Acquisition of lingual obstruents in Greek

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Η παρούσα μελέτη ερευνά την κατάκτηση των γλωσσικών αποφρακτικών συμφώνων της Ελληνικής από τα παιδιά. Προηγούμενες έρευνες έχουν επισημάνει ότι η κατάκτηση ενός συμφώνου μπορεί να επηρεάζεται από τη συχνότητα εμφάνισής του στη γλώσσα καθώς και το φωνηεντικό του περιβάλλον. Στα Ιαπωνικά, π.χ., έχει αναφερθεί ότι το / k/ κατακτάται πριν από το /t/ και αυτό μπορεί να σχετίζεται με (α) τη μεγαλύτερη συχνότητά του, και (β) τη μεγαλύτερη συχνότητα των οπίσθιων φωνηέντων στα Ιαπωνικά, δεδομένου ότι έχει υποστηριχθεί ότι λόγω της φυσιολογίας μας υπάρχει μια προτίμηση για συνδυασμούς συμφώνου-φωνήεντος που παράγονται στον ίδιο τόπο άρθρωσης. Τα Ελληνικά αποτελούν μια ιδανική γλώσσα στην οποία μπορεί να ερευνηθεί η επιρροή των παραγόντων αυτών, δεδομένου ότι το /k/ είναι πιο συχνό από το /t/ και τα εμπρόσθια φωνήεντα είναι πιο συχνά από τα οπίσθια. Η μελέτη παρουσιάζει μέρος των αποτελεσμάτων έρευνας για την παραγωγή των /t, k, s, x/ από παιδιά ηλικίας 3-5 ετών, εξετάζει τη σειρά κατάκτησης των ήχων και τα λάθη που παρατηρήθηκαν σε σύγκριση με δεδομένα από άλλες γλώσσες.

Keywords: phonological acquisition, phoneme frequency, obstruent production, Greek

1. Introduction

Linguists have long been interested in the patterns of errors that children make when acquiring their first languages, because patterns that are common across languages might suggest something basic about the ways in which language is structured. Among phonologists, this interest in acquisition is closely linked to the idea that some sound patterns are more typical or 'unmarked' relative to others. For example, all spoken languages seem to have open syllables, but not all of them have closed syllables. Children

who are acquiring a language with closed syllables often omit coda consonants at an early stage of development. Phonologists have related the markedness of closed syllables relative to open ones to such factors as the greater perceptual salience of cues to a consonant's manner and place of articulation before a vowel as compared to after a vowel (e.g., Steriade, 2001).

In the same vein, Jakobson (1941/1968) suggested that "all children everywhere" tend to substitute [t] for /k/. For example, an English-acquiring child might first produce something like [t^hi] for the word *key*. This substitution pattern is very typical of children acquiring English or German, and it has been cited in the literature as evidence that coronal consonants, such as [t] or [s], are unmarked relative to consonants made at other places of articulation (see, e.g., Stemberger and Stoel-Gammon, 1991). Another potential explanation for this substitution pattern, however, refers to the relative frequencies of the consonants. For example, Stemberger and Bernhardt (1999) suggest that children tend to substitute [t] for /k/ because coronals tend to be more frequent than dorsals across languages. Levelt (1996), moreover, suggests that place substitution patterns might depend on the vowel context. She gives examples such as [tip] for /kip/ 'chicken' but [ku] for /stul/ 'chair' in her longitudinal study of Dutch-acquiring children (see also MacNeilage and Davis, 1993).

Research by MacNeilage, Davis, and colleagues has shown that consonant-vowel combinations in which the consonant and vowel have the same place of articulation have higher frequencies than expected from the independent frequencies of the component sounds in early word productions of young children and even in adult lexicons in an on-line dictionary study of ten languages (MacNeilage, Davis, Kinney and Matyear, 2000). These place co-occurrence patterns may be related to physiological factors and may also affect order of acquisition across languages. For example, a language with a predominance of back vowels such as Japanese, might evidence earlier acquisition of dorsal consonants, while a language with a predominance of front vowels, such as English, might evidence earlier acquisition of coronal consonants.

Data from Japanese-acquiring children has shown that /k/ is acquired earlier than /t/ (Yoneyama, Beckman and Edwards 2003). Work reviewed in Beckman, Yoneyama, and Edwards (2003) shows that [t] for /k/ substitutions are far less typical of Japanese children.

Instead, Japanese children tend to substitute [k] (or some other back articulation) for /t/. This might be due to the large number of words beginning with /k/ in the language. Alternatively, it might be an effect of the typical vowel context, since back vowels /a/, /o/, and /u/ are more frequent than front vowels in the language.

In view of the above, it is interesting to examine whether some vowel contexts may facilitate correct production while other vowel contexts may relate to more errors in production. White (2001) found that English-speaking children made more errors on /t/ when it was followed by a back vowel (/tu/), than when it was followed by a front vowel (/ti/), while they made more errors on /k/ when it was followed by a front vowel (/ki/), than when it was followed by a back vowel (/ku/). Such errors may relate to lack of place co-occurrence for the consonant and vowel.

The above findings suggest that lexical phoneme frequency and vowel context may play an important role in phoneme acquisition. Greek is a good language to use in evaluating the effect of these factors on the acquisition of lingual obstruents, because it has a rich system of lingual obstruents. There are contrasts between coronal and dorsal places of articulation for fricatives (/θ/, /ð/, /s/, /z/, vs. /x/, /ɣ/) as well as for stops (/t/, /d/ vs. /k/, /g/). Moreover, both coronals and dorsals occur before both front vowels and back vowels. A recent cross-sectional study by the Pan-Hellenic Association of Logopedics (1995) suggests that while coronal stops are acquired before dorsal stops, dorsal fricatives are acquired before coronal fricatives. However, that study examined only a single word for each sound for each word position, and we thus have no information on the effect of vowel context.

This paper reports preliminary results from a cross-sectional study of Greek children aged two to five years of age. Before describing that study, we first report results of an online dictionary study that we did to determine the relative frequencies of the different obstruents as well as of the different vowel contexts.

2. Frequencies in the adult lexicon

The online lexicon that we used was a list of the 20,000 most frequent words (lemmas) in the ISLP database (Hatzigeorgiu, Gavriilidou, Piperidis, Carayannis, Papakostopoulou, Spiliotopoulou, Vacalopoulou, Labropoulou, Mantzari, Papageorgiou, Demiros, 2000, Gavriilidou, Labropoulou, Mantzari and Roussou, 1999). The database is based on a

morphologically analyzed corpus of millions of words of mainly newspaper text. Because the corpus is morphologically analyzed, different inflected forms of the same word can be grouped together into the same lemma and frequencies of homonyms can be differentiated. The list was originally provided to us in Greek orthography**.** We adapted a set of grapheme-to-phoneme rules devised in 1997 by Argyris Biris within the Festival Speech Synthesis System (Black and Lenzo, 1999) to convert the words to a phonetic transcription. We then calculated the frequency of all word-initial CV sequences, where C is any of the lingual obstruents of Greek.

The left part of Figure 1 shows the results of this analysis for the voiceless obstruents that we included as targets in the cross-sectional production study. Although coronal /s/ is more frequent than the dorsal fricatives, coronal /t/ is less frequent than the dorsal stops. The relative frequencies for the stops are similar to the proportion of coronals to dorsals in Japanese (see Yoneyama et al., 2003), but it contrasts sharply to the proportions observed in the English lexicon. The right part of the figure shows the number of words beginning with lingual obstruents before front versus back vowels. The much higher frequency of front vowels differentiates Greek from Japanese, and makes it more similar to English.

The fact that in Greek dorsal stops are more frequent than coronal stops and front vowels are more frequent than back vowels gives us a good test bed for differentiating the effects of consonant frequency from the effects of the typical vowel context.

C \ V	/i/	/e/	/a/	/o/	/u/	total
/t/	132	160	98	101	49	540
[k], [k^{j}]	308	106	731	180	34	1359
/s/	910	68	51	81	22	1132
[x], [ç]	58	15	154	67	8	302

front (/i/, /e/)	back (/a/, /o/, /u/)	back (/o/, /u/ only)
2821	1946	758

Figure 1. Left: Number of words that begin with each of the CV sequences included in the cross-sectional study. Right: Number of words beginning with a lingual obstruent before front versus back vowels.

Thus, the analysis of the data presented below aims to examine the following: (a) the influence of the frequency of occurrence of lingual obstruents on their acquisition, (b) the influence of vowel context on the acquisition of lingual obstruents, (c) the error patterns observed during the production of obstruents in different vowel contexts. In particular, the questions that will be addressed include: Is /k/, which has a higher frequency of occurrence in Greek, acquired before /t/? What is the influence of the front vowel context, which is more frequent in Greek, on the order of acquisition of the obstruents? Are there differences in the error patterns observed among lingual obstruents produced in different vowel contexts?

3. Method for the cross sectional study

3.1. Participants

We recorded forty eight typically-developing children between the ages of two and five years. Here we will report only on the two-year olds, eight of whom were girls and five boys. The children were attending a local preschool in Thessaloniki, and were recorded on site. They were screened for normal hearing, and had age-appropriate speech and language development, based on parent and teacher report.

3.2. Speech material

The stimuli were words beginning with /t/, /k/, /s/, /x/ that were likely to be familiar to the children. We chose three words for each consonant in each vowel context. For example, the words for /ta/ were /ˈtavros/ (bull), /ˈtavli/ (backgammon), and /ˈtaksi/ (classroom). While we recorded words for all four consonants before all five vowels, here we will focus on the stop consonants before the non-high vowels /e, a, o/, which were the same CV sequences tested in Yoneyama et al. (2003).

3.3. Procedure

We elicited productions of the words by showing the children a picture to represent each target word. The picture was presented simultaneously with a digitized recording of the

target word which was produced by an adult female native speaker of the language. The children were instructed to repeat the word that they heard. The children's repetitions were recorded onto digital audiotape over a head-mounted microphone.

3.4. Analysis

The recordings were transferred to a PC, and a separate audio file was extracted for each token. The initial consonant and vowel were labeled independently with a narrow phonetic transcription by two phoneticians, one a native speaker of Greek (The transcribers read the audio file into the Praat waveform editor when labeling, so that the transcription could refer to the waveform and spectrogram, and so that the transcription could be recorded electronically in a time-stamped ASCII file.) The most frequent labels were 'target' [t], [k], and [kʲ], followed by [c], [p], [kx], [tɕ], [tʃ], and [ts]. Inter-labeler disagreements were few and were resolved by discussion. The most difficult tokens to label were a group of very front productions of /k/ before /e/. These were initially categorized as an extremely fronted version of the dorsal allophone [kʲ] by the native speaker of Greek, but as an alveopalatal affricate [tɕ] by the other transcriber, who is a bilingual speaker of English (which contrasts /tʃ/ and /kj/ before /u/) and of Japanese (which has a three-way contrast among /k/, /kʲ/, and /tɕ/ before all back vowels). This disagreement was resolved by counting these productions as a 'correct' allophonic variant of front /k/.

4. Results of the cross-sectional study

Figure 2 shows the percent correct productions of each of the two consonants, both overall and in each of the three vowel contexts. The counts include tokens such as [nd] for /t/, that were correct for place and manner, but incorrect for laryngeal features. As you can see, more productions were correct for target /k/ than for target /t/, except in the environment of the front vowel /e/.

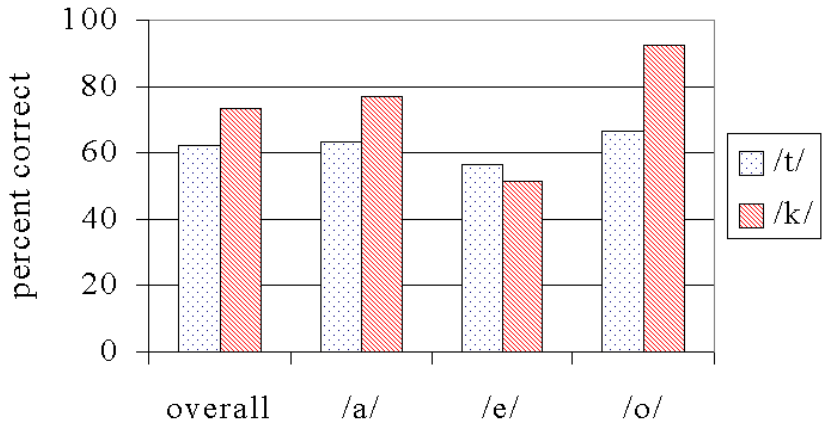

Figure 2. Percent of tokens that were correct for place and manner of articulation.

Figure 3 shows the distribution of errors across different places of articulation. The errors at the dental place for target /t/ were errors of manner such as [ts] and [l], but not productions such as [nd] that fall within the range of allophonic variation of /t/ and /d/. Similarly, the palatal, velar, and uvular place errors for target /k/ were errors of manner, such as the palatal fricative [ç] instead of the front velar or palatal stop in the environment of /e/ and the uvular fricative [χ] instead of the back velar stop in the environment of /o/, but not the productions that were transcribed as [t̠ɕ] by the phonetician who is not a speaker of Greek, since these clearly fall within the range of acceptable allophonic variation for Greek /k/ before a front vowel. Note that for /t/, errors of place include 'fronting' errors, such as [tf] and [p], although 'backing' errors, such as [tʃ], [k] and [kx] were in the majority. For /k/, most errors of place were 'fronting' to [t], [ts] or postalveolar [tʃ] and [tr], and nearly all of these were for /k/ before /e/.

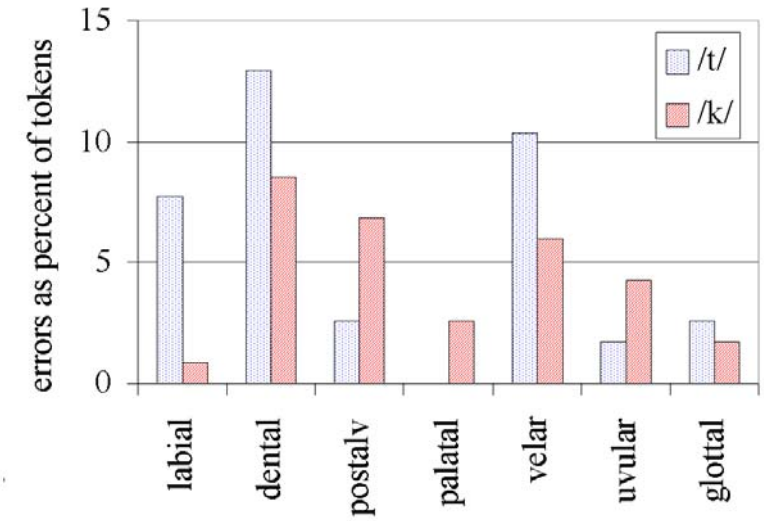

Figure 3. Errors of place and/or manner as percent of tokens.

4. Discussion

As indicated in the introduction, acquisition data on Greek can provide important insights into the effects of consonant frequency and vowel context on phoneme acquisition. Our phoneme frequency analysis has shown that Greek is like Japanese, and unlike English, in that /k/ is more frequent than /t/. It is also like English, and unlike Japanese, in that front vowels are more frequent than back vowels. Such frequency patterns can assist in differentiating the effect of lexical phoneme frequency from place co-occurrence constraints in phoneme acquisition.

Our results have shown a relationship between lexical phoneme frequency and phoneme acquisition. More correct productions were found for target /k/ than /t/ suggesting the earlier acquisition of the dorsal consonant. This finding is in agreement with acquisition data reported for Japanese where earlier acquisition for /k/ has been documented by Joneyama et al. (2003). On the contrary, data from English have shown earlier acquisition of the coronal stop (Smit, Hand, Feilinger, Bernthal and Bird, 1990). Our findings therefore provide supporting evidence to the literature underscoring the need for including phoneme frequency as an important factor in phoneme acquisition. Although research investigating

this factor has been relatively limited, evidence of earlier acquisition of more frequent phonemes has been reported for several languages including Quiché (Pye, Ingram and List, 1987), Swedish, Estonian and Bulgarian (Ingram, 1988). It has been suggested that earlier acquisition of more frequent sounds may relate to fewer resources required to perceive, access and produce these sounds (Stemberger and Bernhardt, 1999).

In addition, interesting findings concerning the role of phoneme sequence frequency in phonological acquisition have become available from our data. The higher frequency of front vowels in the environment of obstruents in Greek does not result in the earlier acquisition of anterior obstruents such as coronal stops. Our data showed that the highest percentage of correct productions was found for the dorsal /k/; this occurred in the back vowel environment where correct production of /k/ exceeded 90% in the /o/ context and came close to 80% in the /a/ vocalic environment. On the contrary the largest number of errors for the dorsal consonant occurred in the front vowel environment. A further interesting finding was that, compared to /k/, relatively fewer errors were produced for /t/ in the front vowel environment. These findings indicate that place co-occurrence constraints play an important role in the production of sounds and the error patterns observed.

These results may be interpreted to suggest that consonant phoneme frequency takes precedence over phoneme sequence frequency in the order of acquisition of lingual stops. Moreover, articulatory constraints resulting from CV place co-occurrence patterns can explain differences in the number of production errors during stop acquisition. For instance, more errors may be expected for a dorsal stop in the front vowel context compared to a coronal stop in the same environment. Thus, on the basis of these findings a tentative hierarchy of the factors influencing the order of acquisition of lingual stops may be suggested to be the following: linguistic factors, i.e. consonant phoneme frequency > physiological factors, i.e. CV place co-occurrence constraints.

The analysis of errors has indicated interesting differences between /t/ and /k/. For the coronal stop, the highest percentage of errors involved errors of manner at the dental place which included production of dental fricatives, affricates and lateral approximants. Place of articulation errors involved mainly backing errors which were more than twice as frequent

as fronting errors; the majority were errors at the velar place followed by errors at the postalveolar, glottal and uvular places of articulation.

A variety of errors in manner of articulation were also observed for the dorsal stop including fricative and affricate production. Manner errors at the velar place were approximately half of those observed for target /t/ at the dental place. Concerning place of articulation errors, the majority involved fronting errors which were three times as frequent as backing errors. Of those errors, the majority involved the production of dentals followed by errors at the postalveolar, palatal and labial places. Some instances of backing errors were also found which were produced especially in the environment of the back vowel /o/.

Interesting differences in substitution patterns have been documented for Japanese and English which have provided supporting evidence for the influence of phoneme frequency on phoneme acquisition. Yoneyama et al. (2003) reported that Japanese children make more than twice as many backing errors for /t/ as fronting errors for /k/. Isermann (2001), on the other hand, reported that children acquiring English make three times as many fronting errors for /k/ as backing errors for /t/. Our Greek data has not shown important differences in the number of fronting vs. backing errors, i.e. the number of fronting errors for /k/ was similar to the number of backing errors for /t/. However, when all errors are considered including fronting errors for /t/ and backing errors for /k/, it becomes obvious that there were a larger number of errors for /t/ than /k/.

There were also some interesting qualitative differences in the error patterns observed. Errors occurred in a variety of vowel environments for /t/ but mainly in the environment of front /e/ for /k/. In addition, there were differences in the distribution of errors across places of articulation. For the coronal stop, there was a large difference in the number of errors involving ‘canonical’ backing, i.e. velar errors, and in the number of backing errors at other places. That is, the majority of errors involved ‘canonical’ backing to the velar place of articulation while backing errors at other places were relatively limited or not present (e.g. palatal place). A relatively large percentage of errors involved fronting to the labial place. For the dorsal stop, fronting errors occurred at all places of articulation and there was a relatively gradual decline from ‘canonical’ fronting at the dental place to errors at other places in the oral cavity. The majority of errors involved ‘canonical’ fronting at the dental

place but there was also a considerable number of errors at the postalveolar place. Substitutions at the postalveolar place have also been reported for /k/ in Japanese but only rarely for /k/ in English.

The earlier acquisition of /k/, related to the smaller number of errors observed for this consonant compared to /t/, is in keeping with the higher frequency of this sound in Greek. Similar findings were reported for Japanese where earlier acquisition of /k/ with overall more errors for /t/ than /k/ were documented (Yoneyama et al. 2003). In addition, as suggested above, place co-occurrence constraints may explain the errors observed for /k/ in the front vowel context. Our results therefore suggest that an explanatory model of phonological acquisition needs to incorporate aspects of both functional and maturational accounts (see Ingram, 1988), thus including important linguistic and biological/physiological constraints in phonological acquisition.

Concluding, this study has investigated the production of lingual stops in the speech of two-year-old Greek children in order to examine two important factors that have been shown to relate to phoneme acquisition, i.e. phoneme frequency and vowel context. The results have shown an effect of both factors on the order of phoneme acquisition and the errors produced. Further research including the analysis of lingual fricatives, all vowel contexts, and data from older children of 3-5 years of age is needed for a comprehensive analysis of the effects of these parameters. The differences reported in the frequencies of the fricatives vs. stops in Greek, i.e. coronal fricatives are more frequent than dorsal ones, may be expected to relate to differences in the order of acquisition of the fricatives and the substitution patterns that occur. In addition, the presence of a dental and alveolar contrast for fricatives as well as strong articulatory constraints during the production of alveolar fricatives may influence their acquisition. Future work will address these issues and examine their influence on phoneme acquisition.

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