THE ACQUISITION OF CONSONANT CLUSTERS IN POLISH: A CASE STUDY

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Abstract

This paper examines the phonological processes affecting consonant clusters in the speech of a child acquiring Polish (1;5-1;9). Word-initial, word-medial and word-final clusters are discussed, and compared to word-initial singleton consonants in the data. The nature of the processes, as well as the wide range of variability within the child's system, lead to the conclusion that articulation, attention and word-based processing are the main factors affecting the child's production.

1. Introduction

There is an ongoing debate in the literature on whether phonological processes used by children reflect a re-organising rule-based system, or a system that is emerging from the interaction of developing motor and cognitive skills. An example of the latter approach is presented in Studdert-Kennedy & Goodell (1993), who found that their data pointed to articulatory factors being the main source of child errors. According to Studdert-Kennedy & Goodell, "a child's errors in early words can arise from paradigmatic confusions among similar gestures in a child's repertoire and from syntagmatic difficulties in co-ordinating the gestures that form a particular word" (p. 82). The authors based their conclusions in the Articulatory Phonology framework (Browman & Goldstein 1989; Browman & Goldstein 1992), according to which real-time articulatory gestures are phonological units, stored and produced in meaningful combinations (i.e. words). Under this view, the process of phonological acquisition would consist of learning to produce particular gestures and learning to co-ordinate them into word-shapes. Predicted errors would therefore include paradigmatic and syntagmatic difficulties, just as the ones found by Studdert-Kennedy & Goodell. Such an approach is compatible with the more general whole-word approach in child phonology, first explicitly proposed by Ferguson & Farwell (1975), who claimed that the word is the first basic unit of phonological organisation in children. Word-based processes were demonstrated for other children by several researchers (e.g. Waterson, 1971; Priestly, 1977; Vihman, 1987), who found that children often employ word templates (Vihman & Velleman, 2000) , i.e. patterns of production that change the overall shape of the word rather than affecting particular segments.

A competing approach, rooted in the generative tradition (Chomsky & Halle, 1968), postulates a rule-based (Smith, 1973) or, more recently, a constraint-based (Fikkert & Levelt, 2008; Łukaszewicz, 2007) system as the starting point of phonological acquisition, and assume the development proceeds through re-organisation or re-ranking of the constraints. Under this approach, the basic units of phonological organisation are segments. An important prediction of such an assumption is that all processes should apply to the same segments and the same syllable positions regardless of the word they appear in, i.e. they should be triggered by the same segment-sized unit every time they occur. This is not the case if we adopt the whole-word approach, as the same segments can behave differently in different words. Also, in the constraint-based approach, the processes should not target units larger than the segment, i.e. they should be blind to other positions in the word. Again, the whole-word approach predicts that phonological processes can change the shape of the whole word, as in

the case of word templates. Finally, we would like to see the constraints apply at every instance of the particular word being produced, while under the articulatory approach, it is to be expected that attempts at articulating a problematic segment may have different outcomes on different occasions.

To test the above predictions, the current paper examines the behaviour of consonant clusters in the speech of a monolingual child acquiring Polish, with a focus on word-medial clusters in particular. Previous investigations (Zydorowicz, 2007; Łukaszewicz, 2007) have shown that word-medial clusters in Polish are acquired early in development, as compared to word-initial clusters. This has been attributed to various constraint-related factors, from syllable structure constraints (Łukaszewicz, 2007), to morphonotactics and markedness effects (Zydorowicz, 2007.) However, a similar effect has been reported for languages which make use of word-medial geminates (Finnish: Savinainen-Makkonen, 2007) and long consonants (Welsh: Vihman & Croft, 2007; Vihman, Nakai & DePaolis, 2006). The authors of these findings suggest that the relative ease with which the segments are acquired can be attributed to the salience of the word-medial, intervocalic position. Such explanation is further supported by the fact that, in both Finnish and Welsh, word-medial geminates and long consonants often affect word onset in children's production, causing them either to lose accuracy or to be dropped altogether. That consonant clusters can affect the accuracy of other sounds in the word in child language in the same way that geminates and long consonants do has been proposed for Hindi, which makes use of both (Vihman & Croft, 2007). If true for Polish, this might contribute to the explanation of why word-medial clusters are acquired before word-initial clusters. It would also suggest that attention factors play an important role in the acquisition of these segments, and in this sense point to formal constraints not being sufficient to explain the course of phonological development in children.

Taking the above facts into account, the goal of the current paper is to examine the processes affecting consonant clusters in the speech of a Polish child, as well as their effects on other positions in the word. We shall primarily be concerned with three questions (1) how the processes relate to those observable for single consonants, i.e. whether they obey the same constraints; (2) how systematic the processes are, i.e. whether they apply to the same clusters regardless of the word-form and the token they appear in; and (3) whether word-medial clusters trigger instability of word onset, as in Finnish, Welsh and Hindi. It is hoped that the answers to these questions will provide evidence regarding the units of early phonological organisation (words vs. segments), the source of child errors (articulatory vs. formal constraints) and the role of attention in the process.

2. Method

The data for the study has been collected from the author's son Grzenio ([gʒɛɲɔ]), a monolingual child acquiring Polish. For the purpose of the current analysis, six half-hour recordings of spontaneous speech in the home environment were selected, with intervals of 12 to 26 days. At the beginning of the study, Grzenio was 1;5.28, with an estimated cumulative vocabulary of about 50 words (MLU 1.2). The recordings ended when he was 1;9.28 and his vocabulary was estimated for about 250 words (MLU 2.6). The total number of interpretable tokens recorded was 1402, and the total number of word forms was 181. As there was no evidence for a qualitative change in Grzenio's phonological organisation, the data will be treated synchronically, with no attention to word form changes over the four months.

To give an idea about the target system, Table 1 presents the consonant inventory of Polish. Consonants marked in grey are those that Grzenio produced at the time of the study. Table 2 (based on data from Milewski, 2005) presents the number of consonant cluster types in different positions in the word in data from preschool children (aged 3-7), spoken Polish, scientific texts and artistic prose.

Table 1: The consonant inventory of Polish.

*the consonant was recorded only once in Grzenio's speech

place/manner of articulation		**bilabial**	**labio-dental**	**dental**	**alveolar**	**palato-alveolar**	**palatal**	**velar**	**glottal**	
plosive		p		t				k		-v
		b		d				g		+v
fricative			f*	s	ʃ	ɕ		x		-v
			v	z	ʒ	ʑ				+v
affricate				ts	tʃ	tɕ				-v
				dz	dʒ	dʑ				+v
nasal		m		n			ɲ			+v
liquid	**lateral**				l					
	rhotic				r					
glide		w					j			

Table 2: Consonant cluster types in Polish (Table based on Milewski, 2005, p. 23)

Position in the word	**Preschool children***	**Spoken adult Polish****	**Scientific Texts*****	**Artistic Prose*****	**Grzenio**
initial N	249	208	283	310	10
%	27.85	23.94	22.4	23.0	22.22
medial N	581	588	883	926	27
%	64.99	67.66	69.9	68.8	60.0
final N	64	73	98	110	8
%	7.16	8.40	7.8	8.2	17.78

* Milewski, 2005, ** Dunaj, 1985, ***Dobrogowska, 1991

3. Results

3.1. Word-initial consonant clusters

As can be seen from Table 2, much fewer clusters occur word-initially than word-medially in Polish. This tendency was also observed for Grzenio, for whom word-initial clusters made up for 22% of all clusters he produced, in line with the frequency observed for preschoolers and adult speakers of Polish (Milewski, 2005). There were only ten types of word-initial clusters in Grzenio's repertoire, all of which are presented in Table 3 along with the targets. It can be observed that all targets are of the structure C1[obstruent] + C2[sonorant], and this structure is preserved in the child form.

Target	Grzenio
br	bw
	bβ
kfj	kx
	tɕl
kl	hj
	kj
	kl
	tɕj
kr	kj
	kl
	kŋ
	tɕj

Table 3: Word onset clusters produced by Grzenio.

However, out of 309 attempts at a target word with a cluster at onset (45 word forms), only in 25 tokens the cluster was not reduced. Moreover, out of those 25, only one was reproduced correctly. Among the remaining 284 child forms, the cluster was reduced to or replaced by a single consonant in 277, and was omitted altogether in 7.

Table 4 presents a selection of target words with consonant clusters in word-initial position along with the child forms. Łukaszewicz (2005) also reports numerous cases of onset cluster reduction, which she finds to be due to either sonority-based deletion, whereby only the less sonorous consonant is retained, or coalescence, where the two consonants are replaced with one, which shares its phonetic properties with both the original sounds. However, Grzenio's forms do not exhibit such consistency, and the process of reduction does not seem to be applied in a systematic fashion. For example, clusters with [s] or [ɕ] as C1 behaved differently in different words. In 'śpi' /ɕpi/ only the stop was retained, in /swɔɲ/ the cluster was replaced with a harmonised consonant, while in 'smok' /smɔk/ it was omitted altogether. The less sonorous stop was retained in /ɕpi/, but it was deleted in 'krab' /krap/, which appeared with an initial nasal palatal [ɲ]. Moreover, different target clusters were often replaced with the same sound, and the initial nasal palatal was also used in the word 'pszczółka' /pʃtʃuwka/. In fact, using coronal and dorsal segments in the place of word-initial

clusters was the only pattern that was to some extent regular, in that 50% of the clusters that underwent reduction were either reduced to or replaced by coronal consonants, a further 44% with dorsal consonants, and only 6% with labials (although they were present in 30% of target clusters.)

Table 4: Selected child forms with a word-initial cluster.

*the only form with an accurate word-initial cluster

CC not reduced			**CC reduced/ omitted**		
Target/ Eng	**Target IPA**	**Grzenio IPA**	**Target/ Eng**	**Target IPA**	**Grzenio IPA**
klocki ‘blocks’	klɔtski	tɕjaçka, klɑçki*	klocki ‘blocks’	klɔtski	koçki, tɕaçki
kredka ‘crayon’	krɛtka	kjaxka	Grzenio	gʒɛɲɔ	ɲɛɲɔ, dʑɛɲa,
krab ‘crab’	krap	tɕjapk	krab ‘crab’	krap	ɲap:ka
grzmi ‘thunders’ (V)	gʒmi	bwi	pszczółka ‘bee’	pʃtʃuwka	ɲupkɛ
chrupki ‘crisps’	xrupki	hlupki	słoń ‘elephant’	swɔɲ	nɔɲ, ɲɔɲ
śpi ‘sleeps’	ɕpi	pɛi	smok ‘dragon’	smɔk	ɔŋk
			śpi ‘sleeps’	ɕpi	pi

In sum, although the proportion of word-onset clusters to all clusters in Grzenio’s data was the same as for adult Polish, their production was still very unstable. Obstruent-sonorant combinations were the only ones produced, but most of the time even target clusters conforming to this pattern were reduced. The only word that was pronounced with the correct cluster (‘klocki’ /klɔtski/ > [klaçki]), had as many as five variants, in two of which the cluster underwent reduction. This indicates that even this one instance of correct reproduction of the cluster [kl] was not stable enough to be considered fully acquired. Finally, there was no clear pattern to how given clusters were treated.

3.2. Word-medial consonant clusters

As we have mentioned earlier, word-medial consonant clusters have the largest number of forms among all clusters in Polish (cf. Table 2), and this tendency was also true for Grzenio’s data. Also, while only obstruent-sonorant clusters were used by Grzenio in word onset, word-medial clusters were mostly of the opposite form, i.e. sonorant-obstruent. It must be noted that this tendency is also present in the adult language, where sonorant-obstruent clusters are relatively rare in the word-initial position. In addition, word-medial clusters were produced far more frequently than were the word-initial clusters. Interestingly, the number of word forms Grzenio attempted was similar for both: 45 word-onset cluster word forms (309 tokens) vs. 50 word-medial cluster word forms (270 tokens.) However, the cluster was reduced in only 70 out of the 270 tokens with medial cluster, as compared to 277 for word-onset cluster; also, there was not a single instance of omission. In the remaining 197 child forms the cluster was retained, although it was often reproduced inaccurately. Zydorowicz (2007) reports that morphonotactic clusters seem to be more stable than lexical clusters (i.e. they are rarely modified), but no such tendency was observed in Grzenio’s data, mainly because of a very small number of morphological endings in his speech, presumably due to his young age. In fact, the only morphological suffix in the data that results in a word-medial cluster is the diminutive suffix, and there is no evidence for the productive use of this suffix (i.e. the words only appear in diminutive form.)

The strategy that Grzenio employed to produce word-medial clusters seems to have been more systematic than what we observed for the word-onset ones. Moreover, the substitution pattern was also more strictly defined. All C2s were either coronal or dorsal obstruents, both in the targets and in the child forms. As for C1, it was most often a non-continuant, usually agreeing in place of articulation (PoA) with C2. The exception to both these tendencies was the stop [p], which appeared as C1 in the place of all labial C1 targets, being also the only stop regularly used in this position.

We can therefore extract three main patterns, which are presented in Table 5. All word-medial clusters produced by Grzenio along with the targets are sorted according to C1 (C2 always being a coronal or dorsal obstruent.)

The first pattern applies to all clusters with a labial C1. The preferred C2 is a coronal or dorsal obstruent, and so the cluster /br/ is replaced with /pt/ or /ptɕ/. Still, there is an instance of a cluster without any labial consonant in the target form turned into /pt/.

The second pattern turns all sonorant-obstruent clusters into a sequence of a homorganic nasal and an obstruent. This sequence was also reported as a frequent cluster modification by Łukaszewicz (2007) and Zydorowicz (2007). Again, however, we can see two target clusters that the pattern applies to, despite the fact that they do not match the criteria: /pk/ and /tʃk/, which both become /ŋk/. We can also see that there is a strong preference for coronal and dorsal segments, as the cluster /mp/ is transformed into /nt/.

The third pattern applies to sequences of obstruents, which are transformed into a non-continuant-continuant cluster. This can be seen in the case of the clusters /tk/, /tsk/ and /tʃk/, in which the C2 is reproduced accurately, but C1 appears as several different fricatives.

Approximately half of the child forms which conformed to one of the above three patterns had a cluster of the preferred structure in the target form, and in this sense they were ‘selected‘ (Vihman & Velleman, 2000); the other half of the forms were ‘adapted’ meaning that the target cluster was transformed to match the pattern. Table 6 presents a selection of child forms with a cluster in word-medial position, sorted according to this distinction.

Again, as was the case with word-onset clusters, we can see that in spite of the general systematicity of the pattern, its application is by no means fully consistent. For example, the word ‘Marta’ /marta/ is reproduced with two different clusters: [əŋka] and [ɲaɲta], and the same is true for ‘soczku’ /sɔtʃku/, which appears in two quite different forms: [ɲɔxku] and [øŋku]. Moreover, in the case of the word /spɔdeŋki/, the child form is [dodandi], despite the child’s preferred cluster being present in the target form. As regards the 75 word tokens in which the medial cluster was reduced, there was also no obvious pattern as to which segment should be retained: in 32 tokens the cluster was reduced to or replaced with a [-continuant] consonant, but in the remaining 45, with a [+ continuant] consonant.

Interestingly, there were also cases of cluster insertion, where the target form had no cluster but the child form did. Table 7 presents selected child forms with an added cluster.

Table 5: Word-medial clusters produced by Grzenio, sorted by C1.

labial (30 tokens)		**nasal (60 tokens)**		**fricative (98 tokens)**		**other (12 tokens)**	
Target	**Grzenio**	**Target**	**Grzenio**	**Target**	**Grzenio**	**Target**	**Grzenio**
br	pt	jdʑ	ɲdʑ	ɕtɕ	ɕtɕ	tʃk	kk
	ptɕ		ɲt	jɕtɕ	jɕtɕ		tɕk
pk	pk		ɲtɕ	sk	ɕt	xts	jtɕ
ptɕ	pt	lk	ŋk	st	ɕt		
	ptɕ	mp	nt		ɕtɕ		
rt	pt	nd	ɲd		xtɕ		
wk	pk	ɲtɕ	ɲtɕ	ʃk	ɕk		
		ŋk	nd		hk		
			ŋk	ʃtʃ	ɕt		
		pk	ŋk		ɕtɕ		
		rdz	ɲd		htɕ		
		rt	ɲt	tk	çk		
			ŋk		hk		
		tʃk	ŋk		xk		
		wk	ŋg	tsk	çk		
			ŋk		ɕk		
					hk		
					jçk		
				tʃk	hg		
					hk		
					xk		
				tʃn	ɕtɕ		
				xts	çtɕ		
					ɕtɕ		
					htɕ		
					χtɕ		

Table 6: Selected child forms with a consonant cluster in word-medial position.

Select			Adapt		
Target/ Eng	**Target IPA**	**Grzenio IPA**	**Target/ Eng**	**Target IPA**	**Grzenio IPA**
świnka ‘pig’	ɕfiŋka	ɕiŋka	spodenki ‘trousers’	spɔdɛŋki	dodandi
nie chcę ‘not want’	ɲɛxtsɛ	ɲɛɕtɕɛ	zebra ‘zebra’	zɛbra	ɲɛptɕa
rybka ‘fish’	rɨpka	ɲʔpka	soczku ‘juice’	sɔtʃku	ɲɔxku, øŋku
po prostu ‘just’	pɔprɔstu	tɔtɔɕtu	pszczółka ‘bee’	pʃtʃuwka	ɲupkɛ
nóżkę ‘leg’	nuʃkɛ	ɲiɕkə	Marta	marta	əŋka, ɲaɲta
Łukaszka (Gen)	wukaʃka	kaɕka, kahka	kredka ‘crayon’	krɛtka	kjaxka
babcia ‘grandma’	baptɕa	ɲaptɕa	grzeczny ‘good’	gʒɛtʃnɨ	kɔɕtɕi

Table 7: Selected cases of cluster insertion.

Target/ English	Target IPA	Grzenio IPA
buty ‘shoes’	butɨ	ʔɲtɕi
chce ‘want’	xtsɛ	tɕɛŋk
czytać ‘to read’	tʃɨtatɕ	tɕiɕtatɕ
dywan ‘carpet’	dɨvan	diɲda
idzie ‘walk’	idʑɛ	iɕdʑɛ
krab ‘crab’	krap	ɲap:ka, tɕjapk
leżeć ‘to lie’	lɛʒɛtɕ	jaɕtɕ
Łukasz	wukaʃ	guçkaɕ
oko ‘eye’	ɔkɔ	əŋkɔ
tukan ‘toucan’	tukan	ɲ:kaɲk

3.3. Word-final consonant clusters

Unlike in the case of word-initial and word-medial clusters, the percentage of clusters Grzenio used in word-final position was relatively higher than observed for adults. Interestingly however, only two types of word-final cluster were used accurately: /ɕtɕ/ and /ɲtɕ/. No other word-final clusters were attempted, and all other clusters present in the data came from cluster insertion, instances of which were presented in Table 8. All the word-final clusters appeared in one of the three forms that were observed for word-medial clusters.

3.4. Word-initial singleton consonants

At the time of the study, the child produced word-initial single consonants with high accuracy, ranging from 75% for labials and 86% for velars to 95% for coronals and palatals. Interestingly, even within this very small margin of variation, there was a difference in the behaviour of the three places of articulation of stops. While the coronals seemed the least variable of the three places, the variability could usually be attributed to articulatory factors, meaning that the sounds often underwent palatalisation, and sometimes even affrication, as in the word 'tatuś' /tatuɕ/, which often appeared as [tɕatiɕ].

Labial stops, on the other hand, were rarely affected by segment-based processes (there were nine cases in total of a change in voicing or manner), but, in comparison to the coronals, they were more prone to whole-word processes such as assimilation, resulting in lower accuracy overall. This is illustrated by the word 'buty' /butɨ/, usually pronounced [nuta], and 'babcia' /baptɕa/, almost always rendered as [ɲaptɕa]. As regards the velar stops [k] and [g], the former was usually pronounced correctly, but the latter was rather infrequent and sometimes replaced with another sound, as in the word 'gitara' /gitara/ > [titaja].

In summary, while the stops were rather stable in word-initial position, coronals and palatals were the least susceptible to the influence of other segments in the word, despite being at the same time the least precisely articulated, whereas labials did not undergo many segment-based processes but were often at least partially assimilated to other consonants in the word.

While coronal stops were sometimes replaced with affricates, word-initial affricates often also underwent reduction to stops. Only the palato-alveolar affricates were present in Grzenio's data and those were usually produced accurately (100% accuracy for [tɕ] and 93% for [dʑ].) Nevertheless, dental and alveolar affricates were palatalised to [tɕ] and [dʑ] approximately half of the time, while at other times being reduced to dental stops (as in the word 'cześć' /tʃɛɕtɕ/, pronounced as [teɕ]), but never replaced by any other consonants.

A similar pattern to that of stops was observed for word-onset nasal segments, whose accuracy ranged from 17% for the dental [n] and 66% for the labial [m] to 83% for the palatal [ɲ]. However, in the case of the coronals [n] and [ɲ], the variability was almost entirely limited to the two varying with each other, i.e. [n] was only replaced with [ɲ], while [ɲ] was pronounced as either [n] or sometimes [j]. Again, labial [m] was an exception: almost all of the 34% of inaccurate tokens were instances of consonant harmony (e.g. 'miś' /miɕ/ > [ɲiɕ]). That the variation among coronals can be attributed to articulatory difficulties is further confirmed by the behaviour of the glide [j], which not only replaced the nasal [ɲ] in some words, but also was replaced by it in others, although it was produced accurately 86% of the time (for comparison, the labial glide [w] was never used accurately.)

As regards fricatives, they were still relatively undeveloped and infrequent. Apart from a single appearance of [f] during the final session, only palato-alveolar [ɕ] (used interchangeably with palatal [ç]) and velar [x] (used interchangeably with glottal [h]) were produced in word-initial position. Those consonants were also used to replace other fricatives, along with a range of other sounds.

Finally, as is typical for children at his age, except for a single instance of [l] Grzenio did not produce liquids, which he usually replaced with glides.

In summary, on the basis of the behaviour of word-initial segments, we can see that obstruents and glides were the most developed consonants in Grzenio's data, and among them coronal and palatal segments played a special part. It is perhaps worth noting that the coronals may be particularly difficult in Polish, as the language distinguishes between four

different places of articulation for those segments. Not surprisingly, at the time of the study, Grzenio did not yet use all of them. He used dental stops (but not affricates), none of the alveolars, all pre-palatals except for the voiced fricative [ʑ] and both palatals (with the occasional addition of [ç].) Still, the consonants that he produced were often used interchangeably. On the other hand, those relatively unstable sounds, when produced in word onset, were seldom influenced by other positions in the word. In fact, if we compare all inaccurate child forms, articulatory errors (i.e. variable degree of voicing, nasalisation, palatalisation and affrication) make up 80% of tokens with word-initial coronal or palatal obstruents in the target, but only 7.5% and 28% of tokens produced for targets starting with labial and velar obstruents, respectively. The rest of the errors are the result of either omission or assimilation. Table 8. presents instances of omission of word onset.

Comparison of those word forms confirms that labial segments were the most susceptible to variation. Whether it was the glide [w], the nasal [m] or the labial stop [p], they were likely to be omitted. Nevertheless, there were also some cases of omission of coronal and palatal segments, even a consonant as stable as the glide [j]. What seemed to trigger those processes was the presence of a consonant cluster later in the word, as in 'jeszcze' /jɛʃtʃɛ/, reduced to [ɛɕtɕɛ]. In fact, even the variability within the articulatorily motivated range appeared most frequently in words with word-medial clusters. Out of the 23 most variable word types (i.e. the ones for which four or more different child forms were recorded), 12 (52%) had a consonant cluster in word-medial position in the target form. In comparison, out of 39 words which appeared in only one form (but in more than one token), only 7 (17%) had a word-medial cluster.

Table 8: Selected cases of word-initial consonant omission.

Target/Eng	**Target IPA**	**Grzenio IPA**
dobranoc 'goodnight'	dɔbranɔts	aɲɛɲɔtɕ
jest 'is'	jɛst	ex
jeszcze 'more'	jɛʃtʃɛ	iɕtɕɛ
łóżko 'bed'	wuʃkɔ	uhkɔ
Łukasz	wukaʃ	ukaɕ
Łukaszek	wukaʃɛk	ukahək
Marta	marta	əŋka
miś 'teddy bear'	miɕ	iɕ
misia 'teddy bear' (Gen)	miɕa	iɕa
piłka 'ball'	piwka	iŋka
pompon 'pompon'	pɔmpɔn	əntən
soczku 'juice'	sɔtʃku	aku

To sum up, while the accuracy of word-initial singleton consonants was very high, the occasional errors that did appear fell into one of two general categories. Firstly, there were errors that could be said to be articulatorily motivated, i.e. resulting from imprecise articulation or, in the case of consonants that had not yet been acquired, from substitution with a similar sound. The processes that fell into this first category all involved variation in voicing, nasalisation, palatalisation and affrication, or from substitution strategies common also in children acquiring English, such as the gliding of liquids (cf. Grunwell, 1985) The

second category comprised errors in which the word-initial consonant was replaced with a sound that shared more properties with consonants appearing later in the word than with the target sound. In this sense, those processes seemed word-based. Table 9 presents selected child forms with inaccurate word onset, sorted according to this distinction.

Table 9. Selected child forms with inaccurate word onset, sorted by type.

Segment-based processes			**Whole-word processes**		
Target/Eng	**Target IPA**	**Grzenio IPA**	**Target/Eng**	**Target IPA**	**Grzenio IPA**
bardzo ‘very’	bardzɔ	maɲdʲɔ	babcia ‘grandma’	baptɕa	ɲaptɕa
burza ‘storm’	buʒa	wuɕa	buty ‘shoes’	butɨ	nuta
co ‘what’	tsɔ	tɕɔ	gitara ‘guitar’	gitara	titaja
czapki ‘hats’	tʃapki	tapki	Łukasz	wukaʃ	guçkaɕ
cześć ‘hi’	tʃɛɕtɕ	tɛɕ	Marta	marta	ɲaɲta
czysty ‘clean’	tʃɨstɨ	tɕiɕtɕɛ	miś ‘teddy bear’	miɕ	jiɕ, ɲiɕ
jestem ‘I am’	jɛstɛm	ɲɛɕɛm	po prostu ‘just’	pɔprɔstu	tɔtɔɕtu
koń ‘horse’	kɔɲ	gaɲ	Wanda	vanda	daɲda
leży ‘lies’ (V)	lɛʒɨ	jɛɕi	zebra ‘zebra’	zɛbra	wɛbɛ, ɲɛptɕa
pan ‘mister’	pan	baɲ	zejść ‘go down’	zɛjɕtɕ	jɛjɕtɕ
robić ‘make’	rɔbitɕ	jɔbitɕ, ɲɔpitɕ			
rybka ‘fish’	rɨpka	ɲʔpka			
sam ‘alone’	sam	ɕam			
szafa ‘closet’	ʃafa	hafa			
tatuś ‘daddy’	tatuɕ	tɕatiɕ			
wylał ‘spilled’	vɨlaw	bɨlaw			

4. Discussion

A comparison of the behaviour of consonants in the four positions discussed above (singletons at word onset, word-initial consonant clusters, word-medial and word-final consonant clusters) suggests that each poses different challenges to the child. This is particularly apparent in the case of four consonant types: labials, coronals, dorsals, and fricatives.

We have seen that labial segments were not very stable in the child’s production at the time of the recordings. The fricatives were only emerging, voiced [v] is not present at all, and voiceless [f] was recorded only once, during the last session. The glide [w] did appear, but was never used accurately (only as a substitute for another consonant.) In fact, of all the labial consonants available in the target language, only stops and the nasal [m] were used consistently. However, even these segments exhibited a much higher degree of variability than their coronal and dorsal counterparts, and in particular variability that was not limited to articulatory distortion, but was often the result of assimilation to another consonant. Perhaps not surprisingly, labial stops were also most likely to be omitted in word-onset clusters. We could argue that they still posed difficulties of articulation for Grzenio, and thus were much more vulnerable when co-articulatory factors came into play. Nevertheless, the situation of labial stops was slightly different when they appeared as C1 in word-medial clusters. Specifically, they seemed to be the only stops immune to the cluster template, which replaced all C1 stops with continuants. Highly susceptible to variation at word onset, even if not

constituting a part of a cluster, they were almost change-resistant when in syllable coda, even though there was another consonant immediately following that could have been expected to affect them.

The situation of coronal and dorsal segments was very different in this respect. Although the fricatives and liquids were still seldom present at word onset and usually replaced by other segments, obstruents (particularly coronals) and glides, while not always precisely articulated, were very rarely affected by other segments in the word. Moreover, they were also usually retained in word-initial clusters, and in fact the very few clusters that Grzenio produced in this position consisted of a coronal or dorsal obstruent followed by a liquid or a glide. But again, the sounds behaved very differently in word-medial clusters. Here, the obstruents, which were so stable at word onset, were almost invariably transformed into fricatives or nasals whenever they appeared as C1 in medial clusters. On the other hand, C2 in word-medial clusters tended to be coronal or dorsal even if C1 was the labial [p].

As regards manner of articulation, liquids were in general produced only as C2 in word-initial clusters, while fricatives occurred as C1 in word-medial clusters. The behaviour of fricatives here thus confirms the findings of Ferguson (1975), according to which fricatives tend to be acquired first in syllable coda. Moreover, this finding shows that even the constraints on the form of clusters differed depending on word position. First of all, Grzenio mainly produced consonant clusters in word-medial position. This was so despite the fact that clusters are equally frequent in both positions in adult Polish. Also, whereas some clusters preferred by Grzenio are not allowed word-initially in the target language (e.g. [ŋk], [nt]), in other cases the target clusters are structurally the same in both positions but were attempted only word-medially by the child. In effect, the sets of clusters that Grzenio produced in the two positions were mutually exclusive. For example, in the word ‘chce’ /xtsɛ/ ‘want’, the onset cluster was reduced to [tɛɛ]; but when negation was added, so that the cluster appeared intervocalically, it was fully preserved in the child form, the resulting ‘nie chce’ /ɲɛxtsɛ/ ‘not want’ pronounced as [ɲɛɛtɛɛ].

The preferred structure of clusters is also apparent in the templates applied to many of them. Thus, the preferred structure of word-initial clusters is C1[-continuant]+C2[+continuant], while for word-medial position it is C1[+continuant]+C2[-continuant] (with the exception of [p]+[obstruent] clusters.) In fact, there are a few examples of targets which meet both those conditions, and they are produced roughly correctly by the child. For example, the word ‘kredka’ /krɛtka/ is rendered as [kjaxka] and the word ‘klocki’ /klɔtski/ is pronounced as [klaçki].

In general, the constraints on the phonological behaviour of consonants in the data seem to be strongly dependent on their particular position in the word, rather than only on the phonetic identity of particular segments. However, this is not to say that the latter is irrelevant. As we have seen, some of the processes affecting the consonants used by Grzenio appear to have been segment-based, i.e. the variation observed for a given sound could not be explained by an influence of other segments in the word. However, similarly to the errors discussed by Studdert-Kennedy & Goodell (1993), the segment-based processes were always articulatorily motivated, in the sense that the child’s rendition of a given segment was close to the target with respect to its articulatory properties. For example, the initial [b] in ‘burza’ /buʒa/ varied with another labial segment, [w]; [ɲ] varied with [j], which differs only in the degree of closure between the tongue and the palate; and the coronal obstruents appeared with variable degrees of palatalisation and affrication. Moreover, the templates applied to clusters often included consonants agreeing in the place of articulation, which would suggest that articulatory factors might also be partly responsible for its emergence . More specifically,

producing a sequence of a continuant and a non-continuant sound with the same place of articulation only in fact requires slowing down the constriction process, and thus is presumably easier to produce for a child than other types of consonant clusters.

Nevertheless, while many processes in Grzenio's data could be explained by imprecise articulation, those processes were more likely to occur under particular conditions. First of all, word-medial consonant clusters showed the same effect as long consonants in Finnish and Welsh, affecting the accuracy of word onset. This suggests that articulatory difficulties were intensified (and sometimes caused) by planning issues and the attentional effort required to produce sounds in a given sequence. Secondly, the fact that the consonant cluster patterns were sometimes applied to consonant clusters irrespective of their structure indicates, that there is more to Grzenio's phonological system than just on-line articulatory difficulties. Specifically, it often seemed that the template targeted clusters on the basis of their abstract property of being a cluster and was not reserved for particularly troublesome combinations of sounds. It was even applied to the same words in different ways on different occasions. While difficulties in articulation can certainly be said to underlie the emergence of the pattern, the strategy employed to deal with those difficulties seems to be based on a generalisation suggesting the presence of an emerging phonological system.

The combination of purely motoric articulatory constraints and articulatorily-motivated yet pre-planned patterns could support the Articulatory Phonology approach (Browman & Goldstein, 1986, Browman & Goldstein 1992), suggesting that the child's phonological organisation is based on articulatory schemata ('gestures' in Browman & Goldstein's terminology.) On the one hand, the approach views gestures as physically real events co-ordinated in real time, which would account for the low degree of systematicity observed in Grzenio's production. On the other hand, they serve as phonological representations, which would account for phonologically determined systematicity on a level higher than that of individual sounds, also observed for Grzenio. Examples (1)-(7) illustrate these two properties of Grzenio's phonology:

1. /buʒa/ > [buɕa], [wuɕa]
2. /miɕ/ > [iɕ], [wɛɕ], [jiɕ], [ɲiɕ]
3. /baptɕa/ > [baptɕa], [japtɕa], [næptə], [ɲaptɕa], [daptɕa]
4. /marta/ > [jaɲta], [əŋka], [ɲapta]
5. /spɔdɛŋki/ > [dɛdɛŋki], [dɔdandi]
6. /klɔtski/ > [tɕjaçki], [klaçki], [tɕaçki], [kɔçki]
7. /krap/ > [ɲapka], [tɕjapk]

In (1) and (2) we can observe the articulatory factors at play, when the initial labials [b] and [m] are substituted by the labial glide [w], although in (1) the accurate form is used as well. However, in examples (2) and (3), there are also forms in which the labial segment assumes a palatal place of articulation, likely due to the influence of the pre-palatal sound later in the word. In addition, the substituted palatal undergoes articulatorily motivated changes as well, when it varies between the glide [j] and the glide [ɲ]. This substituting segment sometimes becomes a coronal, as in (3), and in (2) is deleted altogether. With regard to the word-initial labial, (4) behaves similarily to (3), but at the same time the word-medial cluster appears in three different forms, although each of the forms is compatible with the general cluster template that Grzenio used. The same happens with the word-medial cluster in (5), despite the fact that the target cluster is already of the preferred form, and at the same time the word-initial cluster is reduced and harmonized with the following coronal segment. In (6), the

word-initial cluster has the preferred structure, but is sometimes deleted nevertheless. Where it is retained, it appears in two different forms, one of which, [tɕj], is the same as the one in (7), presumably because of the similar target form. However, (7) also has a form with word-initial palatal [ɲ], which is not the case with (6). In other words, each of the transformations can be explained by at least one of the relatively regular processes that were observed for the data set as a whole. Nevertheless, these processes often not only act together, but are also applied in a broadly unsystematic way, making it impossible to postulate any categorical rules for Grzenio's production.

5. Conclusions

Despite the relative systematicity of the phonological processes in Grzenio's data, the nature of the processes as well as the manner of their application seem to suggest, that articulatory and attentional factors are the main source of the child's errors. Moreover, there is evidence that the word, rather than the segment, is the basic unit of phonological organisation for the child. First of all, the processes are triggered by overall shape of the word, meaning that there is notable interaction between initial and medial position, as word-medial clusters affect the stability of word onset consonants. Secondly, the processes affect the overall shape of the word, in the sense that there are templates for articulatory patterns that replace consonant clusters as whole units, rather than follow from the properties of the particular consonants forming the target cluster. Finally, although motivated with regard to articulation, the processes are neither categorical nor obligatory, as they affect only some potential targets and that only part of the time. Therefore, although there are broad regularities in the child's production, the forms are largely unpredictable and resist formulation in terms of any segment-based rules. The observed patterns suggest that the child's phonological organisation is the combination of articulatory and attentional, as well as their interrelations within particular words.

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