Jpn. J. Spec. Educ., 44 (6), 451-462, 2007.

Original Article

Syllable Weight and Phonological Encoding in Japanese Children Who Stutter

Sachiyo SHIMAMORI* and Tomohiko ITO**

The present study investigated effects of phonological factors on stuttering in Japanese children. Differences in the frequency of stuttering were compared between nonwords beginning with light syllables (i.e., syllables in Japanese with one mora) and nonwords beginning with heavy syllables (two moras). In a nonword reading task, the frequency of stuttering was significantly lower in nonwords beginning with heavy syllables than with light ones (Shimamori & Ito, 2006). However, a reading task requires different linguistic processing from spontaneous utterances. In the present study, a nonword naming task was used. Participants were 50 elementary school students who stuttered. The results were as follows: (1) The frequency of stuttering was significantly lower in nonwords beginning with heavy syllables than with light ones. (2) Among 4 types of heavy syllables, the frequency of stuttering was significantly lower on long vowels than it was on diphthongs and nasal consonants. These results coincided with the results of the reading task (Shimamori & Ito, 2006).

Key Words: stuttering, light syllables, heavy syllables, naming task, children who stutter

Introduction

Linguistic processing in people who stutter has become one of the more interesting themes in current research on stuttering. Recent research on the brain mechanism of stuttering has produced intriguing results with respect to such language processing (De Nil, Kroll, & Houle, 2001; De Nil, Kroll, Kapur, & Houle, 2000; Drokers, 1996; Fiez & Petersen, 1998; Fox, Ingham, Ingham, Hirsch, Downs, Martin, Jarabek, Glass, & Lancaster, 1996; Imaizumi, 2003).

In the present study, we focus on the phonological aspects of language in people who stutter. Many studies have investigated phonetic and phonological factors that affect stuttering (e.g., Brown, 1945; Kim & Ito, 2004; Ohashi, 1984; Sasanuma, 1968; Ujihira, 2000; Williams, Silverman, & Kools, 1969). Although previous studies have investigated the phonetic and phonological factors likely to cause stuttering, few

* Graduate Student, Department of Education for Children with Disabilities, Tokyo Gakugei University
** Department of Education for Children with Disabilities, Tokyo Gakugei University

studies examining the factors that facilitate the production of fluent speech have been reported. What are the phonological factors that promote such fluency? In the present study, we chose to investigate the effect of syllable weight on the frequency of stuttering.

In Japanese, syllable weight equals syllable length (Kubozono, 1998). Syllable weight can be counted from the number of moras, because moras are the unit of length in Japanese. Kubozono (1998) reported that syllable weights can be divided into light, heavy, and superheavy syllables. Light syllables are composed of one mora, heavy syllables of two, and superheavy ones of three.

In the present study, we compare two types of typical Japanese syllables, a light syllable and a heavy syllable. Kubozono (1998) reported that in Japanese, there are four types of heavy syllables, i.e., diphthong, long vowel, nasal consonant, and geminate stop. Although researchers do not agree as to whether diphthongs exist in the Japanese language, and, therefore, whether they should be included as a type of heavy syllable, we used Kubozono's (1998) classification of heavy syllables in the present study.

Shimamori and Ito (2006), using a nonword reading task, investigated the frequency of stuttering on nonwords beginning with light syllables or heavy syllables, and found that the frequency of stuttering was significantly lower in the nonwords that began with heavy syllables. Among the four types of heavy syllables, the frequency of stuttering was lowest on long vowels.

Shimamori and Ito (2006) used a reading task, however, and reading tasks require different linguistic processing from spontaneous utterances (Caplan, 1992). Although some people who stutter have no problem reading, they have difficulty in natural conversation, whereas others who have no problem in natural conversation, have difficulty reading (Moriyama, 1979).

The purpose of the present study was to investigate whether the results of a naming task would differ from those of a reading task.

Method

Stimulus Nonwords

Nonwords were used as stimuli in order to exclude any influence from prior habits of word usage. All of the stimulus nonwords were composed of three syllables, four moras, and began with/k/or/a/, because those have been reported to be the phonemes most likely to be stuttered (Ohashi, 1984).

The stimulus nonwords were divided into two groups, the first consisting of eight nonwords beginning with light syllables, and the second of 16 nonwords beginning with heavy syllables. The second group was further divided into four types of nonwords according Kubozono's (1998) classification: nonwords with diphthongs, nonwords with long vowels, nonwords with nasal consonants, and nonwords with geminate stops. That is, the 16 nonwords in the second group were comprised of four each of those four types. Table 1 lists the 24 stimulus nonwords.

TABLE 1 Stimulus Nonwords

Nonwords Beginning With Light Syllables		Nonwords Beginning With Heavy Syllables			
		Diphthongs	Long Vowels	Nasal Consonants	Geminate Stops
kapinan	apinan	kaipina	kaapina	kanpina	kappina
kabumon	abumon	kaibumo	kaabumo	kanbumo	kabbumo
katosun	atosun	aitosu	aatosu	antosu	attosu
kadarun	adarun	aidaru	aadaru	andaru	addaru

Participants

Participants were 50 children (41 boys, 9 girls) who stuttered. Stuttering in school-age children has been characterized by gender differences, in which males outnumber females at ratios that are usually estimated to vary from 3 : 1 to 6 : 1 (Bloodstein, 1995). The gender ratio in the present study reflects that disparity. Two females were excluded from the study, because they could not perform the task. Thus, data from 48 children were analyzed. Eight of these children also participated in Shimamori and Ito (2006).

The children were attending elementary schools in Tokyo. Three were first graders, 17 second-graders, 10 third-graders, 9 fourth-graders, 4 fifth-graders, and 5 were sixth-graders.

Procedure

Stimulus nonwords were presented to each child with the explanation that they were the names of monsters depicted on 24 picture cards. The name of each monster was written in hiragana at the bottom of each card. The children were tested individually in a room at their schools.

The children did a practice task before the experimental task. First, a picture card with a hiragana nonword was presented. Next, a white paper was presented to gain a little time. Then, a corresponding card was presented without the hiragana nonword. Children were asked to say the name of the monster on the card. The experimental task was similar to that.

All the children could remember almost all of the monster's names. If a participant could not remember a monster's name, the card with the hiragana name was presented again. The cards were presented in a pseudo-randomized order to avoid repetition of the same type of initial syllable. The stimulus nonwords were presented to half the children in the reverse order from the other half.

Responses were tape-recorded using a digital audio tape recorder (TCD-10, SONY) and microphone (ECM-959DT).

Method of Analysis

The measures of stuttering were repetitions, prolongations, and blockings occurring on the initial syllables. Frequency of stuttering was calculated by dividing the total number of words stuttered by the total number of words spoken, and multiplying the result by 100. Reliability was scored by Sander Agreement Index (Sander, 1961), that is, the rate of agreement was calculated by dividing the number of agreements by the total of the number of agreements plus disagreements, and multiplying by 100. The rate of agreement was 90.2%.

Results

Comparison Between Nonwords Beginning With Light and Heavy Syllables

The mean frequency of stuttering on nonwords beginning with heavy syllables was significantly lower than on those beginning with light syllables ($t\,(47)=5.09$, $p<.01$; see Fig. 1).

Individual differences were observed in the frequency of stuttering between nonwords beginning with light syllables and those beginning with heavy syllables. Figure 2 shows each child's frequency of stuttering on nonwords beginning with light syllables and those each child with heavy syllables. The participants' data are arranged in order according to the frequency of stuttering on nonwords beginning with light syllables. The frequency of stuttering on nonwords beginning with the light syllables was higher than on nonwords beginning with heavy syllables in almost all the children who stuttered. However, four children (participants numbered 32, 33, 34 and 35) stuttered only on nonwords beginning with heavy syllables. The frequency of stuttering in participants numbered 1, 9, and 19 was not lower on nonwords beginning with heavy syllables than those beginning with light syllables. Thirteen children (participants 36 to 48) did not stutter during the task.

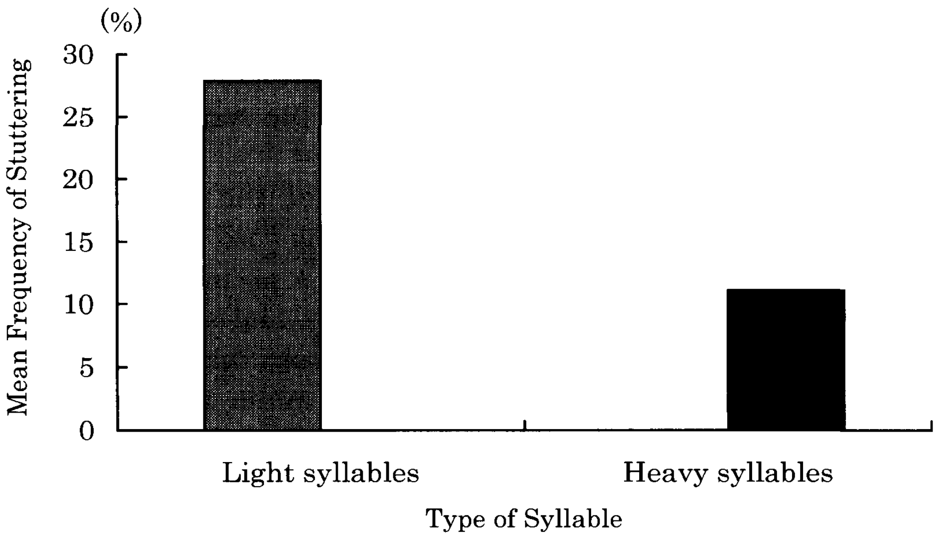

FIG. 1 Mean Frequency of Stuttering: Comparison Between Nonwords Beginning With Light Syllables and Nonwords Beginning With Heavy Syllables

Comparison Among Nonwords Beginning With Four Types of Heavy Syllables

As shown in Fig. 3, the frequency of stuttering was highest on diphthongs, and lowest on long vowels. A significant difference was observed between diphthongs and long vowels, between diphthongs and geminate stops, and between nasal consonants and long vowels ($Mse = 162.91$, $p < .05$).

Individual differences were observed in the frequency of stuttering among the nonwords beginning with the four types of heavy syllables. Figure 4 shows the frequency of stuttering for each child on the nonwords beginning with the four types of heavy syllables. The participants' data are arranged in order according to the frequency of stuttering on the nonwords with diphthongs. Only seven children (participants number 1, 2, 4, 5, 10, 13, and 14) stuttered on nonwords with long vowels.

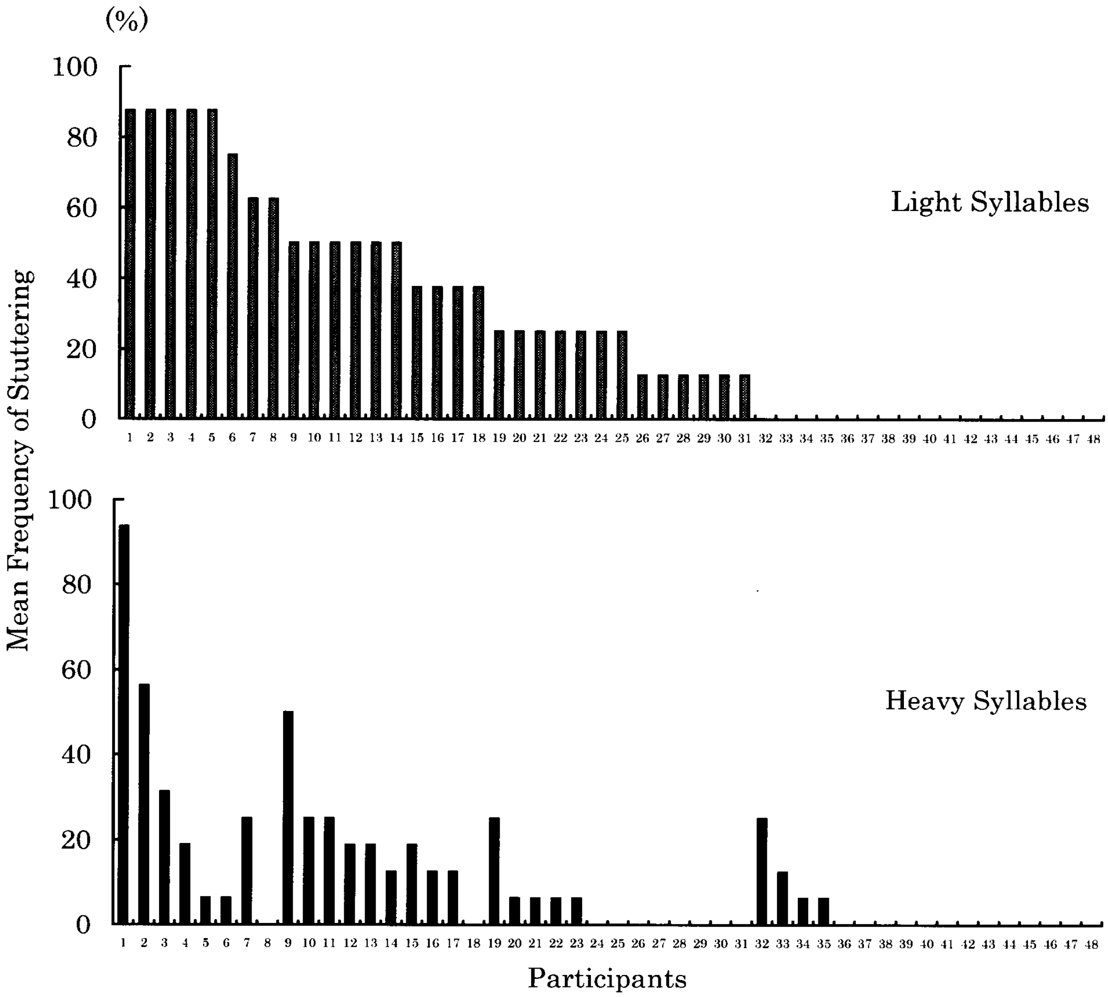

FIG. 2 Frequency of Stuttering in Each Child: Comparison Between Nonwords Beginning With Light Syllables and Four Types of Heavy Syllables

Individual Rresponses

Table 2 shows all of child A's responses. Child A stuttered on all the nonwords beginning with/a/ (responses with ∗). In contrast, she did not stutter at all on nonwords beginning with/k/. She used insertions more than twice in eleven out of twelve nonwords beginning with/a/, but only once in most nonwords beginning with/k/ (see Table 2).

Table 3 shows all of child B's responses. Child B stuttered on eight of the nonwords (responses with ∗). In contrast to child A, child B stuttered on the nonwords beginning with/k/, but not on the nonwords beginning with/a/.

Discussion

Effects of Nonwords Beginning With Heavy Syllables

The frequency of stuttering in the present study was significantly lower on nonwords beginning with heavy syllables than on nonwords beginning with light syllables. The results of the present study in which a naming task was used confirmed the results of Shimamori and Ito's (2006) research, in which a reading task was used. These results suggest that the effect of nonwords beginning with heavy syllables is not different in reading and naming tasks.

The purpose of the present study and of Shimamori and Ito (2006) was to examine factors that facilitate the production of fluent speech. Therefore, in what follows, we discuss nonwords beginning with heavy syllables, rather than with light syllables.

Kubozono (1998) reported that there were many words beginning with heavy syllables in the utterances of infants who were at the one-word stage. He proposed

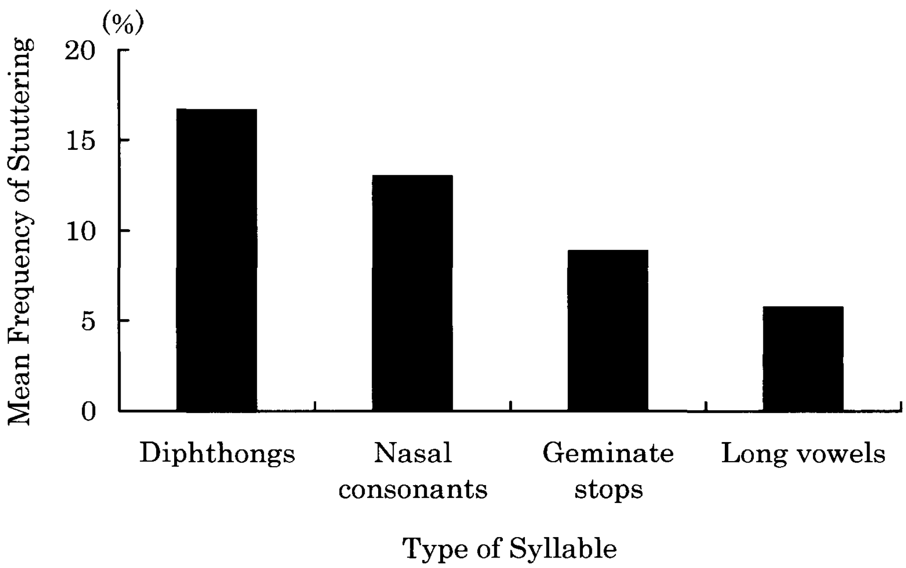

FIG. 3 Mean Frequency of Stuttering: Comparison of Nonwords Beginning With Four Types of Heavy Syllables

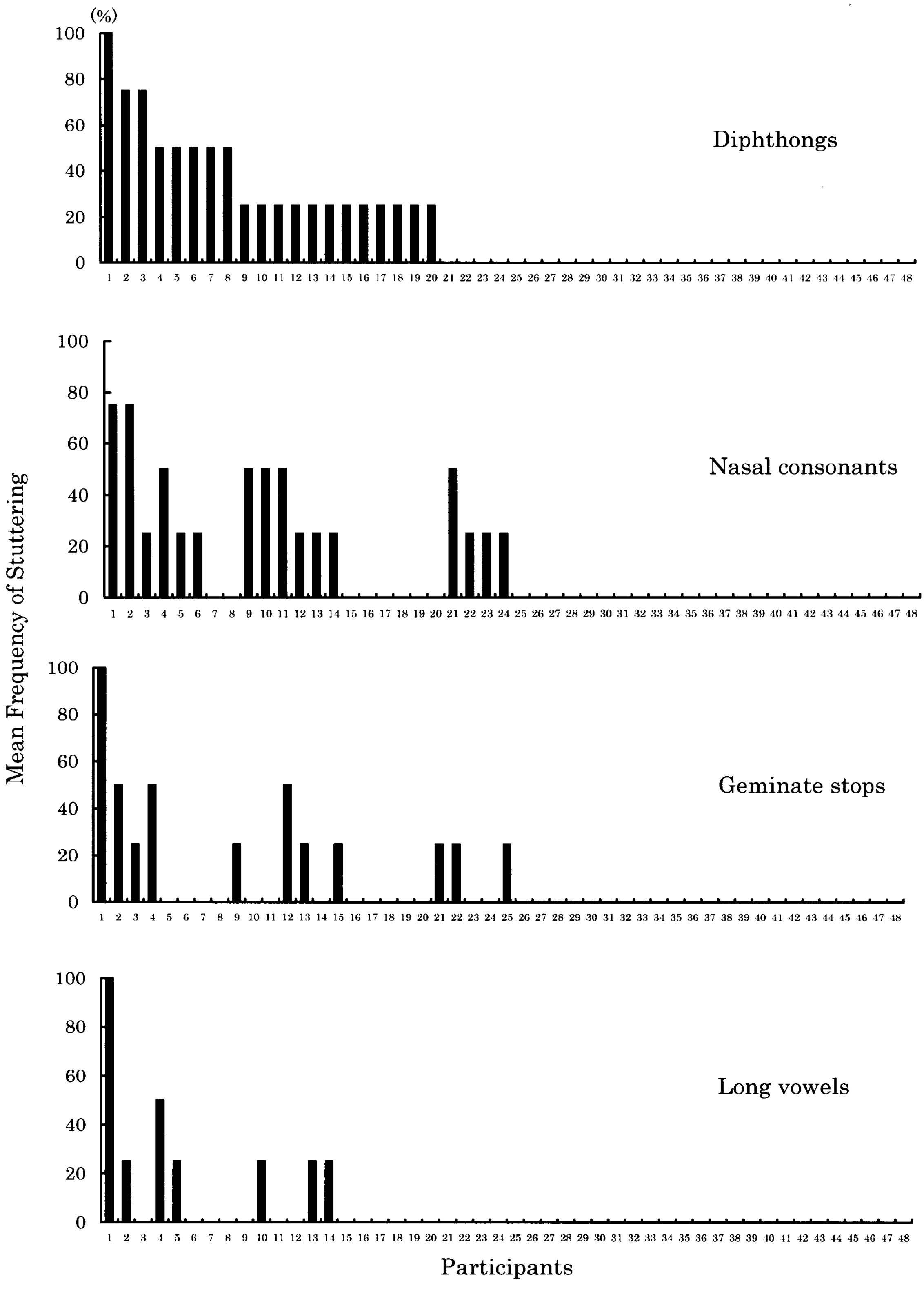

FIG. 4 Frequency of Stuttering by Each Child: Comparison of Nonwords Beginning With Four Types of Heavy Syllables

TABLE 2 Responses of Child A

Initial Phoneme	Type of Syllable	Stimulus Nonword	Response
/a/	Light syllables	apinan	* *etto etto etto* #apinan
		abumon	* *etto etto etto* #abumon
		atosun	* *etto etto etto etto* #atosun
		adarun	* *etto etto* #adarun
	Heavy syllables		
	Diphthongs	aitosu	* *etto etto etto* #aitosu
		aidaru	* *etto etto etto etto* #aidaru
	Nasal consonants	antosu	* *etto etto etto etto* #antosu
		andaru	* *etto etto* #andaru
	Geminate stops	attosu	* *etto etto etto etto etto* #attosu
		addaru	* *etto* #addaru
	Long vowels	aatosu	* *etto etto etto* #aatosu
		aadaru	* *etto etto etto etto etto* #aadaru
/k/	Light syllables	kapinan	*etto* kapinan
		kabumon	*etto* kabumon
		katosun	*etto* katosun
		kadarun	*etto* kadarun
	Heavy syllables		
	Diphthongs	kaipina	*etto* kaipina
		kaibumo	*etto* kaibumo
	Nasal consonants	kanpina	*etto* kanpina
		kanbumo	*etto* kanbumo
	Geminate stops	kappina	*etto* kappina
		kabbumo	*etto* kabbumo
	Long vowels	kaapina	*etto* kaapina
		kaabumo	*etto etto* kaabumo

Notes. * =response with stuttering; "*etto*"=insertion; #=utterance with blocking.

that heavy syllables might be easier to pronounce than other types of syllables. The agreement of the results of the present study with those of Shimamori and Ito (2006) suggests that in both a reading and a naming task, for children who stutter, nonwords beginning with heavy syllables are easier to pronounce than nonwords beginning with light syllables.

Why are nonwords beginning with heavy syllables easier to pronounce? Ujihira (2000) studied causes of difficulty in stuttering from the standpoint of phonetic transition. He focused on the relationship between the initial core vowels and the phonemes that follow them, just as we did. Nonwords beginning with light syllables require a transition from core vowels in the first syllable to the initial phoneme of the second syllable. For example, in the stimulus nonword "kapinan" (which begins with

TABLE 3 Responses of Child B

Initial Phoneme	Type of Syllable	Stimulus Nonword	Response
/k/	Light syllables	kapinan	*#kapinan
		kabumon	*#kabumon
		katosun	*k— #katosun
		kadarun	*k—k—#kadarun
	Heavy syllables		
	Diphthongs	kaipina	*#kaipina
		kaibumo	kaibumo
	Nasal consonants	kanpina	kanpina
		kanbumo	*#kanbumo
	Geminate stops	kappina	*#kappina
		kabbumo	*#kabbumo
	Long vowels	kaapina	kaapina
		kaabumo	#kaabumo
/a/	Light syllables	apinan	apinan
		abumon	abumon
		atosun	atosun
		adarun	adarun
	Heavy syllables		
	Diphthongs	aitosu	aitosu
		aidaru	aidaru
	Nasal consonants	antosu	antosu
		andaru	andaru
	Geminate stops	attosu	attosu
		addaru	addaru
	Long vowels	aatosu	aatosu
		aadaru	aadaru

Notes. * =response with stuttering; #=utterance with blocking; —=utterance with repetition.

the light syllable "ka"), a transition from the core vowel "a" to the initial phoneme "p" of the second syllable is needed. In contrast, nonwords beginning with heavy syllables require a transition to the following phoneme in the same syllable. For example, in "kaipina" (which begins with the heavy syllable "kai"), the transition from a core vowel "a" to the phoneme "i" in the same syllable is needed. According to Kolk (1991) and Kolk and Postma (1997), stuttering is caused by an adaptation to the difficulty of phonological encoding (Covert Repair Hypothesis). A transition between syllables (light syllables) is thought to require more complicated phonological encoding than a transition within the same syllable (heavy syllables). Therefore, for children who stutter, the production of nonwords beginning with heavy syllables is considered to be easier than the production of nonwords beginning with light syllables.

Effect of Nonwords With Long Vowels

Among the four types of heavy syllables in the present study in which the naming task was used, the frequency of stuttering was lowest on nonwords with long vowels. This result also agrees with the results of Shimamori and Ito (2006). This suggests that the effect of nonwords with long vowels was not different between the reading and the naming tasks, and that, for children who stutter, nonwords with long vowels are the easiest to pronounce among the four types of nonwords beginning with heavy syllables, in both reading and naming tasks.

According to Shimamori and Ito (2006), the four types of heavy syllables all require a transition from the second to the third phoneme. Three types of heavy syllables, diphthongs, nasal consonants and geminate stops, require a transition to a different phoneme. In contrast, long vowels do not require a transition to a different phoneme. The transition to a different phoneme is thought to require more complicated phonological encoding than to the same phoneme. Therefore, the production of nonwords with a long vowel is the easiest among the four types of nonwords beginning with heavy syllables.

Comparison of the Results of the Present Study With Those From Shimamori and Ito (2006)

The results of the present study agreed with those of Shimamori and Ito (2006). Why did the results in a naming task agree with those in a reading task? Reading tasks are said to require different linguistic processing from spontaneous utterances (Caplan, 1992). Therefore, the results of the present study suggest that utterances beginning with heavy syllables are easy for children who stutter to pronounce, regardless of the type of linguistic processing.

However, there may be a problem with the method used in the present study. The present study used a naming task to obtain spontaneous utterances. A picture card with hiragana was presented, followed by presentation of a corresponding picture card without hiragana. To say it another way, target nonwords were presented before utterances were produced, just as in Shimamori and Ito (2006). Hence, in this naming task, the utterances were not pure spontaneous utterances. In future research, an effective method of producing pure spontaneous utterances should be devised.

Individual Differences

In the present study, the initial phonemes of the stimulus nonwords were/k/ and/a/. Almost all the children who stuttered did so on the nonwords beginning with both/k/and/a/. However, child A and child B stuttered on the nonwords beginning with either/k/or/a/, but not on both, suggesting that the phonemes likely to be stuttered differ from child to child.

Child A used many insertions in responses to nonwords beginning with/a/. It is suggested that child A may realize that she has problems in producing the/a/sound and she might use insertions in an attempt to cope with the difficulty of producing that sound.

The analysis of individual data revealed that there were children who stuttered only on the nonwords beginning with heavy syllables. Moreover, the frequency of stuttering in some of the children was not lower on the nonwords beginning with heavy syllables than on those beginning with light syllables. These results suggest that there were children not affected by the heavy syllables. For example, child A's frequency of stuttering did not differ between the nonwords beginning with light syllables and those beginning with heavy syllables. She stuttered on all of the nonwords beginning with/a/, yet never on the nonwords beginning with/k/. These results suggest that, in child A, the effect of the initial phonemes is stronger than that of syllable weight.

Acknowledgments

We express our gratitude to the children and the teachers of speech and hearing classes of Kanatomi, Oji, Daisan Haketa, Honda, Oshiage, Naka Koiwa, Karasuyama Kita, Kuhonbutsu, Suginami Daiju, Takaido, Ikebukuro, Shakujii, Minami Machi, Fuchu Daiichi, Hoya, Kodaira Daini, Hachioji Daiyon, Fujimigaoka, and Kabe elementary schools in Tokyo.

References

Bloodstein, O. (1995) *A handbook on stuttering* (5th ed.). Singular, San Diego, California.

Brown, S. F. (1945) The loci of stuttering in the speech sequence. *Journal of Speech Disorders*, 10, 181–192.

Caplan, D. (1992) *Language: structure, processing, and disorders.* MIT Press, Cambridge, Massachusetts.

De Nil, L. F., Kroll, R. M., & Houle, S. (2001) Functional neuroimaging of cerebellar activation during single word reading and verb generation in stuttering and non-stuttering adults. *Neuroscience Letters*, 302, 77–80.

De Nil, L. F., Kroll, R. M., Kapur, S., & Houle, S. (2000) A positron emission tomography study of silent and oral single word reading in stuttering and nonstuttering adults. *Journal of Speech, Language, and Hearing Research*, 43, 1038–1053.

Drokers, N. F. (1996) A new brain region for coordinating speech articulation. *Nature*, 384, 159–161.

Fiez, J. A. & Petersen, S. E. (1998) Neuroimaging study of word reading. *Proceedings of the National Academy of Sciences of the United States of America*, 95, 914–921.

Fox, P. T., Ingham, R. J., Ingham, J. C., Hirsch, T. B., Downs, J. H., Martin, C., Jarabek, P., Glass, T., & Lancaster, J. L. (1996) A PET study of the neural systems of stuttering. *Nature*, 382, 158–162.

Imaizumi, S. (2003) Neural mechanisms of speech production and stuttering. *Japan Journal* *of Logopedics and Phoniatrics*, 44, 111-118. (in Japanese)

Kim, D. & Ito, T. (2004) Difference in rate of stuttering occurrence between words beginning with consonants and those starting with vowels, in Korean and Japanese stuttering children. *Japan Journal of Logopedics and Phoniatrics*, 45, 125-130. (in Japanese)

Kolk, H. H. J. (1991) Is stuttering a symptom of adaptation or of impairment? In H. F. M. Peter, W. Hulsijin, & C. W. Starkweather (Eds.), *Speech motor control and stuttering.* Elsevier, Amsterdam.

Kolk, H. & Postma, A. (1997) Stuttering as a covert repair phenomena. In R. F. Curlee & G. M. Siegel (Eds.), *Nature and treatment of stuttering: New directions* (2nd ed.). Allyn & Bacon, Boston, Massachusetts, 182-203.

Kubozono, H. (1998) Universality and individuality in phonological structure. In M. Nakau (Ed.), *Phonological structure and accent.* Kenkyusha. Tokyo, 1-108. (in Japanese)

Moriyama, H. (1979) Introduction to stuttering. In S, Sasanuma (Ed.), *Delayed language development and its treatment.* Taishukan, Tokyo, 195-243. (in Japanese)

Ohashi, Y. (1984) The consistency of stuttering in the spontaneous speech in stuttering children and its phonetic features. *Japan Journal of Logopedics and Phoniatrics.* 25, 209-223. (in Japanese)

Sander, E. (1961) Reliability of the Iowa Speech Disfluency Test. *Journal of Speech and Hearing Disorders, Monograph Supplement*, 7, 21-30.

Sasanuma, S. (1968) A description of the disfluent speech behavior of stuttering and nonstuttering Japanese children. Unpublished doctoral dissertation, University of Iowa, Iowa City, Iowa.

Shimamori, S. & Ito, T. (2006) Initial syllable weight and frequency of stuttering in Japanese children. *Japanese Journal of Special Education*, 43, 519-527.

Ujihira, A. (2000) Linguistic and phonetic study of speech disfluency. Unpublished doctoral dissertation, Osaka University, Osaka. (in Japanese)

Williams, D. E., Silverman, F. H. & Kools, J. A. (1969) Disfluency behavior of elementary school stutterers and non-stutterers: Loci of instances of disfluency. *Journal of Speech and Hearing Research*, 12, 308-318.

—Received August 9, 2006; Accepted February 17, 2007—