# Multiple partially ordered grammars*

A case study from Greek SLI

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*Abstract*

This paper examines variation in language development based on the case study of a Greek-speaking child with Specific Language Impairment in the phonological component. To account for variation, we extend the empirical coverage of *partial ordering* (Anttila 1997a,b) to language acquisition along the lines of Tzakosta's (2004) *Multiple Parallel Grammars* theory. The theoretical gain of the proposed model is that it provides a principled basis to define developmental paths and also draw a distinction between *smart* and *non-smart* paths. This is stated as the *Grammar Inclusion Hypothesis*: advanced grammars consist of total orders which are proper subsets of early grammars; a smart path is one that subsumes the total order of the target grammar.

## *1. Introduction*

Most children acquire the phonological system of the ambient language in a relative short period of time and without any specific instruction. There are, however, children who appear to have problems in this regard and require clinical attention in order to bring their phonological system in conformity with the target one. Such problems point to a phonological impairment. A central research question in phonological disorder studies is to specify what errors characterize a disorder and whether they are different from errors witnessed at early stages of normal acquisition. Ultimately, this question translates to whether phonological disorders represent a delay in the typical acquisition process or a deviant system. In the former case, the impaired-phonology system is assumed to follow a slower pace of acquisition than in typical development. In the latter case, the impaired-phonology system does not share the same properties with the typical developing system nor does it obey to the structural

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principles of Universal Grammar (UG). In this paper, we present the case study of a Greek-speaking child (male) diagnosed with Specific Language Impairment (SLI) in the phonological component at age 3;6 (Kateri 2003). His speech displays problems in the correct production of mainly consonantal phonemes. Phonological processes, typical of early developmental stages, such as stopping, fronting, devoicing, cluster simplification, syllable deletion, final consonant deletion, apply in this child's speech causing a great amount of variability in output production. In this paper, we focus on devoicing in stops.

The faithful realization of voicing depends on the manner of articulation (stop vs. fricative), place of articulation and on the position of the relevant consonant in the word (i.e. initial/medial, stressed/unstressed). Voiced stops, which attract our interest here, fail to faithfully realized in certain prosodic positions. The degree of unfaithful productions is relative to the position of the target phoneme in the word. Voiced stops are more faithfully produced in medial unstressed positions than in stressed and initial ones. In other words, the scale medial > stressed > initial represents degrees of faithfulness. Moreover, voicing in labials and coronals is less faithfully realized than voicing in dorsals. The described pattern reveals a variable system of contrasts with respect to voicing that gives rise to multiple outputs even for a single lexical item. As we will see in section 3.2, in word initial stressed syllables, /b/ appears to be devoiced 40% (e.g. [páles] for /báles/ 'ball-PL') and faithfully produced 60% (e.g. [bála] for /bála/ 'ball-SG').

In order to account for variation in the SLI child's production outputs, we exploit the inherent property of Optimality-Theoretic grammars (Prince & Smolensky 1993), namely *partial ordering* (e.g. A >> B, C) (Anttila 1997a,b *et seq.*). Furthermore, we extend its empirical coverage to language acquisition along the lines of the *Multiple Parallel Grammar* (MPG) model proposed in Revithiadou & Tzakosta (2004a,b) and further elaborated in Tzakosta (2004) on the basis of Greek longitudinal production data from thirteen typical developing children. More specifically, we claim that the set of possible grammars employed by the child is the sum of total orders of specific markedness and faithfulness constraints, e.g. {A >> B >> C, A >> C >> B}. During the course of acquisition, the child makes use of a subset of these total orders till it reaches the target grammar, i.e. A >> B >> C. The theoretical gain of this approach is that it allows us to formally define developmental paths as sets of total orders which decrease in number as acquisition proceeds. More importantly, it provides the means to define *smart paths* of phonological development, that is, paths that lead steadily and safely to the target grammar. A path qualifies as smart, if the target grammar is *included* in the set of grammars used by the child (*Grammar Inclusion Hypothesis*). Otherwise, a non-smart path has been chosen and regression to other, possibly less advanced grammars is expected to take place.

To sum up, in this study (a) we account for variation in the SLI child's productions by accommodating, at the same time, statistical tendencies in the explanation of SLI, (b) we define the developmental paths that SLI follows in

the acquisition process and (c) we explore whether the Greek SLI case studied here represents a 'delayed' or a 'deviant' system.

The paper proceeds as follows: Section 2 provides a brief overview of studies on SLI phonology. Section 3 presents the case study; the details of the methodology are outlined in §3.1 whereas the data and the results are discussed in §3.2. Section 4 starts with the analysis of the Greek SLI based on Anttila's partial ordering account of variation (§4.1). It then proceeds to the presentation of the partial orders for each phoneme (§4.2) and the formal definition of developmental paths (§4.3). Section 5 concludes this paper.

## *2. Studies on Specific Language Impairment*

Specific Language Impairment constitutes a developmental language disorder that has attracted much attention in the past two decades. Children with SLI present significant language limitations, in the absence of any hearing deficiency, mental retardation or any serious psychological or behavioral problem that would merit intervention (Stark & Tallal 1981). Individuals with SLI may be impaired in one or more of aspects of language (morphology, syntax, phonology, semantic and pragmatics). Impairment in one domain does not presuppose impairment in all the rest. Moreover, the deficit is not necessarily uniform in one area. For instance, an SLI subject may be impaired in some aspects of morphology, but show comparative strengths in others (van der Lely & Howard 1993). This is the reason why SLI is characterized by lack of homogeneity.

There is significant literature in the field of SLI regarding the nature of the deficit. Morphosyntax and syntax have long been investigated and are considered areas of primary difficulty for this population. Impairment in these domains concerns inflectional morphology (Rice, Wexler & Cleave 1995; among others) as well as a number of syntactic phenomena, such as the use of passives, the assignment of theta-roles to syntactic functions and the use of pronouns and anaphors (van der Lely 1996; van der Lely & Stollwerck 1997). Another domain of language that is impaired in SLI children is semantics and pragmatics, i.e. the linguistic meaning of words, phrases and sentences (semantics) and the use of language in an appropriate context (pragmatics) (Fromkin & Rodman 1993).

Phonology, as a component of language, does not remain unaffected either. It has been suggested that almost all children with developmental language impairment have problems with phonology (Panagos & Prelock 1982; Paul & Shriberg 1982). According to Menyuk (1993), there are at least two types of phonological problems in SLI. The first one is a 'marked delay' in the phonological system. SLI children are late in developing phonology. In this case, we observe the phonological pattern that is found in typical development; however, the various phonological processes appear at a later than expected age and they persist over a longer period of time. In the other type of phonological problems, the SLI subjects show great variability in the speech sound realizations which depart from those of Typically Developing (TD) children.

Thus, a deviant pattern of acquisition appears. In this latter case, we can observe unique or idiosyncratic processes, that is, phonological processes that are not typical in TD children.

There is empirical evidence for both cases. A number of studies in English support a delayed system (Leonard 1982; Fee 1995; Orsolini, Sechi, Maronato, Bonvino & Corcelli 2001; Pharr, Ratner & Rescorla 2000; Rescorla & Ratner 1996; Mirak & Rescola 1998; Roberts, Rescola, Giroux & Stevens 1998), not excluding, however, the idiosyncratic and atypical behavior in some instances (Schwartz, Leonard, Folger & Wilcox 1980; Leonard & Brown 1984; Leonard, Schwartz, Swanson & Frome Loeb 1987). For example, Rescorla & Ratner (1996) investigated the vocalization rate, the vowel and consonant inventories and the syllable structure in thirty English-speaking toddlers diagnosed with Specific Expressive Language Impairment (SLI-E), compared with thirty age-matched TD children. They concluded that the SLI-E children vocalized less than their TD peers and their syllable structure was less mature, consisting mainly of V or CV syllables. Moreover, the SLI-E group's phonetic inventories were more restricted, especially regarding the use of consonants. The most commonly used phonemes were voiced stops [b, d], nasals [m, n], glides [w, j] and [h], i.e. phonemes that are among the first to appear in TD children, as well (Stoel-Gammon 1985). However, none of these phonemes appeared in a proportion more than 50% in initial, medial or final position in the SLI-E group, which entails that none of the children had fully acquired them. In contrast, the age matched group was able to use more phonemes at a percentage above 50%. Mirak & Rescola (1998) reached similar conclusions about the phonetic inventories in English SLI, stating that the mean number of consonants used by the impaired group of their study was three times smaller than that used by the age control group. Similarly, Fee (1995) found that SLI children start using nasals and stops correctly, whereas, among fricatives, /s/ and /f/ are the first ones to be used contrastively and /θ/ and /ð/ are the last to be acquired. This is the pattern encountered in typical acquisition, as well (Grunwell 1987; Stoel-Gammon 1985; Menn & Stoel-Gammon 1995). In all these studies, the phonetic inventory of the language impaired children, though limited, did not present any inconsistency compared with that of TD children. They used phonemes that were among the first to appear in TD, just fewer in number, indicating a delay and not a deviance in phonological development.

Furthermore, similar phonological processes have been observed in both SLI and TD children. Pharr, Ratner & Rescorla (2000) observe that SLI-E children use fewer clusters than their chronologically matched group, indicating a preference to the unmarked CV structure. For the same reason (i.e. preference to the CV structure), the SLI-E subjects delete the final consonant of the closed syllables (i.e. those consisting of the CVC structure) and use open syllables instead. Leonard (1982) states that cluster reduction occurred over 90% in word initial clusters in both the SLI and the language ability matched children he studied. Similar findings are attested in Italian SLI, as well. Orsolini, Sechi, Maronato, Bonvino & Corcelli (2001) observed that their SLI subjects had the tendency to reduce clusters to the unmarked shape and to omit coda positioned segments (e.g. /sca.le/ → [ca.le] 'stairs', /por.ta/ → [po.ta]

'door'). Alternatively, they replaced a sonorant in clusters or codas with another sonorant that was easier to pronounce (e.g. /bar.ca/ → [bal.ca] 'ship', where /l/ replaces /r/). No atypical pattern is observed in Italian SLI either, since the Italian-speaking TD children also show these tendencies. Moreover, other phonological processes such as, unstressed syllable deletion, stopping, gliding, backing, as well as assimilation processes are very frequent in SLI and resemble typical phonological development, leading to the conclusion that SLI is a delayed system (Leonard 1982; Chiat & Hunt 1994; Fee 1995; Roberts *et al*. 1998).

Schwartz, Leonard, Folger & Wilcox (1980), however, point out that there are cases where differences between the language impaired and the control group exist. More specifically, in the six children that they studied (three language disordered and three TD children matched on language ability) there were some cases where variation was present. For instance, one SLI child made productive use of prevocalic [f] and [w], a tendency not found in the TD children; intervocalically, the TD group used a wide range of stops, whereas one SLI child made productive use of only one stop ([b]). Additionally, the SLI children, contrary to the control group, pronounced more consonants in postvocalic position. The researchers attributed these differences between the SLI and the TD children to possible individual variation, acknowledging, however, the need for further research in order to determine the nature of the impairment. Leonard & Brown (1984) observe the existence of an unusual phonological pattern in a young girl, aged 3;8, with significant limitations in language development. The child added a final [s] in all words, except those containing final oral or nasal bilabials (e.g. [baes] for *bath*, [dos] for *dog* but [mam] for *mum*, [home] for *home*). She added [s] even in the final position of words that lacked any final consonant, indicating a preference for the CVC or the CVCVC structure (e.g. [gos] for *go*). The researchers concluded that the girl showed a sound preference or had a favorite sound that she constantly added to her word productions. Sound preference constitutes a common characteristic of phonologically disabled children (Weiner 1981) and it is another indication that the SLI population applies unusual processes, that may indicate a deviant phonological system. Furthermore, Leonard, Schwartz, Swanson & Frome Loeb (1987) concluded that the unusual processes reached a percentage of 47.47% for their English-speaking SLI subjects, and only 27.67% for their TD ones. Initial consonant deletion and final consonant addition were the most frequent in this study. Although the small number of the SLI children (only five) in this study does not allow for generalizations, the unusual phonological behavior observed may be an indication of deviant pattern that merits further research.

Next to the limited ability in the contrastive use of speech sounds in the target language, Beers (1995) adds the degree of variability as a factor that distinguishes the speech of phonologically-impaired children from the speech of typically developing ones. In typical development, a fair amount of variation in the production of lexical items is indicative of the acquisition of new contrasts. Grunwell (1981a,b; 1987) considers the use of different contrastive segments in one lexical form as 'progressive variability' because it shows that

the child is actively involved in exploring the target system through variable pronunciations. In typical speech, however, variability is restricted within the ranges imposed by UG, whereas in phonologically-impaired children variation is not of the type that facilitates the acquisition of new contrasts. Lack of systematicity in production results in extreme variability. Examples such as [keig], [seʔz] for *cage*, [sʊm], [s̪ʊm], [tʃʊm], [tʊm], [tɛnt], [kɛnt] for *tent* (Grunwell 1987:105) show that no contrasts have been acquired for [t, s, k, ʃ, s̪, tʃ].

If variation is limited within the normal ranges but does not reduce over time as in the typical development, this may also be an indication of a deviant phonological system. Grunwell (1987) calls an unchanging pattern of variability as *static variable*. Cases where SLI children reach a plateau, i.e. they stop developing some aspects of language before they have fully acquired them, are defined as deviant and not as delayed (Leonard 1998).

Aguilar-Mediavilla, Sanz-Torrent & Serra-Raventos (2002) studied the phonological behavior of five Spanish speaking SLI and five language delayed (LD) children, compared with two groups of TD children, matched on age and language level. The general picture for the SLI and the LD group was that they showed a delay in phonological acquisition. No atypical order was observed. However, there was a significant difference that lead the researchers to support deviance in SLI. The SLI children showed a plateau in the early acquisitions (vowels, stops and nasals), combined with the appearance of later acquisitions (laterals, liquids, complex syllabic structures, etc.). Since mastery levels were not reached for either early or later acquisitions, this pattern could not be considered as a simple delay (Menyuk 1993; Leonard 1998). Thus, Aguilar-Madiavilla *et al*. supported a deviant phonological system in Spanish SLI. Furthermore, Aguilar-Madiavilla *et al*. argued that the simplification processes used by their SLI subjects indicate deviance, as well. The most frequent processes were cluster reduction, deletion of consonants and weak syllable deletion. In fact, the last process was the most frequent in SLI children compared with both the LD and the MLU group. Aguilar-Mediavilla *et al*. interpreted it as an indication of something more than a simple delay. The fact that the LD group shows more similar patterns to the TD children, on the one hand, and that there is significant difference between the SLI and the TD group, on the other, indicates that SLI and LD are not the same. SLI involves deviance. These results coupled Grunwell's (1981a) findings of chronological mismatch detected in the speech of seven LD children. In these children, processes that in TD children appear early in development, namely assimilation, weak syllable deletion, stopping, and so on, co-existed with the faithful realization of (most) clusters. In TD, these processes are only found when the child cannot realize complex structures such as consonant clusters.

Finally, we mention another characteristic of impaired-phonology systems referring to the specification of place of articulation. It is generally assumed that [coronal] is the default place features hence coronals precede the acquisition of labials and dorsals in TD children (Stemberger & Stoel-Gammon 1991; Shaw 1991, among others). In phonology-impaired speech, however, often the more marked place feature [dorsal] is acquired before the other place

features. Beers (1995) claims that in Dutch LD children dorsal segments, i.e. [k, x, ŋ], are predominant.

To conclude, even though the majority of the researchers support a delay in the phonological system of SLI, an unusual or idiosyncratic pattern in phonological acquisition cannot be totally excluded either.

## *3. The case study*

### *3.1. Methodology*

The present work is a single case study, which aimed at investigating the phonological system of a Greek-speaking SLI child, in order to define its delayed or deviant nature. It should be mentioned that Greek SLI in general, and phonology, in particular, has not attracted much attention, therefore few findings are available (see Kateri 2003).

#### *3.1.1. Subject*

One (male) SLI child, aged 5;9, was recruited. He was diagnosed as specifically language impaired by qualified speech and language therapists, at age 3;6, when the parents and the child visited a speech and language center in Thessaloniki, Greece, after a significant delay in language development. After a series of tests and medical examinations, the child was found to have no hearing impairment or any brain damage that would justify the language delay. According to the history profile that was taken by the speech and language therapists that interviewed the parents, the little boy had a typical development in all other aspects of his life. He had gone through all the milestones of development just like TD children (babbling, walking, sitting, etc.). His emotional and behavioral status was normal and his cognitive abilities matched those of the children of his age –as indicated after a series of tests administered by the speech and language therapists. He had been having speech and language therapy for 27 months, three times a week. He was the youngest of three children in his family. No history of speech and language problems was recorded in the family.

#### *3.1.2. Materials*

The Diagnostic Verbal IQ test (DVIQ test) (Stavrakaki & Tsimpli 1999) was used to measure language ability. The test consisted of five subparts that tested vocabulary, production and comprehension of morphosyntax, metalinguistic concepts and sentence repetition.

A semistructured technique of picture naming was used to elicit the child's natural speech. In particular, a number of colored pictures were downloaded from the internet to act as prompts for the child. The pictures depicted words that the child was expected to be familiar with. The words were selected in such a way that would contain all phonemes of the Greek language that the investigator wished to examine both in initial/medial and stressed/unstressed positions. Thus, a complete picture of the realization of the phonemes in all

positions was formed (Stoel-Gammon & Dunn 1985). No word final phonemes were investigated, since the phonemes that may appear word finally in Greek are limited. The pictures were shown to the child on a computer screen, enhancing motivation.

Furthermore, two colored pictured story-books were used to select speech samples, the *Little Red Riding Hood* and the *Bus Story*.[1] The main reason the investigator chose them was to create a naturalistic setting, where the child would feel relaxed and would enjoy interaction with the investigator. Finally, free interaction with the child was employed to collect spontaneous speech samples.

### *3.1.3. Procedure*

Three 40-45 minute sessions were planned over a period of two weeks. The sessions took place in the speech and language therapist's office. The speech and language therapist was present in the first two sessions, whereas she was absent in the third. During the first two sessions, her presence was discreet and she only intervened to facilitate word retrieval (in the picture naming task) and to give reinforcement to the child.

During the first session the investigator administered the DVIQ test (Stavrakaki & Tsimpli 1999). The whole procedure of the test was presented as a game. The child was asked to name pictures (in the vocabulary and morphosyntactic production part), to show which picture depicted the situation that the investigator described (in the morphosyntactic comprehension and metalinguistic concepts part) and to repeat sentences after the investigator (in the sentence repetition part). The child's answers were noted down on the answers sheet of the test.

A similar procedure (presenting everything as a game) was adopted in the rest of the sessions, in order to create a naturalistic setting and to ensure motivation and interest on the part of the child. In the second session, the first part of the picture naming task was administered, where the child was asked to name the pictures that were shown to him. If the child did not know a word, the investigator was trying to elicit it by the use of prompts. In case this technique failed, the investigator provided the target form, encouraging the child to repeat it. However, all such instances were excluded from the data analysis, because they were considered imitations and their pronunciation may have been biased. During this task the researcher kept notes on the pronunciation of each word, on a piece of paper that contained their lexical and phonetic forms and at the same time everything was recorded by using a computer recording program (Audiograbber), accompanied by a microphone, placed on the computer, that isolated all the external noise.

The second part of the picture naming task was administered in the last session, following the same procedure. Furthermore, the two stories were

[1] The *Bus Story* is usually used to investigate discourse cohesion and coherence and the investigator does not intervene while the child is narrating the story. In the present study though, the aim was just to prompt the child and the investigator was free to comment and encourage the production of more speech samples.

presented to the child. Although the *Little Red Riding Hood* is a popular fairy tale in Greece that the majority of children even of preschool age are familiar with, the child of this study was unable to tell it at first place. Thus, the investigator went through it once and then the child retold it. As to the *Bus Story,* this was the expected procedure since it does not constitute a story that Greek children are familiar with (it is rather used in clinical context).

Finally, towards the end of the last session the investigator spent some minutes interacting with the child, playing and talking about everyday activities. The last session was recorded as well, by using the same computer programme. The first session was not recorded since the data from that were not collected for phonological analysis.

### *3.1.4. Data management and analysis*

The speech sample that was recorded in the second and third session was broadly transcribed in the IPA system by trained phoneticians. The transcription was based on the notes taken during the sessions and on multiple listening of the recordings. The Nero Wave Editor (computer program) was used to facilitate the listening of the recordings. This program allowed the isolation and multiple repetitions of each word, so that the listener would be able to identify the sounds heard in an easier and more reliable way. After the completion of the first transcription, additional listening followed, to ensure accuracy. All the unintelligible words and imitations were excluded from further analysis.

Data coding followed. All phonemes of the Greek language were listed. For each phoneme four columns were created, one for initial and one for medial position, one for stressed and one for unstressed position. All the words that started or contained the phoneme under investigation were cited, together with the target pronunciation. In the picture naming task, in cases where two or more successive pronunciations of the same word were found, only the first one was coded, since the rest may have contained some repair strategy. In the story retelling task and in the spontaneous speech, the procedure proposed by Shriberg & Kwiatkowski (1982) was applied. When a word appeared, for instance, three times and it was pronounced correctly in all cases, only the phonemes of the first two words were scored. However, if there was variability in the pronunciation, the phonemes of all the words were calculated. Allophones were not analyzed separately.

The investigator calculated the percentage of the correct use of phonemes, by dividing the number of the phonemes used correctly with the total number of the phonemes coded, and multiplied by 100. Based on this percentage, the distinction between the acquired phonemes, those that were being acquired and those than were not acquired was made. In order for a phoneme to be considered acquired, it had to be correct in approximately 90% of its occurrence (Brown 1973). Phonemes ranging from 50% to 90% were viewed as being in the process of acquisition; since their production was not stable, they could not be considered as having achieved a level of mastery. Finally, those that were below 50% correct were not considered acquired.

### *3.2. Data and results*

The SLI child did not make a systematic and consistent use of all phonemes. He used correctly nasals and the liquid /l/, as well as the voiceless stops. His performance at these phonemes ranged from 92.5% to 100% (Figure 1). We infer from the above that the SLI child has fully acquired voiceless stops. Some representative examples with the voiceless labial /p/ at initial/medial and stressed/unstressed positions are listed in (1).

(1) *voiceless labial stop /p/: faithful productions*

| | | | |
|---|---|---|---|
| a | INITIAL STRESSED | | |
| σσ(σ) | póði | /póði/ | 'foot' |
| | pínune | /pínune/ | 'drink-3PL.PRES' |
| | INITIAL UNSTRESSED | | |
| | poðílato | /poðílato/ | 'bicycle' |
| | pukámiso | /pukámiso/ | 'shirt' |
| | MEDIAL STRESSED | | |
| | alopláno | /aeropláno/ | 'airplane' |
| | lapési | /trapézi/ | 'table' |
| b | INITIAL UNSTRESSED | | |
| σσσ | peðáci | /peðáki/ | 'child-DIM' |
| | puláca | /pulákia/ | 'bird-DIM.PL' |
| | MEDIAL STRESSED | | |
| | tapési | /trapézi/ | 'table' |
| | kapélo | /kapélo/ | 'hat' |
| | MEDIAL UNSTRESSED | | |
| | kapelíno | /kapelíno/ | 'hat-DIM' |
| | ásopi | /ánθropi/ | 'man-PL' |
| c | INITIAL UNSTRESSED | | |
| (σ)σσ | polá | /polá/ | 'many-PL' |
| | paɣotó | /paɣotó/ | 'ice cream' |
| | MEDIAL STRESSED | | |
| | kanapé | /kanapé/ | 'couch' |
| | alepú | /alepú/ | 'fox' |
| | MEDIAL UNSTRESSED | | |
| | apoðó | /apoðó/ | 'from here' |

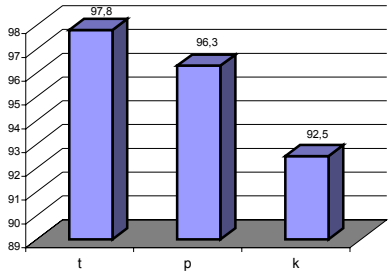


Figure 1. Voiceless stops: percentages of faithful productions

As shown in Figure 2 and Figure 3, voiced stops[2] show low percentages of faithfulness with respect to voicing compared to their voiceless counterparts. Unfaithful productions involve non-realization of the feature [+voice]. Interestingly, the voiced velar /g/ appears to have a higher rate of faithful productions than its coronal and labial counterparts. In SLI acquisition data this is not surprising. Beers (1995) reports similar findings for Dutch language-impaired children.

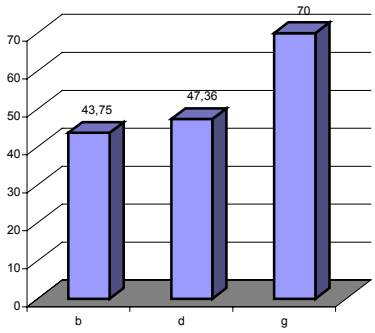


Figure 2. Voiced stops: percentages of faithful productions

[2] Voiced stops in Greek are often prenasalized. There is, however, an inter-speaker variation in the surfacing or non-surfacing of the nasal depending on regional, socio-educational, generational and gender parameters. This led several researchers (Newton 1972; Warburton 1970; Malikouti–Drachman & Drachman 1992, among others) to claim that voiced stops do not occur as independent phonemes in the Greek segmental inventory but are, rather, derived from underlying sequences of nasals plus oral stops. However, we do not share this assumption here. Instead, we take surface voiced stops to be underlyingly voiced (see also Newton 1961; Householder 1964; Setatos 1974; Viechnicki 1996 for a similar view).

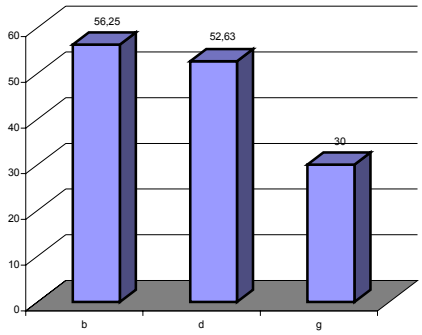


Figure 3. Voiced stops: percentages of unfaithful productions

The voiced labial /b/ was used systematically correct in non-initial unstressed positions. Faithful and unfaithful productions of the same phoneme are almost equally divided among the other positions (i.e. initial, stressed). Table 1 summarizes the results of the distribution of this phoneme. Representative examples of both faithful and devoiced productions are provided in (2) and (3), respectively.

(2) *voiced labial stop /b/: faithful productions*

| | | | |
|---|---|---|---|
| a | INITIAL STRESSED | | |
| σσ(σ) | bála | /bála/ | ‘ball’ |
| | bénume | /bénume/ | ‘enter-3PL.PRES’ |
| | MEDIAL UNSTRESSED | | |
| | kúbosa | /kúbosa/ | ‘button-1SG.PAST’ |
| b | | | |
| σσσ | MEDIAL STRESSED | | |
| | kobjútet | /kobjúter/ | ‘computer’ |
| | labáða | /labáða/ | ‘candle’ |
| | INITIAL UNSTRESSED | | |
| | bixóto | /biskóto/ | ‘biscotti’ |
| | bolúse | /borúse/ | ‘could-3SG.PAST’ |
| | MEDIAL UNSTRESSED | | |
| | kabanáci | /kabanáki/ | ‘bell-DIM’ |
| c | | | |
| (σ)σσ | INITIAL UNSTRESSED | | |
| | bojá | /boγiá/ | ‘paint’ |
| | babás | /babás/ | ‘dad’ |
| | MEDIAL STRESSED | | |
| | kubjá | /kubiá/ | ‘button-PL’ |
| | babás | /babás/ | ‘dad’ |

(3) *voiced labial /b/: unfaithful productions*

| | | | |
|---|---|---|---|
| a | INITIAL STRESSED | | |
| ́σσ(σ) | páles | /báles/ | 'ball-PL' |
| | pánjo | /bánio/ | 'bathroom' |
| | pénume | /bénume/ | 'we enter-1PL.PRES' |
| b | INITIAL UNSTRESSED | | |
| σ́σσ | panánes | /banánes/ | 'banana-PL' |
| | pukáli | /bukáli/ | 'bottle' |
| | pastúni | /bastúni/ | 'stick' |
| | MEDIAL STRESSED | | |
| | kapána | /kabána/ | 'bell' |
| | opéla | /obréla/ | 'umbrella' |
| c | INITIAL UNSTRESSED | | |
| (σ)σ́σ | pufán | /bufán/ | 'rain coat' |

Table 1. Distribution of faithful and unfaithful productions of /b/

| /b/ | INITIAL STRESSED | INITIAL UNSTRESSED | MEDIAL STRESSED | MEDIAL UNSTRESSED |
|---|---|---|---|---|
| FAITH 14/32 (43.75) | 4/10 (40) | 7/16 (43.75) | 3/6 (50) | 2/2 (100) |
| UNFAITH 18/32 (56.25) | 6/10 (60) | 9/16 (56.25) | 3/6 (50) | 0/2 (0) |

A similar picture is witnessed with the coronal /d/ and the velar /g/ voiced stops. Table 2 draws together the results of data coding. Strikingly, the phoneme /d/ is not used correctly on any occasion in word initial stressed and unstressed positions. In this case devoicing applies categorically. /d/, however, exhibits a high percentage (87.5%) of correct use in medial unstressed positions and an average of 50% of correct production in medial stressed positions just like /b/. Devoicing of /d/ appears to be favored in initial (un)stressed positions more than in medial stressed ones. It is favored even less in medial unstressed syllables.

Table 2. Distribution of faithful and unfaithful productions of /d/

| /d/ | INITIAL STRESSED | INITIAL UNSTRESSED | MEDIAL STRESSED | MEDIAL UNSTRESSED |
|---|---|---|---|---|
| FAITH 7/16 (47.36) | 0/3 (0) | 0/4 (0) | 2/4 (50) | 7/8 (87.5) |
| UNFAITH 9/16 (52.63) | 3/3 (100) | 4/4 (100) | 2/4 (50) | 1/8 (12.5) |

The situation is somewhat different with the voiced velar /g/, as shown in Table 3. This phoneme seems to be mastered in medial/initial unstressed

positions where correct use reaches 100%. In stressed syllables, on the other hand, there is an even split between faithful production and devoicing. That is, the voicing contrast in velar stops has 50% chance to be neutralized under stress.

Table 3. Distribution of faithful and unfaithful productions of /g/

| /g/ | INITIAL STRESSED | INITIAL UNSTRESSED | MEDIAL STRESSED | MEDIAL UNSTRESSED |
|---|---|---|---|---|
| FAITH 7/10 (70) | 1/2 (50) | 2/2 (100) | 2/4 (50) | 2/2 (100) |
| UNFAITH 3/10 (30) | 1/2 (50) | 0/2 (0) | 2/4 (50) | 0/2 (0) |

To conclude, the data reveal that the voicing contrast is neutralized in *prosodically salient* (i.e. initial, stressed) positions. Consequently, the inventory of segments found in prominent positions is a subset of those found in non-prominent ones. Moreover, there is a strong tendency to preserve voicing in dorsals, a fact that needs to be accounted for as well. Both issues are examined in the ensuing section where it is argued that only a theory that makes crucial use of multiple grammars and partial ordering can attain explanatory adequacy and provide a uniform interpretation of variation in the SLI child's speech.

## *4. Analysis: multiple partially ordered grammars*

### *4.1 Positional markedness constraints and partial ordering*

In the previous section, we have established that in the SLI child's speech prominent positions cannot house the full set of elements found in non-prominent positions. In order to account for devoicing in prosodically salient positions, markedness constraints-specific to prominent positions are invoked. Such constraints encapsulate the requirement prosodic prominence positions to be unmarked. Prosodic markedness relates to segmental sonority and prosodic structure (de Lacy to appear).[3] For example, initial syllables may be required to have prosodically unmarked, i.e. low sonority, onsets. Such constraints predict that featural distinctions that are not sonority-related (e.g. place of articulation) cannot be invoked in neutralization in prominent positions.

With respect to the SLI data, we claim that syllable margins at stressed and initial positions prefer voiceless stops which have low sonority compared to their voiced counterparts.[4] The respective constraints are stated in (4) and are

[3] The sonority constraints are an adaptation of Prince & Smolensky's (1993) syllable margin and nucleus sonority constraints, relativized to prominent positions.

[4] Voiceless stops in Greek are reported to have stronger and durationally longer bursts compared to voiced ones (Papazachariou p.c.). It is possible that increased duration functionally motivates their occurrence in strong positions.

based on de Lacy's (to appear) *MAR$_{\acute{\sigma}}$/[+voi] and *MAR$_{\sigma 1}$/[+voi] constraints, respectively.[5]

(4) *positional markedness constraints*
   a. *VOI#C: No voiced onsets in initial syllables.
   b. *VOIσ́: No voiced onsets in main-stressed syllables.

In addition to the above prosodic markedness constraints, the analysis calls upon the following constraints as well:

(5) a. *VOI (after Itô & Mester's (1998) VOP): No stop must be voiced.
   b. FAITH(voi):[6] No changes in the voicing of stops.

Having established the technical apparatus required for the analysis, let us now proceed to accounting for variation in the SLI child's speech. Anttila (1997a,b, 2002 *et seq.*) exploits *partial ordering*, an inherent property of OT, to account for variation in Finnish phonology and morphology. In his theory, variation is the result of partial orders. In a total order every constraint is ranked with respect to every other constraint; in a partial order, the ranking remains incomplete. The following abstract example, adopted from Anttila (1997b), helps us understand the distinction between total and partial orders.

The grammar A >> B >> C is a total order. By removing one of the rankings, e.g. B >> C, we obtain the partially ordered grammar in (6):

(6) *partially ordered grammar*
   - Constraints: A, B, C
   - Rankings : A >> B, B >> C

In this grammar, C is no longer ranked with respect to B. It, therefore, corresponds to the following *two* totally ordered tableaux:

(7) *totally ordered tableaux*

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

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

This example shows that *one* grammar corresponds to *two* tableaux which appoint different candidates as winners: *cand2* is the winner in T1 and *cand1* is

[5] Positional markedness relativized to strong positions differs from positional markedness sensitive to weak positions (see Zoll 1998, 2004; Grijzenhout & Krämer 2000 and references cited therein). See de Lacy (to appear) for typological predictions and further discussion.

[6] FAITH(voi) corresponds to the IDENT(voi) constraint. It is preferred here for mnemonic reasons.

the winner in T2. Since the grammar permits two rankings, it also permits two outputs or, in simpler words, it predicts variation. Moreover, if a grammar is defined as a total order, then in the case of variation we deal with multiple grammars (Anttila 1997b: 29).

By adding more rankings in a partially ordered grammar, we generate proper subsets of this grammar. Anttila (2002: 21) explains: "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."

A welcome result of this model is that the machinery to model statistical preferences comes for free. In our abstract example, *cand1* wins in 1/2 of all tableaux; the same holds for *cand2*. Thus, the predicted frequency for each candidate is 50%. Anttila (1997b: 27) states:

(8) a. A candidate is predicted by the grammar iff it wins in some tableau.
b. If a candidate wins in *n* tableaux and *t* is the total number of tableaux, then the candidate's probability of occurrence is *n/t*.

To conclude, partial ordering not only explains how variation arises, but it also predicts the absolute frequency with which variants will be observed. In the next section, motivated by Tzakosta's (2004) MPG model of acquisition, we propose an implementation of partial ordering to SLI.

### *4.2 Partial ordering and Multiple Parallel Grammars in SLI*

Tzakosta (2004) and Revithiadou & Tzakosta (2004a,b) propose a non-linear model of language acquisition according to which acquisition proceeds through a complex network of *multiple parallel grammars* where constraints may be partially unranked. Based on longitudinal production data from thirteen children acquiring Greek, Tzakosta observes a great amount of both inter- and intra-child variation. On the basis of these findings, she comes to the conclusion that acquisition does not consist of a series of linearly ordered grammars, each one corresponding to a clearly defined developmental stage. On the contrary, each child makes use of a set of multiple parallel grammars, which are responsible for the rising of variable output productions for a given input string during the same developmental phase. Tzakosta provides ample evidence that variation is systematic. Moreover, she claims that the grammars or else, *cophonologies*, each child employs at a certain developmental phase are linked to each other; for instance, one may entail another. Those cophonologies that share more properties with the target grammar constitute the backbone of the acquisition process. Because they are reinforced by positive evidence, the child uses them to reach the final state of the adult/target grammar.

The main objection to the MPG model of acquisition is that there is no principled limit on the number of possible grammars, hence any kind of variation is predicted to be possible. In this paper, we show that partial ordering

offers a more restrictive version of the cophonology-oriented model of acquisition proposed by Tzakosta (2004). More importantly, partial ordering allow us to formally define developmental paths. In the ensuing paragraphs, we flesh out the specifics of the implementation of partial ordering to acquisition and, in particular, to the Greek SLI case study.

Let us assume a partially ordered grammar which consist of the constraint set in (9) and has no established rankings. Such a grammar subsumes twenty-four (24) total orders that produce variable outputs. We take the input phoneme to be the voiced labial /b/ and show its distribution to the following environments: initial stressed (#bV́), initial (#bV), medial stressed (bV́) and medial (bV). Given the twenty-four total orders, there will be faithful (i.e. #bV́) and unfaithful (i.e. #pV́) outputs. All total orders with their respective faithful and unfaithful outputs are given in Table 4.

(9) *partial grammar*
- Constraints: VOI#C, *VOI, *VOIσ́, FAITH
- Rankings: none

Table 4: Total orders and (un)faithful outputs

| | RANKINGS | UNFAITH | FAITH |
|---|---|---|---|
| 1 | *VOI#C >> *VOI >> *VOIσ́ >> FAITH | #pV́ #pV pV́ pV | |
| 2 | *VOI#C >> *VOIσ́ >> *VOI >> FAITH | #pV́ #pV pV́ pV | |
| 3 | *VOI#C >> *VOI >> FAITH >> *VOIσ́ | #pV́ #pV pV́ pV | |
| 4 | *VOI#C >> *VOIσ́ >> FAITH >> *VOI | #pV́ #pV pV́ | bV |
| 5 | *VOI#C >> FAITH >> *VOIσ́ >> *VOI | #pV́ #pV | bV́ pV |
| 6 | *VOI#C >> FAITH >> *VOI >> *VOIσ́ | #pV́ #pV | bV́ bV |
| 7 | *VOIσ́ >> *VOI >>*VOI#C >> FAITH | #pV́ #pV pV́ pV | |
| 8 | *VOIσ́ >> *VOI#C >> *VOI >> FAITH | #pV́ #pV pV́ pV | |
| 9 | *VOIσ́ >> *VOI >> FAITH >> *VOI#C | #pV́ #pV pV́ pV | |
| 10 | *VOIσ́ >> *VOI#C >> FAITH >> *VOI | pV́ #pV́ #pV | bV |
| 11 | *VOIσ́ >> FAITH >> *VOI#C >> *VOI | pV́ #pV | #bV́ bV |
| 12 | *VOIσ́ >> FAITH >> *VOI >> *VOI#C | pV́ #pV | #bV́ bV |
| 13-18 | *VOI >> *VOIσ́, *VOI#C, FAITH | #pV́ #pV pV́ pV | |
| 19-24 | FAITH >> *VOI, *VOI , *VOI#C | | #bV́ #bV́ bV́ bV |

The target grammar is an order where FAITH is top-ranked (e.g. 19 in Table 4). This ranking guarantees correct production of voiced stops at all contexts. At the time the recordings were made, the SLI child had already applied some rankings between the respective constraints and, therefore, only a subset of the

total orders are actively used. This accounts for the variable pronunciation of a particular phoneme, e.g. /b/, at the same and/or different environments. However, the data makes clear that mastery level seems to depend on place of articulation as well: dorsal voiced stops are more faithfully produced than coronals and labials (see Figure 2). This clearly suggests that phonemes are linked with different partial orders.

With respect to the voiced labial stop /b/, we have seen that it displays 60% devoicing in initial stressed positions, 56.25% devoicing in initial unstressed positions, 50% in medial stressed ones; no devoicing takes place in medial unstressed syllables. These results hint at a partially ordered grammar composed of six (6) total orders listed in (10). Numbers refer to the rankings in Table 4. Note that the target grammar is included in the rankings as well.

(10) /b/-grammar

| RANKINGS: 10, 4, 11, 5, 19, 20 | UNFAITH | FAITH |
|---|---|---|
| *VOIσ >> *VOI#C >> FAITH >> *VOI | #pV #pV̥ pV̥ | bV̥ |
| *VOI#C >> *VOIσ >> FAITH >> *VOI | #pV #pV̥ pV̥ | bV̥ |
| *VOIσ >> FAITH >> *VOI#C >> *VOI | #pV pV̥ | #bV̥ bV̥ |
| *VOI#C >> FAITH >> *VOIσ >> *VOI | #pV #pV̥ | bV̥ bV̥ |
| FAITH >> *VOI#C >> *VOIσ >> *VOI | | #bV̥ #bV̥ bV̥ bV̥ |
| FAITH >> *VOIσ >> *VOI#C >> *VOI | | #bV̥ #bV̥ bV̥ bV̥ |

Table 5 presents the predictions and observed frequencies of the unfaithful productions of the voiced labial /b/. It should be noted that, as the quantitative predictions of the partial ordering model are discrete probabilities (4/6, 3/6, etc.), it is difficult to get any closer to the observed frequencies. A larger corpus of data or a more fine-grained grammar with more constraints might resolve this problem.

Table 5: /b/ unfaithful outputs

| **outputs** | **wins in** | **PRED. %** | **OBS. %** | **EXAMPLES** |
|---|---|---|---|---|
| a. #pV̥ | 4/6 | 66.66 | 60 | páles /báles/ |
| b. #pV̥ | 3/6 | 50 | 56.25 | panánes /banánes/ |
| c. pV̥ | 3/6 | 50 | 50 | kapána /kabána/ |
| d. pV̥ | 0/6 | 0 | 0 | ___ |

The coronal voiced stop /d/ is totally unfaithful in initial positions and totally faithful in medial unstressed ones. In medial stressed positions, on the other hand, there is an even split. The partial order responsible for these results is given in (11). It contains two fixed rankings which yield the described pattern of variation. The target grammar is not represented in this partial order, that is, FAITH is not ranked high in any of the observed rankings. Table 6 presents the predictions and observed frequencies of the unfaithful productions of this phoneme.

(11) /d/-grammar

| RANKINGS: 4, 5 | UNFAITH | FAITH |
|---|---|---|
| *VOI#C >> *VOIσ >> FAITH >> *VOI | #tV #tV̩ tV̩ | dV |
| *VOI#C >> FAITH >> *VOIσ >> *VOI | #tV #tV̩ | dV̩ dV |

Table 6: /d/ unfaithful outputs

| outputs | wins in | PRED. % | OBS. % | EXAMPLES | |
|---|---|---|---|---|---|
| a. #tV̩ | 2/2 | 100 | 100 | tíni | /díni/ |
| b. #tV | 2/2 | 100 | 100 | tiváni | /diváni/ |
| c. tV̩ | 1/2 | 50 | 50 | potíci | /podíki/ |
| d. tV | 0/2 | 0 | 12.5 | ðéto | /ðédro/ |

The velar voiced stop /g/ exhibits variation only in word medial (stressed and unstressed) environments. In (initial, medial) unstressed positions, it displays correct use. The partial order responsible for this distributional pattern is given in (12). It contains two total orders: VOIσ >> VOI, *VOI#C and FAITH >> VOI, *VOI#C, which yield the described pattern of variation. Interestingly, the target grammar is contained in this partial order. Table 7 presents the predictions and observed frequencies of the unfaithful productions of this phoneme.

(12) /g/-grammar

| RANKINGS: 11,19 | UNFAITH | FAITH |
|---|---|---|
| *VOIσ >> FAITH >> *VOI#C >> *VOI | #kV̩ kV̩ | #gV gV |
| FAITH >> *VOIσ >> *VOI#C >> *VOI | | #gV gV̩ #gV gV |

Table 7: /d/ unfaithful outputs

| outputs | wins in | PRED. % | OBS. % | EXAMPLES | |
|---|---|---|---|---|---|
| #kV̩ | 1/2 | 50 | 50 | kási | /gázi/ |
| #kV | 0/2 | 0 | 0 | ___ | |
| kV̩ | 1/2 | 50 | 50 | akúli | /agúri/ |
| kV | 0/2 | 0 | 0 | ___ | |

To sum up, we propose a model of *multiple partially ordered grammars* for acquisition. More specifically, we claim that the child starts with a partially ordered grammar and continues with establishing ranking relations among the constraints involved. Thus progressively, partial grammars contain fewer and fewer total orders. This process is completed when the child reaches the final state; that is, when it acquires the constraint order of the target grammar. In the SLI case examined here, the child associates phonemes with specific partial orders. This accounts both for variation in his outputs, e.g. [páles] for /báles/ 'ball-PL', [bála] for /bála/ 'ball-SG', as well as for the difference in voicing contrasts among voiced stops. The relation between these partial orders is

discussed in section 4.3, where the issue of developmental paths is also addressed.

### *4.3. The 'Grammar Inclusion Hypothesis'*

Once we assume that grammars are partial orders, it is easy to see some interesting relations between them. One is the inclusion relation: grammars that include other grammars (Anttila 1997b). For instance, in (13), Grammar 2 is included within Grammar 1 or, to put it differently, Grammar 2 is a subset of Grammar 1.

(13) *grammars include other grammars*

Grammar 1: A >> B >> C
A >> C >> B
} Grammar 1 ⊃ Grammar 2
Grammar 2: A >> C >> B

Now, let us explore whether the partial orders of /b, d, g/ are related to each other. Table 8 summarizes the partial orders for each phoneme with their respective total orders and highlights some interesting relations holding between them and the target grammar. Firstly, the /b/ partial order includes the /g/ and /d/ partial orders; in other words, the rankings of /d/ and /g/ are subsets of the rankings of /b/. Secondly, the partial orders associated with /b/ and /g/ include the target grammar; the /d/ partial order doesn't.

Table 8: inclusion relations between partial orders

| | RANKINGS | INCLUSION |
|---|---|---|
| b-partial order | {10, 4, 11, 5, 19, 20} | b ⊃ d, b ⊃ g, b ⊃ target grammar |
| d-partial order | {4, 5} | ∅ |
| g-partial order | {11, 19} | g ⊃ target grammar |
| target grammar | {19} | |

Looking at the SLI facts from this perspective, one may claim that the /b/ partial order reflects a more primitive grammar typical of an early phase of acquisition. It contains less total orders, thus, is a grammar that needs to be worked out more. In contrast, the /g/ partial order is very close to the final state because, first, it contains less total orders compared to /b/ and, second, it subsumes the target grammar. This explains in part the high percentage of faithfulness in the realization of the dorsal voiced stop. Let us assume that an earlier, less advanced version of the /g/ grammar was typologically like /b/. Then, it is evident that the child has followed a 'smart' path; it picked out those rankings that include the target (more faithful) grammar. On the contrary, the /d/ partial order reflects a less 'smart' path of acquisition for the following reason: the child has confined the total orders to a set in which the target grammar is not included. The described state of affairs is depicted in Figure 4.

| | | | | |
|---|---|---|---|---|
| target grammar | $\not\subset$ | /d/-grammar | $\subset$ /b/-grammar | 'non-smart path' |
| target grammar | $\subset$ | /g/-grammar | | 'smart path' |

Figure 4. Smart and non-smart developmental paths

To summarize, partial ordering allow us to formally define developmental paths by means of the inclusion relation. Early grammars are partial orders which have less rankings and, consequently, more total orders. Advanced grammars, on the other hand, are partial orders which have more refined rankings and hence fewer total orders which are proper subsets of early grammars. Moreover, partial ordering makes it possible to draw a distinction between *smart paths*, i.e. partial orders that subsume the target grammar and *non-smart paths*, i.e. partial orders that leave out the target grammar. The implementation of the inclusion relation to acquisition is expressed as the *Grammar Inclusion Hypothesis*, stated in (14):

(14) *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.

An alternative view to account for variation in the realization of voiced stops would have to call upon *context-sensitive radical underspecification*, (cf. Kiparsky 1993; Dinnsen 1996 *et seq*.). Dinnsen (1996) has suggested that the representation of the unmarked value of a feature may vary by syllable position. For instance, the default value for [voice] prevocalically is [+voice], hence voiceless stops become voiced before their distinctive feature is acquired. The reverse holds for word-final position. Possibly, the account can be extended to include other prosodic positions (e.g. word initial positions, etc.) or it can be relativized to headedness (e.g. heads of feet, prosodic words, etc.).

According to context-sensitive radical underspecification, the absence of a voicing contrast in early developmental stages suggests that the feature [voice] is underspecified for all stops in all contests and is filled in by default as [-voice]. At a subsequent stage, the voicing contrast emerges in certain contexts yielding a new class of sounds, namely voiced stops. The new set of sounds diffuses gradually through the lexicon affecting only a portion of it. In the SLI case, the relevant context is the word medial unstressed position, which would now be specified as [+voice]. The specification of more and more words over time results in phonetic changes in these words and brings them in compliance with the target system.

It is crucial in this approach that the values of a contrastive feature available for specification at the underlying level cannot occur at the same context; they are in complementary distribution. This account, however, makes certain predictions that are not confirmed by the Greek SLI data. First, it predicts alternating sounds, i.e. voiced and voiceless stops, to be in complementary

distribution, a prediction that is clearly not met in Greek SLI case since there are environments where both sounds occur, e.g. word medial position. The occurrence of voiceless stops in this case is viewed as a continuation of an earlier error pattern. After all, the change does not apply across-the-board. The higher degree of faithfulness productions in dorsals, however, is left unaccounted for. Second, it excludes the possibility of having variable outputs for the same lexical item. Contra expectations, however, 'impossible' variants such as [bénume] and [pénume] for /bénume/ 'we enter-3PL.PRES', [banánes] and [panánes] for /banánes/ 'banana-PL' are largely attested. Third, the underspecification approach makes no predictions about developmental paths. It asserts that language development proceeds through gradual lexical diffusion without spelling out the details of how this is accomplished. Finally, it cannot accommodate statistical preferences.

We conclude, therefore, that only a theory that makes crucial use of multiple partially ordered grammars can provide a uniform interpretation of the acquisition facts examined in this study. Moreover, we maintain that any full-fledged theory of acquisition must address the issue of variation in the production of children's outputs, if it wants to attain explanatory adequacy. For this purpose, a comprehensive theory of developmental paths needs to be constructed as well.

## *5. Conclusions*

In this paper, following Tzakosta (2004), we propose a non-linear order of language acquisition to account for the production data of a young Greek boy diagnosed with SLI. We focused on voiced stops which show no systematic and consistent use compared to their voiceless counterparts. More specifically, we showed that first, dorsal stops are more faithfully realized than coronals and labials and second, voicing is less likely to be neutralized in prosodically non-prominent positions; that is, voiced stops tend to be replaced by their voiceless counterparts in word initial and/or stressed positions. As a result, variation is observed in the SLI child's speech. To account for the observed patterns of variation, we proposed a grammatical model that incorporates partial ordering along the lines of Anttila's (1997a,b) theory of phonological and morphological variation. Thus, we attributed variation not to differences in the SLI child's phonological representations but to the existence of partially ordered grammars. The implementation of partial order to language acquisition has a number of advantages: first, it allows us to confine the set of possible grammars a child makes use of during the acquisition process. As a result, the partially ordered model dispenses with the problem of the unrestricted explosion of grammars that the MPG theory encounters. Second, it offers a principled basis to define developmental paths, namely the *Grammar Inclusion Hypothesis*. Third, because it is intrinsically liable to a quantitative

interpretation, it can explain statistical tendencies: the number of total rankings that generate each output is proportional to the relative frequency of this output.

It remains an open question, however, whether the SLI phonology represents a delayed or a deviant system. Without any doubt, devoicing is a common practice in typically developing young learners' speech (Levelt 1994; Fikkert 1994, among others). It is possible, therefore, that we are dealing with a delayed pattern of language acquisition. The fact that dorsals, however, exhibit a much higher percentage of correct use than coronals and labials suggest a deviant behavior. We acknowledge that our findings are based on a case study and, therefore, more needs to be understood about both SLI and typical development in Greek before this question receives a definitive answer. In future research, the predictive and explanatory power of the *Grammar Inclusion Hypothesis* should also be tested, especially, its predictions regarding the construction of 'smart' and 'non-smart' developmental paths.

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