable suggestions. All errors are of course our own.

Notes

1. For different versions of constraint demotion algorithms, the interested reader is referred to Tesar & Smolensky 2000.

2. According to Tesar and Smolensky (2000), the learner does not get information about the target-language ranking based on positive evidence only. Every piece of data brings with it a body of implicit negative evidence. More specifically, having being exposed to a positive datum *p*, the learner knows that, with respect to the unknown constraint hierarchy of the language being learned, the alternative parse of the same input *p*' is less harmonic (Tesar & Smolensky 2000:30–43). Therefore, each piece of positive initial data conveys a large amount of inferred information.

3. For a different definition of developmental paths, the interested reader is referred to Levelt & Van de Vijver 2004.

4. See Kiparsky 1993 for a view of variation in terms of competing grammars.

5. 'W' stands for weak syllables and 'S' for strong (stressed) syllables.

6. 'Faithfulness' here refers to prosodic form and not to segmental content and structure.

7. The notation 'S', 'W', 'W_1', 'W_2' refers to syllable types that, production-wise, remain intact, whereas 'CV' stands for the form produced with unmarked segments.

8. The total rankings for each grammar are provided in Appendix A. The statistics for the Faith-G for each child are given in Appendix B.

9. The outputs of the ConstrSyll-G may vary in size depending on the exact rank of the constraints that promote truncation in the system. In the vast majority, these outputs are monosyllabic and disyllabic; longer ones cannot be excluded but they are practically unattested in our speech sample. This is expected given the high rank of T constraints in the grammar.

10. In a language like Greek, where both SW and WS stress patterns emerge on the surface, this constraint is technically an encapsulation of different rankings of the foot-type constraints Iamb and Trochee.

11. Although there is no ranking relation between Fσ́ and Fsize or between T and W, we take this grammar to be a total order because the constraints in each respective pair cannot contrast with each other since they belong to the same stratum. This is indicated with the absence of commas between the constraints.

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Appendix A: Grammars and total rankings

The tables below provide all total orders of the (partial) fundamental grammar.

1. Faith-G	**Fǿ Fsi » T W**

2. Trunc-G	**T, Fǿ, W » Fsi**
ranking-1/subgrammar-1	T » Fǿ » W » Fsi
ranking-2/subgrammar-2	T » W » Fǿ » Fsi
ranking-3/subgrammar-3	Fǿ » T » W » Fsi
ranking-4/subgrammar-4	Fǿ » W » T » Fsi
ranking-5/subgrammar-5	W » Fǿ » T » Fsi
ranking-6/subgrammar-6	W » T » Fǿ » Fsi

3. WeakSyll-G	**T, W » Fǿ, Fsi**
ranking-1/subgrammar-1	T » W » Fǿ » Fsi
ranking-2/subgrammar-2	W » T » Fǿ » Fsi
ranking-3/subgrammar-3	W » T » Fsi » Fǿ
ranking-4/subgrammar-4	T » W » Fsi » Fǿ

4. RevRhythm-G	**¬R, Fsi » Fǿ, T**
ranking-1/subgrammar-1	¬R » Fsi » Fǿ » T
ranking-2/subgrammar-2	Fsi » ¬R » Fǿ » T
ranking-3/subgrammar-3	¬R » Fsi » T » Fǿ
ranking-4/subgrammar-4	Fsi » ¬R » Fǿ » T

5. ConstrSyll-G	**T, M » Fǿ, Fsi**
ranking-1/subgrammar-1	T » M » Fǿ »Fsi
ranking-2/subgrammar-2	T » M » Fsi » Fǿ
ranking-3/subgrammar-3	M » T » Fǿ » Fsi
ranking-4/subgrammar-4	M » T » Fsi » Fǿ

Appendix B: Statistics of the Faith-ǿ

The tables below provide the statistics for Faith-ǿ Grammar for each child. The first row presents the statistics for faithful productions whereas the remaining rows provide the statistics for non-faithful ones. For instance, Marilia produces an input WS faithfully in 63.8% of her data, whereas in 29% of her productions she reverses the input rhythm and in 3.7% truncates the input form into W. Other patterns are produced in 2.4% of Marilia's data.

1. Marilia (2;07.26–3;05.23)

SW		**WS**	
SW	61.6	WS	63.8
W	8.2	SW	29
WS	2	W	3.7
SWW	1	SWW	0
WSW	0.8	WSW	1
WWS	0	WWS	0.6
Other	19.8	Other	0.8
Total	100	**Total**	100

SWW		**WSW**		**WWS**	
SWW	74.8	WSW	63.8	WWS	69.4
SW	12.5	W	14.9	WS	9.7
W	1.9	SW	9.2	W	4.8
WSW	0.8	WS	5.2	WSW	3.2
WWS	0.5	SWW	0.7	SWW	1.6
WS	0.2	WWS	0.3	SW	0
Other	9.8	Other	7.9	Other	1.5
Total	100	**Total**	100	**Total**	100

2. *Baby-M* (1;09.22–2;0.23)

SW		**WS**	
SW	82.7	WS	69.9
WS	7	W	21.3
W	3.6	SW	3.6
WS	1.3	WWS	1.5
WSW	1.1	WSW	0.5
SWW	0	SWW	0.1
Other	4.3	Other	3.1
Total	100	**Total**	100

SWW		**WSW**		**WWS**	
SWW	76.1	WSW	70	WWS	59.6
SW	11.5	SW	11	*WS*	11.8
WSW	1.7	W	4.9	W	10
WS	1.1	WS	4.4	SW	1.9
W	0.4	SWW	1.9	WSW	0.6
WWS	0.1	WWS	0.2	SWW	0
Other	9.1	Other	7.3	Other	15.5
Total	100	**Total**	100	**Total**	100

3. Ioanna (2;04.03–3;04.26)

SW		**WS**	
SW	79.7	WS	61.5
W	9.5	W	27.6
WS	1	SW	6.1
SWW	0.6	WWS	1.2
WSW	0.6	WSW	0.4
WWS	0	SWW	0.1
Other	8.6	Other	3.1
Total	100	**Total**	100

SWW		**WSW**		**WWS**	
SWW	79.7	WSW	70.6	WWS	60.1
SW	9.5	SW	10.7	WS	10.1
W	1	W	7.8	W	6.9
WS	0.6	WS	3.9	SWW	4.3
WSW	0.6	SWW	1.2	SW	2.1
WWS	0	WWS	0.3	WSW	2.1
Other	8.6	Other	5.5	Other	14.4
Total	100	**Total**	100	**Total**	100