



# Cross-Linguistic Acquisition of Voiceless Lingual Fricatives

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## ABSTRACT

This study investigated the effects of phoneme frequency on the emerging phonologies of typically-developing children from four linguistic communities – English, Greek, Japanese, and Cantonese. To this end, it compared cross-linguistic production accuracy of voiceless fricatives in a variety of vowel contexts in the initial position of words. A total of 81 preschool children (ages 25-47 months) representing four language groups participated in a word-repetition task designed to elicit production of target word-initial, consonant-vowel sequences. It was predicted that differences in production accuracies of word-initial, voiceless fricatives would be found within and across language groups. Furthermore, it was predicted that these differences would reflect differences in the relative frequencies with which target sounds and sound sequences occur in the lexicon of each language. Results from this study indicated that frequency effects do influence production accuracy in young children. These findings have important implications for the clinical assessment and remediation of phonological disorders.

## INTRODUCTION

The notion of a “universal grammar” of phonological acquisition (Jakobson, 1941/1968) has been challenged in recent years by empirical research, which has evidenced cross-linguistic differences in the sounds produced in infant babble and subsequent first words (de Boysson-Bardies and Vihman, 1991; Vihman, 1993). However, current theories of child phonological and lexical development do not adequately address what we know about frequency effects and how they affect speech and language learning.

## A BRIEF REVIEW OF THE LITERATURE

- The frequency of sounds within the adult lexicon of the ambient language affects the order of phoneme acquisition in the developing child. Cross-linguistic observational studies found that /f/ and /s/ were produced earlier by children whose native languages had higher frequencies of those sounds in child lexicons (Pye, Ingram and List, 1987; Ingram, 1988).
- Production accuracy is affected by lexical phoneme frequency and vowel and in child-directed speech. In Japanese and Greek, /k/ is more frequent than /l/ in the adult lexicon and in child-directed speech. Furthermore, investigators found that /k/ was produced more accurately than /l/ by young children acquiring these two languages (Yoneyama, Beckman and Edwards, 2003; Nicolaidis, Edwards, Beckman and Tserdelakis, 2004).
- Phoneme sequence frequencies affect production accuracy. Children produced high-frequency diphone sequences more accurately than low-frequency sequences and this frequency effect interacted with vocabulary size – the larger the vocabulary, the smaller the effect (Edwards, Beckman and Munson, 2004; Vodopivec, Edwards and Beckman, 2004).
- Phoneme sequence frequencies influence lexical acquisition. Children more readily learned novel words which contained high-frequency sequences than those which contained low-frequency sequences (Storkel and Rogers, 1999; Storkel, 2000).

## PURPOSE OF THIS EXPERIMENT

To study the influence of phoneme frequency on the production of voiceless lingual fricatives in the word-initial position across four languages (English, Greek, Japanese and Cantonese).

## RATIONALE

- The phonological inventories of English, Greek, Japanese, and Cantonese provide for an interesting series of cross-linguistic comparisons with respect to word-initial voiceless lingual fricatives.
- Lingual fricatives include sounds such as /s/, which are difficult for many young children, and errors can provide for interesting analyses.
- There is some evidence that fricative acquisition in English may be influenced by frequency. For example, /f/ is typically acquired later than /s/ in English and is much less frequent.

## VOICELESS LINGUAL FRICATIVES BY LANGUAGE

English	Greek	Japanese	Cantonese
/s, ʃ, θ/	/s, ç, θ, x/	/s, ʃ, ç/	/s/

## PARTICIPANTS

- Forty 2-year-old and forty-one 3-year-old, typically-developing children representing four language groups (English, Greek, Japanese and Cantonese), who were native speakers of their language.
- Participants were recruited through school and community advertisement in Columbus, Ohio; Thessaloniki, Greece; Tokyo, Japan; and Hong Kong.

	English	Greek	Japanese	Cantonese
Age range in months (mean)	26-35 (30)	32-35 (33)	28-35 (31)	25-35 (31)
N	N=9	N=9	N=12	N=10
3-year-olds	36-46 (39) N=11	37-47 (42) N=10	36-47 (43) N=8	38-47 (43) N=12

## METHODS

- A table was constructed for each language, pairing each voiceless fricative with each of five vowels /i/ (including lax /i/ in English), /e/ (and /ɛ/), /a/, /ɔ/, /u/ (and /o/).
- Each cell of the table was filled with words that a child might know, trying to get three words for each cell. An attempt was made to balance the number of syllables across cells for each language and for stress where relevant.

Example target words beginning with /s/ across the four languages.

	/i/	/e/	/a/	/ɔ/	/u/
English	/sɪt seat /sɛstɪr sister	/sɛm same /sɛf safe	/sɪk sock /sɪs sauce	/sɒp soup /sɒbʊb sofa	/sɒpʊp soap /sɒtʃkɪs suitcase
Greek	/sɪmɪ sign /sɪkɔ sign	/sɛlɪ middle /sɛlɪmɛlɔ celery	/sɛlɪ scarf /sɛlɪmɛlɔ same	/sɔmɔ body /sɔmɔ ɣɛmɪ family	/sɔpɔ soup /sɔtʃɔt shoe
Japanese	* /sɛkɛtɪ soap /sɛrɔtɪ celery	/sɛmɛlɔ same /sɛmɛlɔ shark	/sɔtɪ slide /sɔtɪ nɔdɔle noodle	/sɛkɔtɔ shirt /sɛmɛlɔ sand	
Cantonese	/sɛiʊ to smile /sɛiʊ tʃɛrɔ driver	/sɛiʊ smile /sɛiʊ tʃɛrɔ taxi	/sɛmʊ three /sɛmʊ mountain	/sɛiʊ comb /sɛiʊ sɛiʊ kɛy	*

- Audio recordings of each target word were made by a female native speaker of each language.
- Target words were paired with culturally-appropriate color photographs.
- The target and picture stimuli were presented simultaneously on a color, 10- by 12- inch laptop monitor.
- Children participated in a word-repetition task designed to elicit production of target initial sounds. Participants were instructed to repeat each word after the computer presentation.
- Responses were recorded and subsequently transcribed by a native speaker (experimenter) of each language. Target initial consonants and the following vowels were scored as correct, incorrect, or voicing error only.

## MEASURES

The relative log frequencies of each consonant and consonant-vowel combination for each language were calculated using existing adult online lexicon databases for each language.

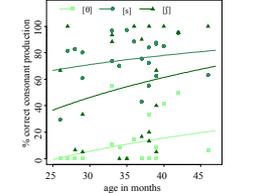
	/s/	/ʃ/	/θ/	/ç/	/x/
English	-2.9	-4.8	-5.4	**	**
Greek	-2.9	**	-4.4	-5.4	-4.6
Japanese	-2.3	-2.5	**	-3.9	**
Cantonese	-2.1	**	**	**	**

## ANALYSES

### PERCENT CORRECT BY AGE

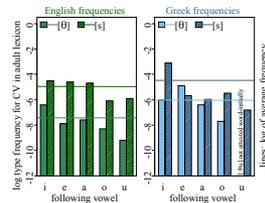
Scatterplots were generated in order to view general developmental trends within and across languages.

Example 1: Percent correct by age for English /s/, /ʃ/, /θ/.



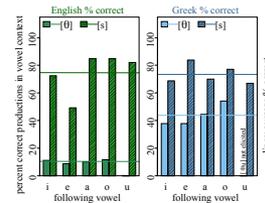
These results mirror the frequency data for English: /s/ is the most frequent sound and is produced more accurately than /ʃ/ and /θ/ even by the youngest children, while /θ/ is the least frequent sound and is produced much less accurately than /ʃ/ and /s/ even by the oldest children. However, cross-linguistic comparisons are needed to establish that these results are related to relative phoneme frequency and not to differences in inherent difficulty of the sounds.

Example 2a: Frequency data for English and Greek /θ/ and /s/.



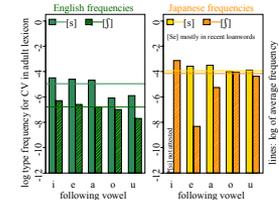
These bargraphs show that /θ/ is much less frequent than /s/ in every vowel context in English. The frequency difference between English /θ/ and /s/ is smaller in Greek.

Example 2b: Percent correct data for English and Greek /θ/ and /s/.



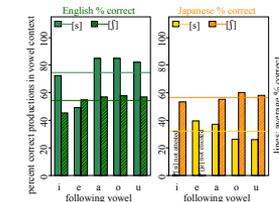
The difference in production accuracy between /θ/ and /s/ is considerably smaller in Greek than in English.

Example 3a: Frequency data for English and Japanese /s/ and /ʃ/.



These bargraphs show that /ʃ/ is less frequent than /s/ in every vowel context in English. /ʃ/ and /s/ have very similar frequencies in Japanese.

Example 3b: Frequency data for English and Japanese /s/ and /ʃ/.



/s/ is produced more accurately than /ʃ/ in English, while the reverse is true in Japanese. The difference in production accuracy between /ʃ/ and /s/ in Japanese is greater than expected based on the frequency data. These effects may be explained (at least in part) by palatalization of /s/ to /ʃ/ in the child-directed speech of Japanese mothers. In English, /s/ for /ʃ/ substitution errors were common while in Japanese, /ʃ/ for /s/ substitution errors were more usual.

## CONCLUSIONS

- Young children's production accuracy of voiceless lingual fricatives varies across languages. For example, while word-initial /s/ was produced more accurately than /ʃ/ in all vowel contexts in English, /ʃ/ was consistently produced more accurately than /s/ in Japanese.
- Cross-linguistic comparisons show that lexical phoneme frequency may affect accuracy of production. For example, Greek 2- and 3- year-olds produced /θ/ more accurately than English-speaking children across all vowel contexts, and /θ/ occurs more frequently in Greek.
- Production accuracy of voiceless lingual fricatives by young children may be influenced by frequencies relative to child-directed (not adult) lexicons. For example, /ʃ/ was substituted for /s/ by some Japanese participants, and /ʃ/ may be more frequent than /s/ in child-directed speech in Japanese.

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