Morphosyntactic Illusions in Down Syndrome
The Role of Phonetics and Phonology[1]

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Abstract
This study brings together morphosyntactic and phonetic/phonological analyses, which have not informed each other to date, to determine what conditions omissions and substitutions of phonemes, resulting in a change of morphosyntactic features. Effects of omission and substitution of inflectionally (/s/, /n/, /t/) and non-inflectionally relevant phonemes were examined in word-initial, word-medial, and word-final positions for all morphosyntactic features with 16 Cypriot Greek individuals with Down Syndrome aged 19–45, and 17 Cypriot Greek typically developing children aged 7–8. Results show that the majority of omissions and substitutions of inflectionally related phonemes are due to phonetic/phonological restrictions rather than morphosyntactic difficulties. Percentages of incorrect use with morphosyntactic features are significantly reduced once phonetic/phonological restrictions are factored out. This is especially evident for /s/ omission with nominative (83% vs. 99.3%). Consistencies with consonant omissions (specific consonants are more prone to omission) and substitutions (certain phonemes substitute for certain other phonemes) are observed. This study's findings stress the importance of a parallel phonetic/phonological and morphosyntactic analysis when studying the language development of individuals with DS and show that lack of parallel analyses could lead to a misrepresentation of the morphosyntactic abilities of individuals with DS.

1. Introduction

Down Syndrome (DS) is one of the most common genetic causes of cognitive and linguistic restrictions, caused by the presence of an extra copy of chromosome 21, generally known as trisomy 21, with one in six to seven hundred births (Epstein 2006, Nelson and Gibbs 2004). Linguistic, cognitive, and physiological characteristics particular to individuals diagnosed with Down Syndrome have been argued to play a vital role in their reported articulation and language difficulties (Chapman et al. 1998, Stoel-Gammon 2001). This study brings together results from morphosyntactic and phonetic/phonological analyses, which have not informed each other to date, to determine what conditions omissions and substitutions of phonemes, resulting in a change of morphosyntactic features.

Phonological studies show evident problems with a number of consonants, especially /r/ and /s/ (Stoel-Gammon 2001, Bacsfalvi 2008). Studies examining the morphosyntax of English individuals with DS report that assignment of inflectional marking (e.g. past tense *–ed* or 3rd person *–s*), along with other syntactic operations, is impaired (Chapman *et al*. 1998, Eadie *et al*. 2002, Laws

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and Bishop 2003). In Greek, /s/, /n/, and /t/ are the consonants mainly used in verbal and nominal inflectional environments. Therefore, in productions like those given in (1) it is difficult to determine whether the omission of /s/ is due to a morphosyntactic disability or an articulation restriction, related to the distinct physiology of the articulation apparatus of individuals with DS.

(1)	a.	Scott	swim-∅	every	day.
	b.	Esi	kolimb-a∅	kaθe	mera.
		2SG-NOM	*swim.IMPF-PRES.3?.SG*	*every*	*day-FEM.ACC.SG*

/s/ omission in (1a) results in a change of the 3rd person feature to either the infinitival form or another feature value. In (1b) it causes the produced form to be of the same form as the one used for 3rd person even though we would expect the production of 2nd person. It is unclear whether *–s* omission surfaces as a result of a morphosyntactic disability related to subject-verb agreement, or alternatively whether physiological restrictions make it difficult for individuals with DS to produce /s/, thus surfacing these morphosyntactic illusions.

I present results on the production, omission and substitution of consonants by Cypriot Greek (CG) individuals diagnosed with DS, and compare their performance with that of CG children with typical language development (TLD). The goal of this study is to establish whether morphosyntactic problems observed with adults with DS are due to phoneme omissions and substitutions, a more general physiological restriction that ultimately results in a deviant phonetic and phonological system. These may cause the production of a word to differ from what we would typically expect to be produced by an adult speaker in a parallel environment. To address this goal I consider two types of morpho-syntactic analyses: one where phonetic/phonological effects are integrated and one where they are not taken into consideration. This study also aims to call into question previous reports on inconsistent phonological patterns (Dodd 1976, Kumin 2006) by attributing some of the unexpected consonant substitutions to surface due to morphosyntactically triggered processes.

Beyond the fact that this study calls into question previous reports on severe morphosyntactic impairment, it also makes the following new contributions:

- It is the first study to date that brings together results from morphosyntactic and phonetic/phonological analyses, which consequently allows for a more inclusive analysis on the overall linguistic abilities of individuals with DS.
- It shows the significant effects that phonetic/phonological restrictions may have on morphosyntactic features and how these may be misrepresented, due to the absence of a joined analysis.
- It offers an alternative analysis on the inconsistent phonological patterns by showing them to be morphosyntactic in nature.
- It determines the level of full acquisition of individuals with DS and children with TLD. Once that is established, the information will be used to trace the beginning and the intermediate steps for younger children.

In the rest of the paper I first discuss previous work on the phonetic/phono-logical and morphosyntactic abilities of individuals with DS (section 2). I then

present the methodology employed for this experimental study (section 3). Following that, I discuss overall results on consonant production, omission and substitution. Then, I zoom in to examine effects caused by /s/ omission and substitution and determine the nature of those omissions and substitutions. A discussion on the effects of the results on the individuals' with DS morpho-syntactic abilities is offered in section 5. In section 6 I conclude.

2. The Linguistic Profile of Down Syndrome

Down syndrome is associated with certain cognitive, linguistic and physiological restrictions and distinct characteristics, which have been argued to cause their language production to appear different than that of individuals with TLD (Chapman *et al*. 1998, Stoel-Gammon 2001). Individuals diagnosed with Down Syndrome may present apraxia of speech (Dodd, 1976, Kumin 2006). It is believed that verbal short-term memory limitations (Buckley 2008, Conners et al. 2001, Vicari et al. 2001) as well as mild to moderate hearing loss (Nittrouer 1996, Roberts 1997, Stoel-Gammon 2001) may significantly affect the language development of individuals with DS. The cognitive level of individuals with DS may vary from mild (IQ: 50–70), to moderate (IQ: 35–50) and rarely to severe (IQ: 20–35) (American Academy of Pediatrics, Committee on Genetics 2001). The mental age of approximately 5 years is suggested for mean chronological age of 30 (Rondal and Comblain 1996). However, Chapman et al. (1998) and Fowler et al. (1994) among others, argue that their linguistic abilities are lower than those of their suggested mental age: parallel to a 2-year-old with TLD, for 5–8 year old children with DS. Adults with DS may exhibit slight improvement reaching the linguistic capabilities of 3-year-old children with TLD.

Studies across different languages on the linguistic abilities of individuals with DS present comparable results as to their performance with complex syntactic structures. Several weaknesses and restrictions are reported with: (non-)referential *wh*-questions (Tsakiridou 2006), reflexives, referential and quantificational antecedents and binding (Stathopoulou 2009) for Greek individuals with DS; or interrogatives in general for Dutch individuals with DS (Bol and Kuiken 1990); binding (Principle A) for English and Serbo-Croatian DS (Perovic 2006); passive constructions for French individuals with DS (Tager-Flusberg 1994) and Portuguese individuals with DS (with the exception of one participant) (Coelho de Barros and Rubin 2006); and 10 different types of complex structures, including conjoined and multiple embedding for English adolescents with DS (Thordardottir et al. 2002).

Studies on their morphosyntactic abilities across different languages report contradicting results. Inflectional marking (e.g. 3rd SG *–s*, regular past tense *–ed*) is reported impaired by the majority of studies on English individuals with DS (Chapman *et al*. 1998, Eadie *et al*. 2002, Laws & Bishop 2003). Less problematic use of *–ing*, regular plural *–s* as well as the use of determiners, but a relatively strong performance for irregular past, modals, and 3rd person irregular

present tense forms (*does* and *has*) have been reported (Eadie et al. 2002, Laws and Bishop 2003). In an earlier study Chapman et al. (1998) report that English children and adolescents with DS regularly omit words receiving inflectional marking (plural *–s*, possessive *–s*, 3rd person singular, contractible auxiliaries and copulas, present progressive *–ing* and past tense *–ed*) as well as function words (copulas, auxiliaries, prepositions, modals, articles, pronouns, adverbials, conjunctions, and infinitival *to*). However, a number of inconsistencies were observed in results across these studies, especially with regular past tense. While on the one hand in the Laws and Bishop (2003) study participants with DS did well with past tense *–ed*, results from Eadie et al. (2002) show participants to perform considerably lower than their controls. Moreover, while English individuals with DS exhibit at most 40% accuracy (Eadie et al. 2002) with S/V agreement quite the contrary is true for German adults with DS, since percentages of accuracy with S/V agreement reach 98.4% (Schaner-Wolles 2004). Similarly, previous work on CG adults with DS reports 95% – 99% accuracy with the production of aspect, tense, person, number and case (Christodoulou 2011, 2013). Similarly, Stathopoulou (2009) and Stathopoulou and Clahsen (2009) report high scores with the comprehension of past perfective for Greek adolescents with DS who performed as accurately as with their age-matched controls. They do observe however, that their performance was significantly better with verbs where aspect is marked with an *–s–* suffix (regular), as opposed to verbs where aspect is encoded in the verbal root (irregular). On the contrary, morphosyntactic features with Spanish and Italian children with DS are also reported impaired without any specific reference as to what is actually affected (Galeote et al. 2008, Galeote et al. 2013 for Spanish and Caselli et al. 2008, Vicari et al. 2000, Vicari et al. 2002 for Italian).

Physiological restrictions, such as differences with their oral cavity and phonological limitations associated with DS, are reported to affect the production of a several phonemes (Dodd, 1976, Kumin, 2006, Stoel-Gammon 2001). For instance, hypotonia of facial muscles and limitations in lip movement may affect the production of labials (/b/, /p/, /m/) and round vowels (/o/, /u/). Increased tongue volume causes difficulties in the production of lingual consonants; liquids (/l/, /r/), stops (/k/, /g/, /t/, /d/), fricatives (/s/, /x/) etc. (Bacsfalvi 2008, Stoel-Gammon 2001). Additionally, word or utterance edges or consonant clusters trigger consonant omission. Previous studies argue for inconsistencies concerning the phonological limitations and phoneme production, omission and substitution when not using the expected/targeted form (Dodd 1976 and Kumin 2006).

Given the phonemes used in the inflectional paradigms for each language, phonetic and phonological restrictions may affect the surfacing of inflectional marking. Note that while /s/, /z/, /t/, /d/ are consonants used for English inflectional marking, mainly /s/, /n/ and /t/ are used for Greek inflectional marking. Hence, this study examines the production of CG adults with DS to determine if there is an overall problem with the production of certain phoneme. Further, I examine whether the inconsistencies reported for English individuals

with DS are also observed with CG adults with DS or whether potential inconsistencies can be accounted for under a different analysis (i.e. they could be morphosyntactically triggered). Finally, I examine inflectionally related phonemes to determine whether their omission and substitution is conditioned by phonetic and phonological restrictions or morphosyntactic impairment. To achieve this, I study the effects of production, omission and substitution of phonemes used in inflectional marking, in both inflectional and non-inflectional environments, to determine what triggers their omission or substitution.

3. Methodology

3.1 Participants

Sixteen CG adults aged 19;0 to 45;11, who had previously been diagnosed with DS and moderate mental disability (Raven's IQ test) participated in this study. All participants had undergone auditory screening and received minimal to no speech-language therapy. The control group consisted of seventeen CG children with typical development, aged 7;0 to 8;11, who matched the suggested mental age[2] of the CG participants with DS. All participants were bilectal speakers of the Cypriot Greek variety (cf. Rowe and Grohmann 2013). The *Wechsler Intelligence Scale for Children (WISC-III)* IQ test for ages 6-16 was administered to assess the cognitive level of the participants. Both MLU and IQ scores are considerably higher for TD children than for adults with DS. A one-to-one matching comparison between the two groups is restricted by the choice of the control group and IQ test. These were considered the best options, based on the limited information available in the literature at the time of data collection. I acknowledge this to be a limitation of this study, which however does not affect the participants' performance in any way. IQ and MLU scores[3], along with other participant information are reported in Table 1.[4]

[2] The mental age of German individuals with DS individuals participating in the Schaner-Wolles (2004: 108) experiment ranged between 2;5 and 7;4 (chronological age: 7;3 to 41;10). Moreover, Stoel-Gammon (2001: 96) reports that it is possible for DS individuals to reach the mental age of 7 or 8 years. Since adults with DS were tested, it was decided that control participants should match approximately the highest mental age reported. Hence, TD children aged 7 to 8 were recruited. Moreover, I wanted to compare adults with DS to children at their latest stages of language/ grammar acquisition, or children who had fully acquired the grammar of (Cypriot) Greek.

[3] Following Marinis (2003), MLU scores are counted in words.

[4] The choice of the IQ test was made based on two factors: (i) whether the IQ test included both verbal and non-verbal tests, and (ii) the availability of a version standardized for Greek. 11 verbal and non-verbal IQ tasks were used. WISC III cannot calculate IQ for ages younger than 6;2, therefore we cannot have the exact mental age for participants with Down Syndrome. We only know that their IQ scores are lower than 6;2. This finding is in agreement with Rondal and Comblain, (1996) suggesting that the mental age of approximately 5 years for adults with DS.

Groups	N	Gender		Age Range	MA	IQ WISC	MLU
		F	M				
CG_{DS}	16	9	7	19;0 - 45;11	>6;2	31	5;10
CG_{TDC}	17	8	9	7;0 - 8;11	8;6	106	7;10

Note: M= Male, F= Female, MA= Mental Age, MLU= Mean Length of Utterance
TABLE 1: Participant Information for CG adults with DS and CG children with TLD

3.2 Materials and Method

Phonemes were examined in word-initial, word-medial, and word-final positions, as singletons and clusters, in naturalistic speech rather than embedded in carrier phrases or aided by the use of other phonetic/phonological methods. The nine experimental tasks used were primarily studying inflectional marking in a number of simple and complex syntactic structures: (a) subjunctives, (b) relative clauses, (c) *wh-* questions, (d) nominal/adjectival predication, (e) negation, (f) conjoined DP subjects, (g) commands, (h) clefts, (i) gerund constructions, etc. After a general analysis, phonemes were separated based on whether they occurred in inflectional or non-inflectional environments. All possible verbal and nominal feature combinations were examined by the nine experimental tasks. These result in a large variety (over 200) of phonological exponents, with different phonemic representations. The morphosyntactic features affected by /s/ omission and substitution are: aspect, person and number for both *nominal* features (determiners, adjectives, nouns, clitics, etc.) and *verbal* features (verbs and copulas), case and gender. All of the above are accounted for in this study.

Experiment	Task (no. of items) and Target
Experiment 1 (visual stimuli)	***Task 1*** (13): **VERCS**: Video Elicitation of Relative Clauses and Subjunctives
	Examines relative clauses and subjunctive clauses
Guided Production	***Task 2*** (13): **MaWiC**: 'Magic Window' Clauses
	Examines relative clauses, verbal and nominal Inflection
	Task 3 (27): **PTEDS**: Past Tense Elicitation in Down Syndrome
	Examines past tense and subject–verb agreement (S/V Agr)
Experiment 2 (audio stimuli)	***Task 1*** (47): 'Say what I say'
	Examines S/V Agr, case, aspect and tense combinations in simple and complex structures
Elicited Imitation	***Task 2*** (11 sets): **GAC**: Gerund–Agreement Clauses
	Examines S/V Agr and gerunds
Experiment 3 (audio stimuli)	***Task 1***: **STEDS–Pres**: Story Telling Elicitation in Down Syndrome – present ***Task 2***: **STEDS–Past**: Story Telling Elicitation in Down Syndrome – past
Story Telling	Examines present and past (respectively), but also S/V Agr, case and different clause types for both
Experiment 4 (visual stimuli)	***Task 1***: **EPIC**: Elicited Production of Imperatives and Commands
	Examines imperatives and commands
Elicited Production	***Task 1***: **QuForm**: Questions Formation
	Examines construction of questions through an interview

TABLE 2: Summary of Experimental Tasks

What is different about this study is the methodology of data collection and analysis, which attempts to control for factors external to morphosyntax. Namely, articulation restrictions are controlled for in order to determine what is truly responsible for grammatical differences between the two groups. Additionally, this study employs a variety of experimental methods in data collection combining elicited production, elicited imitation, storytelling, spontaneous speech, etc. Finally, an innovative approach to data analysis was introduced, where productions that do not match the target were further analysed to determine in what way they differed from the target and what was triggering the alternative production, namely, articulation restrictions, differences in the phonological system or a morphosyntactic disability.

Example (1) illustrates one of the experimental stimuli used in *Experiment 1 – Task 3* to elicit past tense. The story narrated in the video clips is about a party that happened the night before. During the party some friends were mis-behaving. Because their behaviour was upsetting, a forgetting fairy appeared to teach them a lesson. She put fairy-dust on her arrows and touched them to make them forget what had happened the night before. Participants were asked to remind the people in the video what they each did the night before. When it appeared on the screen, participants had to produce a sentence along the lines of (2). Examples in (3) give some of the syntactic structures used in the imitation production task (*Experiment 2 – Task 1*).

(2) <u>PTEDS - Past Tense, and Nominal Inflection</u>

Mia	kopell-a	e-krat-us-en	en-a(n) ...
one-FEM.SG.NOM	*girl*-FEM.SG.NOM	PAST-*hold*.IMPF-PAST.3.SG	*one*.NEU.SG.NOM

... aγor-i	s-tus	om-us	tis.
boy-NEU.SG.ACC	*on*-DET.MASC.SG.ACC	*shoulder*-MASC.SG.ACC	3.FEM.GEN.SG

'A girl is holding a boy on her shoulders.'

(3) <u>"Say what I say" – Imitation of Simple and Complex Structures</u>

(a) *Clause Targeting a Cleft, Past, and Subjunctive*

En	ton	Andre-an	pu	ið-a …
BE.PRES.3.SG	DET.MASC.SG.ACC	*Andreas*-MASC.SG.ACC	*that*	*see*.PRF-PAST.1.SG

… na kle-i.
SUBJ *cry.IMPF-PRES.3.SG*
'It's Andreas that I saw crying.'

(b) *Clause Targeting Predication and Conjoined DP Subjects*

Ta mil-a ke i banan-es ...
*DET.NEU.**PL.NOM*** *apple-NEU.**PL.NOM*** *and* *DET.FEM.**PL.NOM*** *banana-FEM.**PL.NOM***

... ine ɣlik-a frut-a.
be.IMPF.PRES.3.SG/PL *sweet-NEU.**PL.NOM*** *fruit-NEU.**PL.NOM***
'Apples and bananas are sweet fruit(s).'

Productions were recorded in Praat at a sampling rate of 22,050Hz with an attached microphone (Logitech 980240-0914 analog desktop microphone with mono recording), plugged directly into the laptop.[5] All utterances were transcribed while listening to the audio, and observing both the spectrogram and the waveform in Praat, using narrow transcription. Productions are evaluated based on: (a) matched the targeted or expected utterance[6] and (b) what and how something is actually produced, based on the linguistic environment in which it is produced. Instances where participants would reform the structure to a grammatical alternative were observed. Data collection resulted in a database of approximately 48,000 words, and over 50,000,000 data cells with phonetic, phonological, morphosyntactic (inflectional, structural, etc.) information.

Given previous reports on the individuals' with DS linguistic abilities, our natural null hypothesis is that adults with DS present impairment in the morpho-syntactic mechanisms pertaining to the assignment of inflectional features. Thus, phoneme omissions and substitutions in inflectional and non-inflectional environments resulting in a change of morphosyntactic features by CG adults with DS (and by extension any differences observed between adults with DS and children with TLD) are conditioned by morphosyntactic restrictions. However, given the reports on evident problems with physiological restrictions affecting the production of certain phonemes, we could also hypothesize general phonetic/phonological restrictions, with surfacing morphosyntactic effects being a mere accident. Note that this is the first study to date, to bring together results from morphosyntactic and phonetic/phonological analyses.

4. Results

An analysis of the participants' productions, omissions and substitutions with vowels presented minimal to no effects. Therefore, the participants' performance with vowels is not discussed in this paper. For more information with the participants' performance with vowels see Christodoulou (2011).

[5] An Olympus16 GB handheld stereo voice recorder was also used, in case of technical failure.
[6] *Targeted utterance* is the one based on controlled elicitation stimuli. *Expected utterance* is the one we would expect to be produced based on what adults would produce in the same context.

Initially, I discuss a general analysis with the phonemes presenting the majority of omissions and substitutions. Then, I zoom in and discuss the participants' performance with the voiceless fricative /s/. As explained in section 2, /s/ is observed both verbal and nominal inflectional marking, in all words positions. The confusion matrices in Table 3 and 4 illustrate the number of productions (diagonal), substitutions (vertical) and omissions (final column) for the majority of phonemes examined in this study. Specifically, the diagonal cells note the number of matched productions for each phoneme: e.g. /t/ was produced as expected 5,552 times by CG adults with DS. Moreover, vertical cells give the number of instances where a consonant was produced instead of what we would expect to find, based on TD adult production: e.g. /t/ was produced instead of /k/ 317 times. The highest number of omissions is recorded with /s/. We also see a relatively high percentage of omission with /ɾ/ and /v/.

Contrary to what is reported in past research, there is a clear consistency in substitution patterns. This shows that individuals with DS have a phonological system, based on which they perform phoneme omissions and substitutions, as opposed to performing random phonological processes. Namely, we observe a clear tendency to substitute consonants for other consonants that share the same manner of articulation, i.e. stops for other stops, or fricatives for other fricatives. Further, participants show preference for one phoneme over others sharing the same manner of articulation, e.g. /t/ for stops.[7] We observe a similar tendency with fricatives (especially voiceless ones), where /x/ plays the role of the underspecified fricative. Even though we would expect [s] to assume the role of the under-specified fricative, given that /s/ appears severely affected, another sound, namely [x], takes over. The choice of /x/ is rather unexpected, but there might be two different explanations for this choice. First, in terms of articulatory restrictions, the production of [x] makes minimal or no use of the tongue and lips, the articulators mostly affected in DS. Second, /x/ might be also a dialectal (CG-specific) preference, as we often observe that in some sub-dialects /x/ is used quite frequently to substitute for other voiceless fricatives: /**θ**ɛlɔ/ ➡ [**x**ɛlɔ] 'want', or /**f**ilɔs/ ➡ [**x**ilɔs] 'friend'. We also see a slight preference for using [x] but also its voiced equivalent [ɣ] to substitute for voiced fricatives. Finally, we also observe a slight tendency for [l] to substitute for /ɾ/ or /n/ more frequently than any other phoneme. Finally, within group statistical analysis evidenced a highly significant difference for adults with DS between omissions in consonant clusters as opposed to omission of consonants as singletons, excluding /l/ and /ð/. For the control group environment (CV vs. CCV) did play a significant role for /p/, /k/, /x/ and marginally for /ɣ/ and /v/. All comparisons across the two groups evidenced highly significant differences $p < .001$

[7] /t/ is underspecified both in terms of place and manner of articulation (Stemberger and Stoel-Gammon 1991, Stoel-Gammon and Stemberger 1994). They suggest that underspecified segments play the role of "substitutes" for consonants that develop at a later stage.

Cypriot Greek Adults with Down Syndrome																				
	Voiceless Stops			Voiceless Fricatives						Voiced Fricatives				flap	Lat app	Nasal		Omission		
Target	p	t	k	f	θ	s	ʃ	ɬ	x	v	ð	z	ɣ	ɾ	l	n	m	N		%
p	3650	99		1	3				10	1				1	1	4	17	147	p	3.7%
t		5552	51						1									332	t	5.6%
k	1	317	3481						23		1		8	1		1	3	170	k	4.2%
f	12			823	7	1			33	65	1				1			118	f	11.1%
θ	9	7	1	12	457	23	5		232	1	3	1	3			1		92	θ	10.9%
s		6		3	77	3739	15	51	115		10	8		2		14	8	2057	s	33.7%
ʃ			6		3	38	147		3			3						32	ʃ	13.8%
ɬ								∅										∅	ɬ	--
x						32			1246							5		175	x	12.0%
v	54	8	1	12						797	4		5	1	1	2	7	255	v	22.2%
ð	3	11	5		1	4			4	15	592	18	21	6	16	8	1	147	ð	17.3%
z					3	28			8		11	586						59	z	8.5%
ɣ	4		4						9	1			593		3	7	2	112	ɣ	15.2%
ɾ		4	1	3	2	2			13	3	6	1	13	2288	60	19	1	883	ɾ	26.8%
l		1	1	1						1	4		4	18	2424	12	1	223	l	8.3%
n		16													73	4812	17	835	n	14.5%
m	19	2				19				8						9	3033	67	m	2.1%

TABLE 3: Confusion Matrix for Consonant Substitutions and Omissions by Cypriot Greek Adults with Down Syndrom

Cypriot Greek Children with Typical Language Development																					
	Voiceless Stops			Voiceless Fricatives						Voiced Fricatives				flap	Lat app	Nasal		Omission		
Target	p	t	k	f	θ	s	ʃ	ɬ	x	v	ð	z	ɣ	ɾ	l	n	m	N		%
p	4158	3	6	2					2	1						1	3	21	p	0.5%
t		6496	65															54	t	0.8%
k		33	4459						3									27	k	0.6%
f				1522					6	11								5	f	0.3%
θ				2	953	2			28									3	θ	0.3%
s					3	7777			3			7		1		5		199	s	**2.5%**
ʃ						2	159		1									0	ʃ	0.0%
ɬ								∅										∅	ɬ	
x			7	1					1328		2							17	x	1.3%
v	1			5					1	1592								49	v	**3.0%**
ð				1		1			4	1	1502	1						14	ð	0.9%
z						4						614						6	z	1.0%
ɣ			2						2				974					8	ɣ	0.8%
ɾ											1	1		3635	9	1		65	ɾ	1.8%
l				5									1		3047	2		14	l	0.5%
n						2					3			2	2	7272	3	256	n	**3.4%**
m			1			4										4	3381	39	m	1.1%

TABLE 4: Confusion Matrix for Consonant Substitutions and Omissions by Cypriot Greek children with Typical Language Development

4.1. /s/ Omission

Given that /s/ is (a) the most affected phoneme, and (b) the consonant used more frequently with inflectional marking, where its omission or substitution may cause a change in morphosyntactic features, we examine the participants performance with /s/ further. The data set in (4) shows how /s/ omission and /s/ substitution may affect the morphosyntactic features inflected on a verb or a nominal in word-initial, word-medial and word-final positions. It also includes instances where /s/ has no effect in inflectional features in the same positions.

(4) **Phonetic/Phonological**

	CG_{TLD}		CG_{DS}
a.	ˈ***sp***i.t-i	➟	ˈ∅pi.t-i
	house-NEU.SG.ACC		*house-NEU.SG.ACC*
b.	ɐ.***s***ti.nɔ.mi.-ɐ	➟	ɐ.[x]ti.∅ɔ.mi-ɐ
	police-FEM.SG.NOM		*police-FEM.SG.NOM*
c.	i.ˈkɔ.n-ɛ***s***	➟	i.ˈkɔ.n-ɛ[ɬ]
	picture-FEM.PL.ACC		*picture-FEM.PL.ACC*

Morphosyntactic

	CG_{TLD}		CG_{DS}
d.	***s***ɐs	➟	**[m]**ɐs
	2*PL-GEN*		***1****PL-GEN*
e.	ɣɐ.lɐ.ˈn-ɔ***s***	➟	ɣɐ.lɐ.ˈn-ɔ∅
	*blue-MASC.**NOM**.SG*		*blue-MASC.**ACC**.SG*
f.	ˈɛ.nɐ***s***	➟	ˈɛ.nɐ**[n]**
	*one.MASC.**NOM**.SG*		*one.MASC.**ACC**.SG*

/s/ omission in (4a) and (4b) results in cluster simplification of the onset. The omission of final /s/ in (4f) also results in a CV syllable. As shown in the data set in (4), some of the CG individuals' with DS productions may result in a form with different inflectional features than those targeted. For example, /s/ omission in (4f) changes case inflection from nominative to accusative, and /s/ substitution in (4d) and (4e) change person (2^{nd} to 1^{st}) and case (nominative to accusative) features, respectively. This study investigates whether the difference in the inflectional features marked on the TD form /ɣɐlɐnɔ**s**/ and the form [ɣɐlɐnɔ∅] produced by individuals with DS in (4f) are (i) a result of restrictions related to the DS physiology and phonological system, or (ii) a morphosyntactic disability (i.e. it is grammatical).

Tables 5 and 6 give details on the overall number and proportion of /s/ productions, omissions (∅) and substitutions (/s/ → [C][8]) under each evaluation category, based on the change caused by an omission or substitution. Instances where /s/ omission and substitution does not affect the surfacing of inflectional features other than those targeted, as shown by (4a), (4b), and (4c), are included under *Phonetic/ Phonological Effects*. Instances where /s/ omission results in forms that appear to have different inflectional features than those targeted, as with (4d), (4e), (4f) are noted under *Potential Morphosyntactic Effects*.

[8] Capital C refers to any consonant that was used to substitute for any of the three tested phonemes: /s/, /n/, or /t/.

CG_{DS}	Potential Morphosyntactic Effects				Phonetic/Phonological Effects			
/s/	Tokens	Prod	∅	/s/ → [C]	Tokens	Prod	∅	/s/ → [C]
Initial	83	77	--	6	1,045	731	252	62
		92.8%	--	7.2%		60.0%	25.6%	7.9%
Medial	568	488	50	30	1,661	1,342	256	63
		85.9%	8.8%	5.3%		80.8%	15.4%	3.8%
Final	1,727	731	989	7	1,040	510	372	158
		42.3%	57.3%	0.4%		35.8%	45.0%	15.2%
TOTAL	2,378	1,296	1,039	43	3,746	2,583	880	283
		54.5%	43.7%	1.8%		69.0%	23.5%	7.6%

TABLE 5: Distribution of /s/ in Terms of its Nature and Effects for CG_{DS}

There is a clear tendency to omit word-final /s/ over the other two word positions in purely phonetic/phonological environments as well as environments where inflectional features are affected. Overall, all statistical comparisons revealing a significant difference between the two environments show that participants with DS are more likely to substitute /s/ in environments where omission or substitution has purely phonetic/phonological effects, than morphosyntactic effects. I later argue that some of these /s/ substitutions are indeed morphosyntactically conditioned, given the (i) consistency in the change of inflectional features (i.e. the surfacing inflectional feature) and (ii) the choice of the specific consonants used to substitute for /s/, like /n/ for /s/. *Paired samples t-test* for within-group comparisons revealed a significant difference with word-initial /s/ substitution, but that was due to the fact that there were no instances of /s/ substitution with morphosyntactic effects: $M = 0.000$, $SD = 0.000$ causing morphosyntactic effects, and $M = 0.261$, $SD = 0.164$ causing purely phonetic/phonological effects, $t(15) = -6.37$, $p = <.001$. No statistical significance was recorded with word-initial /s/ omissions which might cause morphosyntactic changes; the slight preference that adults with DS show for /s/ omission causing morpho-syntactic effects was not statistically significant: $M = 0.094$, $SD = 0.188$ causing morphosyntactic effects, and $M = 0.066$, $SD = 0.016$ causing purely phonetic/phonological effects, $t(15) = 0.61$, $p = .552$. Despite the fact that individuals with DS exhibit higher percentages of word-medial /s/ omission in purely phonetic/phonological environments, statistical analysis evidences a non-significant result: $M = 0.108$, $SD = 0.108$ causing morphosyntactic effects, and $M = 0.151$, $SD = 0.104$ causing purely phonological effects, $t(15) = -1.88$, $p = .080$. A non-significant result is also recorded with word-medial /s/ substitution: $M = 0.054$, $SD = 0.063$ causing morphosyntactic effects, and $M = 0.038$, $SD = 0.040$ causing purely phonetic/phonological effects, $t(15) = 1.23$, $p = .238$. The considerably high means of word-final /s/ omission causing morphosyntactic effects presents higher means, as opposed to word-final /s/ omission in purely phonetic/phonological environments. This difference did not reveal a significant result between the two environments: $M = 0.610$, $SD = 0.325$ causing morpho-syntactic effects, and $M = 0.552$, $SD = 0.310$ causing purely phonetic/ phonological effects, $t(15) = 1.69$, $p = .112$. Adults with DS are more likely to substitute a word-final /s/ with a different consonant with purely phonetic/

phonological effects, than with morphosyntactic effects: M = 0.004, SD = 0.010 causing morphosyntactic effects, and M = 0.106, SD = 0.145 causing purely phonological effects, $t(15)$ = -2.87, p = .012.

Table 6 offers a categorization of /s/ production, omission and substitution for children with TLD. /s/ production rates for TD children are at ceiling. This posits a level of difficulty determining whether TD children present a difficulty towards a certain category over another, which makes statistical analysis a necessity, to ensure that any differences would not result due to ceiling effects.

CG_{TLD}	**Potential Morphosyntactic Effects**				**Phonetic/Phonological Effects**			
/s/	Tokens	Prod	∅	/s/ → [C]	Tokens	Prod	∅	/s/ → [C]
Initial	337	337	--	0	1,351	1,343	8	0
		100%	--	0%		99.4%	0.6%	0%
Medial	898	871	15	12	1,355	1,327	24	2
		97.0%	1.7%	1.3%		98.1%	1.8%	0.15%
Final	2,697	2,586	106	5	1,363	1,308	46	9
		95.9%	3.9%	0.2%		96.0%	3.4%	0.66%
TOTAL	3,932	3,794	121	17	4,069	3,978	78	11
		96.5%	3.1%	0.4%		97.8%	1.9%	0.27%

TABLE 6: Distribution of /s/ in Terms of its Nature and Effects CG_{TDC}

Given that the significant result for word-initial /s/ omission is due to lack of omissions causing morphosyntactic effects, statistical significance is only recorded with word-medial /s/ substitution. In sum, the overwhelming majority of /s/ omissions and substitutions by both groups are not morphosyntactically conditioned. Lack of word-initial /s/ omission in morphosyntactic environments evidenced a highly significant difference: M = 0.000, SD = 0.000 causing morphosyntactic effects, and M = 0.006, SD = 0.008 causing purely phonetic/ phonological effects, $t(16)$ = 3.06, p = . 007. A word-medial /s/ omission comparison surfaced a non-significant result between the two categories: M = 0.017, SD = 0.027 causing morphosyntactic effects, and M = 0.017, SD = 0.015 causing purely phonetic/phonological effects, $t(16)$ = 0.11, p = .991. In contrast, statistical analysis on word-medial /s/ substitution revealed a significant difference, such that TD children are more likely to substitute word-medial /s/ where it could change morphosyntactic features rather than in environments where it can cause purely phonetic/phonological effects: M = 0.014, SD = 0.015 causing morphosyntactic effects, and M = 0.002, SD = 0.004 causing purely phonetic/phonological effects, $t(16)$ = 2.92, p = .010. Similarly to adults with DS, a comparison between the two categories with word-final /s/ omission surfaced a non-significant difference, providing further evidence that TD children are equally likely to omit a word-final /s/ causing purely phonetic/ phonological effects, as with morphosyntactic effects: M = 0.040, SD = 0.029 causing morphosyntactic effects, and M = 0.034, SD = 0.023 causing purely phonetic/phonological effects, $t(16)$ = 0.90, p = .383. Word-final /s/ substitution also revealed a non-significant result between the two categories: M = 0.002, SD = 0.003 causing morphosyntactic effects, and M = 0.006, SD = 0.010 causing purely phonological effects, $t(16)$ = -1.59, p = .132.

A long list of independent evidence confirms that /s/ omissions and substitutions are not morphosyntactically triggered. First, there is an overall problem with /s/ production in all word positions. Second, there are a wide variety of inflectional and non-inflectional environments /s/ omission occurs in; i.e. /s/ omission does not target a specific inflectional environment or feature value. Third, we record high percentages of accuracy with all inflectional features. Fourth, the surrounding morphosyntactic environment (i.e. other lexical elements inflected with the same feature, e.g. 2nd person on pronouns when related to the verb or determiner and adjective when related to the noun) is used accurately despite the morphosyntactic effects that /s/ omission might have on the production of a specific word/feature. For more evidence as well as an analysis on morphosyntactic features and effects form /n/ and /t/ omissions and substitutions not discussed in this paper see Christodoulou (2011, 2013).

5. Discussion

The current study records the full phonetic and phonological acquisition level of adults diagnosed with DS who had not received any speech-language therapy. It also presents results on 7–8 year-old children with TLD. In this paper I only discuss results relevant to the research question pursued in this paper. We observe that participants from both groups make use of the same alternative strategies when not producing a word as we would expect to hear it being produced from an adult native speaker. Phoneme omission, phoneme substitution and phoneme simplification are recorded.

(5) a.	ˈ***ɾ***u.x-ɐ	➡	ˈ∅u.x-ɐ	/ɾ/	omission
	cloth-NEU.ACC.PL		*cloth-NEU.ACC.PL*		
b.	***θ***ɔ.ˈɾ-i	➡	[x]ɔ.ˈɾ-i	/θ/ → [x]	substitution
	see*.IMPF-PRES.3.SG*		***see****.IMPF-PRES.3.SG*		
c.	ɛˈpsɛ***s***	➡	ɛˈ[t͡s]ɛ∅	/ps/ → [t͡s]	simplification
	last night		*last night*		

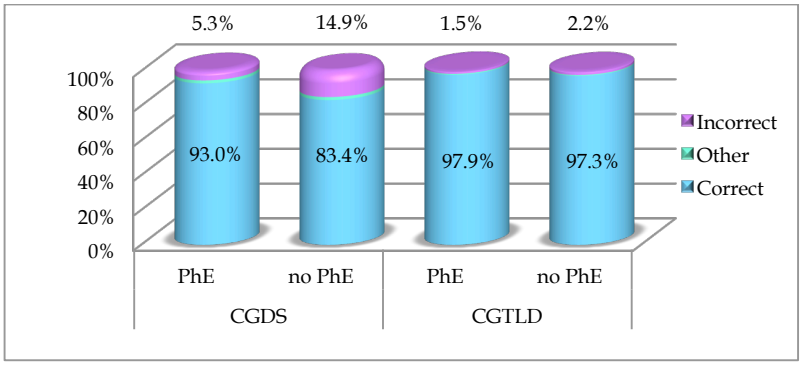
General analysis evidenced clear consistencies with consonant productions, omissions and substitutions. Therefore, the purported inconsistencies with both phonemes and inflectional features result from lack of dual analysis of the data. It appears that what is inconsistent for phonetics/phonology surfaces due to morphosyntactically triggered processes and vice versa:

(6) a.	ti***s***	➡	ti[n]	/s/→[n]	➡ expected for morphosyntax
	*DET.FEM.**GEN**.SG*		*DET.FEM.**ACC**.SG*		➡ unexpected for phonology
b.	ˈʧin-ɐ	➡	ˈ[t͡s]in-ɐ	/ʧ/→[t͡s]	➡ unexpected for morphosyntax
	those-NEU.PL.ACC		*those-NEU.PL.ACC*		➡ expected for phonology

The overall performance of CG adults with DS evidences a clear difficulty with the production of /s/. What is interesting however, is that the problem is not

only observed with /s/ in environments where its omission or substitution causes a change in the inflectional features marked on a word but also in instances where /s/ omission or substitution has a purely phonetic/phonological effect. Statistical analysis showed that for the most part there were no significant differences between the two categories and in the only instances where a significant difference did occur for adults with DS, it was phonetically/ phonologically triggered. Concerning the control group, we find only one environment where a statistically significant difference suggests that in word-medial positions CG children with TLD are more likely to substitute /s/ with another phoneme for morphosyntactic reasons. It should be noted that the greater majority of these differences concerns the change of aspectual features from perfective to imperfective. However, it should be clarified that the use of imperfective aspect in the specific environment it was used was perfectly grammatical.

In the remainder of this paper I discuss how morphosyntactic features are affected by phonetic/phonological restrictions and the significance this finding bears on how the morphosyntactic abilities, specifically use of inflectional marking, of individuals with DS is viewed. As a first step, I offer a comparison of an analysis where phonetic/ phonological issues are taken into consideration, as opposed to an analysis that does not account for these issues. Graph 1 illustrates the difference in percentage rates for the two groups when the phonetic and phonological effects (henceforth, PhE) are considered in the morphosyntactic analysis and when they are not (no PhE). It includes all production cases, excluding omission and incomplete utterances. PhE effects refer to productions where the surfacing form appears to be of the same form as another form with different inflectional features than those expected, as with; 2nd person singular *S/V* agreement, nominative and genitive case (singular forms), accusative case (plural forms), and perfective aspect.



GRAPH 1: Comparison of Overall Production with and without Phon. Analysis

Next, I zoom in to discuss the effects of /s/ omission with case and the difference in results when incorporating a phonetic/phonological analysis into the morphosyntactic analysis, as opposed to not taking there these effects into consideration. First, Table 7 (confusion matrix) shows results before phonetic/ phonological effects are incorporated into the analysis. Results are divided based on the targeted and produced case value. The number of productions that matched the target for each case value can be found diagonally, highlighted in dark grey. All values listed under any other column-row combination are productions where the target case value did not match the produced case value. The sum of each row gives the overall number of tokens targeted (horizontally), and the overall number of productions for each case (targeted and substituted) is obtained by adding the numbers under each column (vertically). For instance, there were 6,845 instances where accusative was used as targeted by children with TLD and 8 times were adults with DS used genitive, instead of the targeted nominative case.[9] Second, Table 8 summarises results after incorporating results from the phonetic/phonological analysis presented in Section 4.

	CG_{DS}					CG_{TLD}				
	NOM	ACC	GEN	VOC	%	NOM	ACC	GEN	VOC	%
NOM	3,262	**663**	8	0	82.9	4,411	**41**	2	0	99.0
ACC	187	4,760	**63**	1	95.0	19	6,845	**16**	0	99.5
GEN	12	**68**	834	0	91.3	2	**16**	1,569	0	98.9
VOC	0	0	0	100	100	0	0	0	59	100

(Legend: NOM= Nominative, ACC= Accusative, GEN= Genitive, VOC= Vocative)
TABLE 7: Confusion Matrix of Case Production before Incorporating PhE

Despite the fact that results from the phonetic and phonological analysis are not incorporated in Table 7, the overwhelming majority of nominal phrases are inflected with the targeted case value. There is a large number of non-match productions where accusative appears to be used instead of nominative (N=663). Almost all of these forms surface as a result of /s/ omission, which was shown to be phonetically/phonologically conditioned. Results summarised in Table 8 show that the number and percentage of match instances is increased significantly for the productions of adults with DS for nominative and to a lesser degree for genitive and accusative case, when phonetic/phonological effects are taken into consideration, while the same is not true for children with TLD. This aims to illustrate the significance of the ground breaking analysis employed in this study. The approach followed in the current study brings together linguistic domains that are interrelated but have not informed each other, and as we can see from the example of case production, it is paramount when working with populations with atypical language development. It enables us to examine their performance from different angles to provide a more complete and representative evaluation of their linguistic abilities.

[9] Note that numbers across the two groups are not identical because (i) there were 16 CG adults with DS and 17 CG children with TDC and (ii) a greater or lesser numbers of certain Case values were produced by participants during the spontaneous tasks, as with vocative for adults with DS.

	CG_{DS}					CG_{TLD}				
	NOM	ACC	GEN	VOC	%	NOM	ACC	GEN	VOC	%
NOM	3,905	20	8	0	99.3	4,456	3	2	0	99.9
ACC	187	4,812	11	1	96.0	19	6,854	7	0	99.6
GEN	12	6	926	0	98.1	2	5	1,583	0	99.6
VOC	0	0	0	100	100	0	0	0	59	100

TABLE 8: Final Confusion Matrix of Case Production after Incorporating PhE

Table 8 shows that productions with almost all case values, for both groups are (almost) at ceiling. The lowest percentage of match value for participants with DS, after eliminating phonetic effects, is the one recorded with accusative case at 96%. Two clear conclusions can be drawn from this analysis. First, the means of non-match case productions that are not phonetically/phonologically conditioned are considerably low. Second, comparing the number of instances where accusative was used as an alternative to nominative with and without considering phonetic/phonological effects, we detect a considerable discrepancy. Namely, 643 instances (663-20=643) of accusative being produced as an alternative to nominative could have mistakenly been labelled as such, as opposed to matched productions of nominative. A parallel effect is also recorded with productions of accusative as an alternative to genitive (68-6=62), and vice versa (63-11=52). Clearly, lack of a phonetic/phonological analysis would have resulted in a highly inaccurate representation of the participants' with DS performance with all cases values, but especially nominative case. Undoubtedly, this leads us to conclude that adults with DS present an impairment and consequently deviance in the production of case inflectional marking. Productions like the one given in (6a) show that there were a few instances where substitution of /s/ was morphosyntactically triggered, but those instances, as shown in Table 8, were observed in less than 0.3% of the overall productions for adults with DS and 0.01% of the children with TLD. It could therefore be concluded that factors external to morphosyntax, like phonetic/phonological restrictions, methodology of data collection and analysis, play a vital role in evaluating the individuals' with DS performance with inflectional marking.

6. Conclusions

The findings presented in this paper show the importance of a parallel phonetic/phonological and morphosyntactic analysis when studying the language development (especially the morphosyntactic abilities) of individuals with Down Syndrome. A number of issues and implications, which arise from the results presented in this paper, are addressed below. Physiological (phonetic) and phonological restrictions (i.e. factors external to morphosyntax) associated with DS play a vital role in their language development, even with the development of their morphosyntactic system, a fact not considered to date. Therefore, if the performance of individuals with DS is conditioned by the

distinct physiology of the participants' articulatory apparatus, and this is in turn conditioned and restricted to only individuals with DS, could we therefore argue that their distinct genome is responsible for this distinct performance, at least with regards to the acquisition of their phonetic and phonological system?

Results are at odds with previous arguments on (a) severely impaired morphosyntactic abilities, but also (b) inconsistent phonological patterns with regards to consonant productions, omissions and substitutions. A comparison of Tables 7 and 8 provide evidence for the former, while the latter is supported by substitution and omission patterns presented in Table 3. A comparison of results with and without the incorporation of a phonetic/phonological analysis into a morphosyntactic analysis suggests that the linguistic abilities of individuals with DS could indeed be misrepresented. A parallel analysis on the phonetic/ phonological and morphosyntactic abilities of English and Spanish individuals with DS, where inflectional marking includes many of the phonemes that individuals with DS exhibit problematic use, may also yield parallel effects.

Moreover, despite the evidently low IQ scores, participants are indeed able to develop a functioning grammar, with morphosyntactic abilities almost at ceiling, at least with regards to the inflectional system. Therefore, cognitive limitations do not prevent the development of a functioning grammar in individuals with DS.

Results and insights from this study are now used as a basis to study the linguistic abilities of children with DS and younger children with TLD. They give us an insight as to what is the level of full phonetic and phonological acquisition CG individuals with DS can reach and how their articulation restrictions, without speech and language therapy, affect their use of inflectional marking. Knowing the full acquisition level that individuals with DS can reach, what remains to be studied is where they start from and which are the intermediary states of their language development.

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