Language Learning 53:3, September 2003, pp. 429–462

Phonological Memory, Phonological Awareness, and Foreign Language Word Learning

Chieh-Fang Hu
Taipei Municipal Teachers College

The role of phonological memory and phonological awareness in foreign language (FL) word learning was examined. Measures of phonological memory and phonological awareness were administered to 58 Chinese-speaking 4-year-olds 4 times (T1 to T4) across 2 years. FL (English) word learning was assessed at T3, and children's ability to relearn the words was assessed at T4. Phonological memory was related to FL word learning at T3, whereas phonological awareness was not. However, phonological awareness emerged as a significant predictor at T4, even after allowing for FL word learning at T3 and phonological memory. The results suggest that phonological memory and phonological awareness may support FL word learning, but phonological awareness may play a specific role when the words are relearned.

Recently, a growing body of research has begun to support the notion of learning disabilities in the field of foreign language

This research was supported in part by grants from the National Science Council of Taiwan. The author thanks Hugh W. Catts, C. Melanie Schuele, and three anonymous reviewers for comments on a previous version of this article. The author also thanks the people and institutions that helped locate the children, the parents who gave their consent, and the children who participated in the study.

Correspondence concerning this article should be addressed to Chieh-Fang Hu, Department of English Instruction, Taipei Municipal Teachers College, 1 Ai-Kuo West Road, Taipei, Taiwan, R. O. C. Internet: cfhu@mail1.tmtc.edu.tw

(FL) acquisition. This research has identified that FL learning disability finds its root in subtle phonological, syntactic, and/or semantic coding difficulties of the first language (Chen, 1999; Ganschow, Sparks, Javorsky, Pohlman, & Bisho-Marbury, 1991; Sparks & Ganschow, 1993a, 1993b, 1995). Though intriguing, this line of research is limited in nature. Usually, the research has begun with the identification of a group of unsuccessful FL learners in college, followed by the description of their performances on a battery of standardized native language tests or self-reports of language learning history. However, a concomitant existence of native and FL difficulties among college students does not say much about how native language abilities affect FL learning in the first place. The specific mechanism linking native language and FL learning abilities is of theoretical and practical importance but so far has not been specifically delineated.

This study presents an initial attempt to explore the potential mechanism linking native language and FL learning by focusing on FL word learning and its relation to native phonological processing ability in young FL learners. One aspect of FL word learning is investigated, namely, mapping a novel sound sequence onto a known concept, operationally defined as the recall and the production of a newly learned phonological form for a pictured animal. Whether in first or second language, vocabulary learning essentially involves the learning of the arbitrary link between the sound patterns and the meanings of individual words. However, in the early stages of FL acquisition, the phonological aspect of word learning appears to be more important than the semantic aspect. The initial lexical items young FL learners are taught in an FL usually denote concepts that are generally similar to the concepts denoted in one's native language. This is especially true for lexical items denoting objects (e.g., fruit names or basic animal names) and body parts (e.g., *face, eyes, nose*). In other words, initial FL word learning normally involves learning neither new concepts nor new ways to categorize old concepts. Rather, it involves more of the learning of new sound patterns and the mapping of the sound patterns onto old concepts, a simple translation of vocabulary from one language to another.

This is not to say that FL word learning can be reduced to a simple phonological issue. Factors such as cognate status or word concreteness affect the ease with which words are acquired (de Groot & Keijzer, 2000). Knowledge of words undergoes constant modification and specification with extended learning experiences. Subtle nuances of word meaning are assembled (Clark, 1993). Word recognition processes are automatized (Segalowitz, Segalowitz, & Woods, 1998). But all of these processes rely on the child's initial acquisition of a phonological form to denote some meaning. Modification and specification of the word-referent relationship cannot proceed if the phonological pattern is obscure and incomplete. Thus, even though FL word learning is not a simple phonological issue, the establishment of a complete and solid phonological representation for a word still appears to be the first and most important springboard to success in early FL vocabulary acquisition for a young FL learner.

But what abilities developed through the acquisition of one's native language are essential to establishing a solid phonological representation in an FL? Phonological memory is an ability shown to be important in the acquisition of vocabulary in one's native language as well as that in an FL (Avons, Wragg, Cupples, & Lovegrove, 1998; Cheung, 1996; Gathercole & Baddeley, 1989, 1990; Gathercole, Hitch, Service, & Martin, 1997; Michas & Henry, 1994; Service & Craik, 1993; Service & Kohonen, 1995). Baddeley and his colleagues proposed the notion of a phonological loop in explaining variance in vocabulary acquisition (Baddeley, Gathercole, & Papagno, 1998). According to the phonological loop model, phonological memory provides a temporary store of unfamiliar phonological forms while more permanent memory representations of novel words are being constructed. A fragile phonological loop hampers the construction of phonological representations in long-term memory, especially when the words to be learned have highly unfamiliar sound structures. Under this view, it is the phonological short-term memory that supports vocabulary acquisition rather than vice versa.

However, it has also been suggested that the phonological memory typically measured by nonword repetition is mediated by children's existing lexical knowledge (Metsala, 1999; Snowling, Chiat, & Hulme, 1991). Multisyllabic nonwords containing a word in the position of a stressed syllable tend to elicit better repetition performances than those containing no lexical components (Dollaghan, Biber, & Campbell, 1995). Thus it is conceivable that vocabulary acquisition supports nonword repetition rather than the reverse. With only one exception (Service & Craik, 1993), the aforementioned studies have focused on the relationship between phonological memory and vocabulary acquisition *within* one language system. The direction of the relationship remains elusive, because knowledge of the materials tested can always be a mediating factor. The current study may shed some light on the issue by examining the relationship *across* languages. If the ability to create and use accurate phonological representations to repeat native-sounding nonwords predicts the learning of new, non-native-sounding foreign words, this provides further evidence that phonological memory is specifically related to vocabulary learning and that the relationship cannot be simply reduced to mediation by vocabulary knowledge.

In contrast to that paid to phonological memory, less attention has been paid to the role of phonological awareness in FL word learning. Phonological awareness refers to the ability to attend to, detect, and manipulate the sound units of one's native words independent of their meanings. It also involves the ability to organize the phonological representation of a word as a sequence of phonemes (Fowler, 1991; Swan & Goswami, 1997). There are several reasons to believe that phonological awareness may play a role in FL word learning. First, as has been argued by Snowling et al. (1991), the difficulty in phonological memory as measured by nonword repetition involves many factors, one of which concerns difficulties with phoneme segmentation. According to a simple model of speech processing developed by Snowling, Goulandris, Bowlby, and Howell (1986), there are at least two routes through which a word can be repeated. One involves direct access to the word's articulatory specification. The other is the nonlexical route, which involves phoneme segmentation. This second route is particularly important for learning foreign words that do not have lexical representations from which an articulatory program for output can be compiled. According to Snowling et al. (1986), words processed by the second route have to be analyzed at the phonemic level before articulatory commands can be executed. In this case, children who have developed an insight into the phonological structure of the native language (i.e., phonological awareness) are expected to be able to employ the second route when learning foreign words. On the other hand, children who have not developed or are slow at developing the ability to attend to the sound units of their native language would have great difficulty in segmenting a foreign word into phonemes for the purpose of articulation.

Other models have proposed slightly different views on how the pronunciation of a novel word is generated (Glushko, 1979; Taraban & McClelland, 1987). For example, in the lexical analogy model proposed by Glushko (1979), the pronunciation of a novel word can be achieved on the basis of units extracted from the phonological representation of words stored in the lexicon. These units are larger than individual phonemes (e.g., rimes), but generally smaller than syllables. Still this lexical route depends upon the structure and integrity of underlying phonological representations (Harm & Seidenberg, 1999). There has been evidence that a segmented phonological representation is less rigidly bound to the immediate phonetic context and is more readily generalized to new phonetic contexts for reproduction (Munson, 2001; also see Storkel, 2001).

Another reason that phonological awareness may be important in the learning of foreign words is that poor phonological awareness has been found to be closely associated with various language learning problems (Catts, 1989; Cornelissen, Hansen, Bradley, & Stein, 1996; Elbro, 1996; Fazio, 1997; Katz, 1986; Swan & Goswami, 1997). It has been suggested that children who have poor phonological awareness organize their phonological representations at units larger than phonemes (Fowler, 1991; Swan & Goswami, 1997). Phonological representations that are organized at larger units such as the holistic shape of a word are believed to be primitive and underspecified and thus are more difficult to remember, to recall, and to articulate than fine-grained, more distinct phonemic representations, particularly in the case of phonologically complex items (de Jong, Seveke, & van Veen, 2000; Elbro, 1996; Fowler, 1991; Studdert-Kennedy & Goodell, 1995).

This difference in the phonological representations of children may have an even greater impact where FL word learning is concerned. For foreign words, not only are the individual sounds unfamiliar, but the phonological structures involve novel sound patternings, stress assignments, and syllable configurations. The phonemic composition of a foreign word, masked by unfamiliar overall syllable structure, should pose great difficulty for an FL learner to attend to. In this case, sensitivity to or an emergent insight into the phonological structure of a word developed from the acquisition of one's native language should be critical, because such awareness would enable a learner to attend to the internal structure of an acoustically integrated sound. A distinct phonological representation can be established as a result of clear insight into the constituents of the foreign syllables. Without such insight, young FL learners may attend merely to the primitive characteristics or the salient acoustic shape of the foreign word, such as [+abrupt onset] for *cat* or *pop* or [+sibilant] for *fish* or *sauce*, resulting in a crude mental copy of the target word.

There is little evidence directly linking phonological awareness with FL word learning. However, studies on native vocabulary acquisition provide some empirical evidence that indirectly suggests that difficulties in FL word learning may be linked to a lack of phonological awareness developed through the acquisition process of one's native language. For example, Metsala (1999) found that phonological awareness explained additional variance in vocabulary among a group of 4- to 6-year olds, after differences in phonological memory were controlled for, whereas phonological memory did not account for any extra variance after phonological awareness was taken into account. De Jong et al. (2000) found that measures of phonological awareness in 5-year-olds accounted for a significant portion of variance in paired-associate learning of phonologically unfamiliar names after age, nonverbal IQ, vocabulary, and nonword memory were controlled for. Bowey (1996) found that phonological awareness explained variance in receptive vocabulary after age, nonverbal IQ, and phonological memory were controlled for. Gathercole, Willis, and Baddeley (1991), on the other hand, found that phonological awareness did not account for significant variance in receptive vocabulary after the effects of age and nonverbal IQ were controlled for in 4- and 5-year olds. However, these different findings may be attributable to the phonological awareness tasks employed in the studies that generated them. Unlike the other studies cited above, Gathercole et al. (1991) used a rhyme categorization task, which did not measure phonological awareness at the phoneme level and placed high demand on phonological memory (Oakhill & Kyle, 2000).

The aim of the present study was to evaluate the role of native language phonological processing skills in children's FL word recall and pronunciation learning. Two aspects of phonological processing skills in the participants' native language were tested four times (T1 to T4), at 6-month intervals, across 2 years: phonological memory and phonological awareness. An FL word recall and pronunciation task was administered at the 2nd year (T3) and readministered 6 months later (T4). The same set of words was used in both the first and the second testing. Given that forgetting and relearning are natural processes of FL acquisition, retention of word learning and the role of phonological memory and phonological awareness in word relearning were explored. Evidence from first language development has indicated that the basic phonological production unit in the period of early phonology is the whole word shape, with no awareness of individual phonemes (Ferguson, 1986; Studdert-Kennedy, 1987; Studdert-Kennedy & Goodell, 1995; Walley, 1993). Phonological representations become increasingly segmental across the preschool and early school years. Older children, even with certain awareness of individual phonemes, may still attend to the most salient phonological features when the words to be learned are not familiar; they will attend to the individual phonemes when the words become more familiar (see Walley, 1993, for a review). Given that the words to be learned in the present study differ from the words in the child's native language not only in phonemic segments, but also in the overall word shape, such as syllabic structure, stress assignment, and prosodic features, it is likely that phonological awareness may play a more significant role when the words are relearned than when the words are completely novel at all levels of phonological information, including the overall phonological shape and the individual segments.

Method

Participants

Fifty-eight children (28 males, 30 females) from two preschools in Taiwan participated in the study. The children were first tested when they were 57 months old ($SD = 3.8$; range 50–63 months), and testing was completed 18 months later. According to their classroom teachers, all participants were progressing normally in speech, language, and hearing development. The native language of the participants was Mandarin and the FL was English, which was not used in the children's daily conversation. Children from one preschool had twelve 30-min English classes taught by native speakers of English each week. Children from the other preschool had two or three 30-min English classes taught by native speakers each week and a 30-min section for review each day by a teacher whose native language was Mandarin. These children were first tested individually in January and again in June/July across two school years, for a total of four testing times. Testing took place in a quiet area in the school.

Tasks and Procedure

There were six tasks. All the tasks were administered and readministered during four sessions of 20–30 min each. These sessions, referred to as T1, T2, T3, and T4, were approximately 6 months apart. All six tasks (native vocabulary, *Zhuyin fuhao* word-reading ability, phonological memory, and three phonological awareness tasks) were given in all four sessions. An FL word recall and pronunciation-learning task was given only in sessions 3 and 4.

Native vocabulary. The Chinese version of the Peabody Picture Vocabulary Test–Revised (PPVT-R) was used to measure the child's receptive vocabulary in his or her native language. The PPVT-R consists of a series of 125 plates, each containing four line drawings of objects or actions. For each plate, the experimenter provided a stimulus word orally. The child was asked to respond by pointing to the line drawing on the plate that best illustrated the meaning of the stimulus word. Test administration proceeded until the test error criterion (six errors in eight consecutive test items) was reached.

Zhuyin fuhao *word reading*. In the *Zhuyin fuhao* word-reading task, the child read a list of 22 wordlike stimuli written in *Zhuyin fuhao*, the Mandarin phonetic symbols, which in Taiwan are introduced and printed alongside the Chinese written characters as an aid for pronouncing characters when instruction in reading begins. This task was included because of its close association with phonological awareness among Chinese speakers (Hu & Catts, 1998; Read, Zhang, Nie, & Ding, 1986). The test included 12 real monosyllabic words written in *Zhuyin* *fuhao* and 10 monosyllabic nonwords. No corrective feedback was given during testing.

Phonological memory. The phonological memory task, adapted from Hu and Catts (1998), required the child to repeat sets of three bisyllabic nonwords given orally by the experimenter.[1] Six syllables were first constructed by combining one of the six consonants *b, d, k, g, zh*, and *sh* with one of the six vowels *u, a, ai, au, an*, and *ang*. These sets of consonants and vowels can be freely combined with each other without violating the phonological rules of Mandarin. In fact, all the syllables created for the task were real syllables existing in Mandarin Chinese. Two syllables were then combined into each bisyllabic nonword, and each nonword was assigned a tonal structure. None of the successive syllables in a nonword were assigned Tone 3. In Mandarin, when two syllables with Tone 3 occur in succession within a word, the tone of the first syllable changes to Tone 2. Because the stimuli used in this task were nonwords, the change of tone would make it difficult to document the child's response. A total of six trials were conducted, with three bisyllabic nonwords in each trial. For each trial, the child listened to the bisyllabic nonwords spoken by the experimenter. The child was instructed to repeat the nonwords immediately in the order in which they had been presented. The child's responses were audio recorded and were later transcribed. The child's nonword memory performance was scored in terms of the average number of syllables the child recalled correctly in the correct position in a trial (Max = 6).

Phonological awareness. Three tasks were used to measure phonological awareness: vowel substitution, syllable substitution, and vowel detection. The vowel substitution task followed the format described by Wimmer, Landerl, Linortner, and Hummer (1991). For each trial in this task, the experimenter provided a test word containing the vowel /a/, and the child replaced /a/ with /u/ and produced a new word. The change from /a/ to /u/ represents a substantial alteration, because these two vowels are quite different with respect to articulatory and acoustic gestures. The task was introduced by presenting a stuffed toy, which the child was told had invented a secret language and always said /u/ instead of /a/. The child was asked to repeat what the toy would say instead of the given word. All of the "new words" were pronounceable and obeyed the phonotactic constraints of Mandarin Chinese. No corrective feedback was given during testing. There were 3 practice trials involving one-syllable words, followed by 10 test trials (Max = 10).

The syllable substitution task was similar to the vowel substitution task but involved the awareness of constituents of units that were larger than phonemes. In this task, the child changed a syllable in a given bisyllabic word. For each trial, the child was presented with a test word containing the syllable /feng/ and asked to replace the /feng/ with a /dou/. For example, when presented with the word *fengzheng*, 'kite,' the child had to change the word *fengzheng* into the word *douzheng*. The task was introduced by showing the child another (different) stuffed toy and telling the child that the toy had invented a secret language and always said /dou/ instead of /feng/. The child was asked to repeat what the toy would say instead of the given word. The responses were pronounceable and obeyed the phonotactic constraints of Mandarin Chinese. It should be noted, however, that the syllable substitution task was not a purely phonological task in Mandarin, as the syllables to be produced had semantic associations. No corrective feedback was given during testing. There were 3 practice trials with /feng/ in the first syllable of the word (e.g., *fengzheng*, 'kite'), followed by 10 test trials. Then 3 practice trials introduced the substitution of the second syllable of the word (e.g., *xinfeng*, 'envelope'), followed by 10 test trials with /feng/ in the second syllable of the word (Max = 20).

The vowel detection task required the child to indicate whether a monosyllabic word such as /da/ or /fei/ contained a target sound /a/. The experimenter said a word to the child and asked the child to listen for the sound /a/. The child had to say "yes" if the word heard contained /a/ and "no" if it did not. No corrective feedback was given during testing. This task was judged to be less complex than the vowel substitution task, and thus the vowel detection task might tap more rudimentary or primitive phonological awareness skills in the young children participating in the study. An awareness of the similarity of the acoustic features of the two syllables presented to the child (for example, /a/ and /da/) was sufficient for a correct response in the vowel detection task. Ten test trials were used at T1 and T2. At T3 and T4, an additional 10 trials were included that required the child to detect the vowel /u/ in a given syllable (Max = 10 at T1 and T2; Max = 20 at T3 and T4).

FL word recall and pronunciation learning (FL-WRP learning). The FL word recall and pronunciation-learning task was similar to that adopted by de Jong et al. (2000), which allowed for a close empirical examination of the child's ease in acquiring FL words with little confounding effect from individual differences in experiences with FL. Children were taught three new bisyllabic English words, with accompanying pictures: *conger, minnow*, and *triton*. These words differ from Chinese words in terms of segmental contents, phonotactic constraints, and prosodic features. Hence, children clearly should perceive these words as foreign words rather than just new Mandarin Chinese words. In pretesting, when children were asked for the English names of the pictures, children either gave no response or gave a general term (e.g., "fish" for *conger*), indicating that the word forms chosen for instruction were initially unfamiliar to the children.

In the first trial, for each of the three words, the examiner showed the child a color picture and labeled the picture with its English name. The child was asked to repeat the name. No feedback was given as to correctness of the child's pronunciation, so that every child received an equivalent amount of instruction (i.e., input) on the FL words. When the child had been given the opportunity to repeat the name of all three pictures, the three pictures were shown again in a different order and the child was asked again to name the pictures (without an immediately preceding model). The accuracy of the child's production attempt to name the pictures was scored. Thus, one trial consisted of the examiner's saying each of the three words, the child's attempting to repeat each word, and the child's being shown the pictures a second time and asked to produce the label without an immediately preceding model. Given that children might differ in their knowledge of the Chinese equivalents of the target words, the corresponding Chinese names were not used to introduce the new words. A maximum of nine trials were administered; the trials were discontinued if the child named all three pictures correctly in two consecutive trials (Max = 27). A correct name was defined as a production with no obvious phoneme replacements, omissions, or additions. The tasks were administered in January of the 2nd year and readministered 6 months later. During the readministration, the child was asked to name the three pictures before the learning task was initiated again.

Results

Fifty-eight children completed the tasks at T1. Three had moved to other communities at T2, and another seven had left the preschools at T3. Only 48 were therefore available for the word-learning part of the study. Data are reported for these 48 children. Data for a small number of children ($n = 9$, 8, 4, and 2 at T1, T2, T3, and T4, respectively) were excluded from the analyses of phonological memory because their responses were unintelligible or because they gave no responses.

Descriptive statistics and reliabilities (Cronbach's alpha) for all measures are presented in Table 1. PPVT-R raw scores were used in the analyses. The standard scores associated with the raw scores at T1, T2, T3, and T4 were 108.7, 109.7, 101.1, and 105.5, respectively. As expected, children's performances on each measure generally improved over time. Severe floor effects were observed on many phonological awareness tasks administered at T1 and T2, which was not surprising given the young age of the participants. More than 90% of the children scored

Table 1

Descriptive statistics for the measures

Measures	Sessions	*M*	*SD*	Max	Reliability
PPVT-R raw score	T1	37.23	11.10		
	T2	43.27	10.03		
	T3	45.38	11.16		
	T4	54.71	12.79		
Zhuyin fuhao word reading	T1	.00	.00	0	1.00
	T2	1.36	3.69	15	.95
	T3	4.73	5.99	19	.97
	T4	8.83	7.04	22	.92
Phonological memory	T1	2.37	.85	6	.79
	T2	2.61	.74	6	.81
	T3	2.94	.96	6	.84
	T4	3.03	1.09	6	.79
Vowel detection	T1	5.81	2.29	10	.76
	T2	6.73	2.03	10	.66
	T3	13.71	3.61	20	.72
	T4	15.21	3.43	20	.70
Syllable substitution	T1	3.77	5.59	20	.98
	T2	5.64	5.90	20	.96
	T3	11.40	7.20	20	.98
	T4	15.23	6.47	20	.98
Vowel substitution	T1	.17	1.15	10	1.00
	T2	.02	.15	10	.98
	T3	.50	1.88	10	.99
	T4	.90	2.63	10	.99
FL-WRP learning	T3	11.04	7.22	27	.97
	T4	16.94	8.00	27	.96

zero on the vowel substitution tasks administered at T1 and T2. The means of the vowel detection scores were 5.81 at T1 and 6.73 at T2, both of which were only slightly higher than the expected outcome of pure guessing (5). Virtually all of the children scored zero on the *Zhuyin fuhao* word-reading task completed at T1, indicating that the children were preliterate when they were first tested. At T2, 80% of the children scored zero on the *Zhuyin fuhao* word-reading task. Given the severe floor effects, the data obtained from these tasks at these measurement points were excluded from the following analyses. On the FL-WRP learning task, 60% ($n = 29$) of the children did not name all three words correctly after nine trials of instruction at T3. At T4, 31% ($n = 15$) of the children failed to learn the words after nine trials of instruction.

Table 2 presents the correlation matrix for the principal measures across sessions. To simplify the presentation of the correlations, the phonological awareness measures and the *Zhuyin fuhao* word-reading measures at T1 and T2 were not included in the table because of the floor effects observed in these tasks. The PPVT-R tests at T1 and T2 were also excluded because they showed little relevance to the following analyses. The intrameasure correlations across testing sessions were significant in most cases, indicating that the measures were reliable across times. As for intermeasure correlations, the measures of native vocabulary were not correlated with the FL-WRP learning tasks. Neither were the measures of the *Zhuyin fuhao* word-reading ability related to the FL-WRP learning tasks. The phonological memory scores at T1, T2, and T3 were correlated with the FL-WRP learning scores at T3 ($r = .40$, .48, and .32, respectively), and those at T2, T3, and T4 were correlated with the FL-WRP learning scores at T4 ($r = .38$, .31, and .36, respectively). In contrast, none of the three measures of phonological awareness (vowel detection, syllable substitution, and vowel substitution) were correlated with children's performance on the FL-WRP learning task at T3. However, the two simpler phonological awareness measures, vowel detection and syllable substitution, taken at T3 and T4 were significant correlates of the FL-WRP learning scores at T4 ($r = .40$ and .42 for vowel detection at T3 and T4; $r = .37$ and .44 for syllable substitution at T3 and T4), but not of the FL-WRP learning scores at T3. Scores on the vowel substitution task administered at T4 were correlated with the FL-WRP learning scores at T4 ($r = .30$).

A somewhat surprising finding was that the measure of phonological memory was not related to the measure of native

Table 2

Correlation matrix for principal measures

	1. PPVT-R–T3	2. PPVT-R–T4	3. *Zhuyin fuhao* word reading–T3	4. *Zhuyin fuhao* word reading–T4	5. Phonological memory–T1	6. Phonological memory–T2	7. Phonological memory–T3	8. Phonological memory–T4	9. Vowel detection–T3	10. Vowel detection–T4	11. Syllable substitution–T3	12. Syllable substitution–T4	13. Vowel substitutuin–T3	14. Vowel substitution–T4	15. FL-WRP learning–T3	16. FL-WRP learning–T4
1		**.46**	.16	.25	.17	.04	−.01	.19	.20	**.38**	.18	**.34**	.04	.06	.07	.21
2			.21	.18	.28	.28	.11	**.40**	.07	**.34**	**.30**	.23	−.05	.04	.02	.09
3				**.51**	−.13	−.14	.03	**.30**	.21	**.30**	.08	−.00	.09	.25	−.20	−.15
4					.29	.28	.12	**.38**	**.51**	**.58**	**.35**	.25	**.35**	**.31**	.05	.13
5						**.61**	**.37**	**.33**	.03	.12	.17	.02	.12	−.31	**.40**	.09
6							**.43**	**.45**	.14	.23	.02	.08	−.06	.04	**.48**	**.38**
7								**.68**	.05	.12	.08	.12	−.25	−.10	**.32**	**.31**
8									.12	.21	.09	.19	.02	.19	.28	**.36**
9										**.66**	**.42**	**.32**	**.40**	**.33**	−.01	**.40**
10											**.53**	**.56**	**.35**	**.34**	.02	**.42**
11												**.72**	**.30**	.17	.18	**.37**
12													.17	.12	.12	**.44**
13														**.35**	.03	.08
14															.06	**.30**
15																**.39**
16																

Note. $N = 48$. Sample size involving phonological memory is 39, 40, 44, and 46 at T1, T2, T3, and T4, respectively. Correlations in boldface are significant at $p < .05$.

vocabulary. Only 1 out of 8 correlations between these two measures was significant. This result was inconsistent with the findings on English-speaking children (e.g., Gathercole &

Baddeley, 1989) and will be discussed further in the "Discussion" section.

To examine the relative variance in the FL-WRP learning scores at T4 predicted by phonological memory and phonological awareness, hierarchical regression analyses were performed. In the first set of regression analyses, the FL-WRP learning scores at T4 were entered as the dependent variable. The FL-WRP learning scores at T3 and the categorical variable *school* were entered as step 1 in each of the analyses to control for the variance due to early experience with the words to be learned and the variance in English-learning experience due to school education. Children's *Zhuyin fuhao* word-reading scores were entered as step 2. Phonological memory scores were entered in step 3. At step 4, the final step in each regression, a different one of the three phonological awareness measures at T4—vowel detection, syllable substitution, or vowel substitution—was entered. Table 3 shows the results of the regression analyses. Phonological memory accounted for a significant 7% of the variance in the FL-WRP learning scores at T4 after the differences in the earlier FL-WRP learning scores, *school*, and the *Zhuyin fuhao* word-reading scores were controlled for. Vowel detection, as step 4, accounted for a significant unique variance of 16% in

Table 3

Unique variance in FL-WRP learning (T4) accounted for by phonological awareness

Step	Predictors	*df*	Multiple *R*	R^2 change
1	FL-WRP learning (T3) *school*	2, 43	.44	.20**
2	*Zhuyin fuhao* word reading (T4)	3, 42	.48	.03
3	Phonological memory (T4)	4, 41	.55	.07*
4a	Vowel detection (T4)	5, 40	.68	.16**
4b	Syllable substitution (T4)	5, 40	.61	.07*
4c	Vowel substitution (T4)	5, 40	.65	.12**

$^{**}p < .01$. $^{*}p < .05$.

the FL-WRP learning scores at T4 after the earlier FL-WRP learning scores, *school*, the *Zhuyin fuhao* word-reading scores, and phonological memory were controlled for. With the same set of variables controlled for, syllable substitution explained an extra variance of 7% and vowel substitution explained an extra variance of 12%.

In the second set of regression analyses, phonological memory and the phonological awareness measures were entered in the reverse order from that of the first. The earlier FL-WRP learning scores, *school*, and the *Zhuyin fuhao* word-reading scores were entered at steps 1 and 2, just as in the first set of regression analyses. At step 3 in each regression, a different one of the three phonological awareness measures at T4—vowel detection, syllable substitution, or vowel substitution—was entered. Phonological memory scores were entered at step 4. As shown in Table 4, when the earlier FL-WRP learning scores, *school*, and the *Zhuyin fuhao* word-reading scores were forced into the equation as steps 1 and 2, vowel detection explained an extra variance of 16% in the FL-WRP learning scores at T4. An extra variance of 9% was accounted for by syllable substitution, and an extra variance of 14% by vowel substitution, with the

Table 4

Unique variance in FL-WRP learning (T4) accounted for by phonological memory

Step	Predictors	*df*	Multiple *R*	R^2 change
1	FL-WRP learning (T3) *school*	2, 43	.44	.20**
2	*Zhuyin fuhao* word reading (T4)	3, 42	.48	.03
3	Vowel detection (T4)	4, 41	.62	.16**
4	Phonological memory (T4)	5, 40	.68	.07*
3	Syllable substitution (T4)	4, 41	.57	.09*
4	Phonological memory (T4)	5, 40	.61	.05
3	Vowel substitution (T4)	4, 41	.61	.14**
4	Phonological memory (T4)	5, 40	.65	.05

$^{**}p < .01$. $^{*}p < .05$.

same set of variables controlled for. Phonological memory, when entered as step 4, predicted an extra variance of 7% in the FL-WRP learning scores at T4 when vowel detection was entered as step 3, but not when step 3 involved entering syllable substitution or vowel substitution. This is probably because syllable substitution and vowel substitution required phonological awareness at a more explicit level than vowel detection. Further, it should be noted that the FL-WRP learning scores at T3 shared variance with phonological memory but not with phonological awareness. This probably resulted in some variance in the FL-WRP learning scores at T4 that would be accounted for by phonological memory's now being partialed out together with the FL-WRP learning at T3.

The unique association of phonological awareness with FL-WRP learning at T4 could be the result of the words' becoming more familiar at T4. It could also be that there was a time lag between the development of phonological awareness and the use of phonological awareness in FL-WRP learning. There might also be other possibilities. For example, children's FL vocabulary knowledge at T4 might be more enriched or more segmentally represented at T4 than at T3, resulting in the unique association of phonological awareness with FL-WRP learning at T4. Unfortunately, the third possibility cannot be tested in the present study as children's FL vocabulary knowledge was not measured, because of the constraints on the amount of time that each child was allowed to be tested. To distinguish between the first two possibilities, similar sets of regression analyses were run separately for children who had learned the three FL words at T3 ($n = 19$) and children who demonstrated no evidence that they had successfully learned the three words ($n = 29$). If the unique association between the phonological awareness measures and FL-WRP learning is a result of the words' becoming familiar, we would expect that the phonological awareness measures would uniquely predict the variance in the ability to relearn the words among the former group of children but not among the latter group of children.

Table 5

Unique variance in FL-WRP learning (T4) for successful FL word learners and less successful learners at T3

		Successful learners		Less successful learners	
Step	Predictors	Multiple R	R^2 change	Multiple R	R^2 change
1	FL-WRP learning (T3) *school*	.16	.03	.34	.11
2	*Zhuyin fuhao* word reading (T4)	.17	.00	.48	.11
3	Phonological memory (T4)	.19	.00	.59	.12*
4	Vowel detection (T4) Syllable substitution (T4) Vowel substitution (T4)	.79	.59*	.71	.15
3	Vowel detection (T4) Syllable substitution (T4) Vowel substitution (T4)	.76	.55*	.67	.22
4	Phonological memory (T4)	.79	.05	.71	.05

*$p < .05$.

The results of hierarchical regression analyses for the successful FL word learners and the less successful learners are reported in Table 5. To simplify the presentation, the three phonological awareness measures were entered into the regression as a set. For the successful FL word learners at T3, after the *school* differences, the initial FL-WRP learning scores, and the word-reading scores at T3 were taken into account in steps 1 and 2, phonological memory, included in step 3, did not account for any extra variance in the FL-WRP learning scores at T4. The three phonological awareness measures as a set accounted for a substantial and significant extra 59% of the variance in step 4. For the less successful FL word learners, phonological memory described a significant additional 12% of the variance at step 3.

Phonological awareness did not account for extra variance when entered as step 4. Even when the phonological awareness measures were entered as step 3, before the variance in phonological memory was controlled for, the phonological awareness measures still accounted for a nonsignificant extra percentage of the variance in the FL-WRP learning scores at T4.

Note that the successful FL word learners, as a group, performed better on phonological memory than the less successful FL word learners, $t(42) = 2.56$, $p < .05$, at T3; $t(44) = 2.59$, $p = .01$, at T4. However, they did not perform better on any one of the phonological awareness measures than the less successful FL word learners either at T3 or at T4, $t(46) = .36$ for vowel detection, $t(46) = 1.21$ for syllable substitution, and $t(46) = .86$ for vowel substitution, all ps $> .05$, at T3; $t(46) = .25$ for vowel detection, $t(46) = 1.37$ for syllable substitution, and $t(46) = .22$ for vowel substitution, all ps $> .05$, at T4.

Discussion

The major aim of the study was to examine the relationship of the two phonological processing skills of a person's native language, phonological memory and phonological awareness, to FL word recall and pronunciation learning in young FL learners. The investigation was a preliminary evaluation of the hypothesis that a person's native language phonological memory and phonological awareness influence his or her ability to learn an FL. In this study, FL word learning was explored in young Chinese-speaking children at 6 years of age and involved the ability to recall and pronounce three unknown, uncommon English words. The results provide preliminary support to Baddeley et al.'s (1998) proposal that phonological memory plays a crucial role in the learning of unfamiliar phonological forms. The measures of phonological memory taken at T1, T2, and T3 were related to the FL-WRP learning scores at T3, and those taken at T2, T3, and T4 were related to the FL-WRP learning scores at T4. The FL word recall and pronunciation-learning task used in the present study is similar to that employed by de Jong et al. (2000). It essentially involves learning to associate the pronunciations of unfamiliar FL words with specific corresponding pictures and produce the pronunciation. When a child is said to have learned the words, it means that the child has successfully paired the phonological representations with the designated pictures and created the phonological representations of the words for reproduction. In the present study, the FL-WRP learning task was first administered when the children were 6 years old. About 40% of the children learned all the three English words during this initial testing (T3). Retention of the learned words between T3 and T4 was nonexistent; 6 months later (T4) none of the children who were able to produce all three words at T3 were able to name all three pictures prior to readministration of the task.

The results of the study shed some light on the two prevailing accounts of the close relationship between phonological memory measured by nonword repetition and vocabulary acquisition. Recall that one account has been that phonological short-term memory capacity, measured by nonword repetition, affects the ease with which new phonological information is established in long-term memory (for a review, see Baddeley et al., 1998). The other account takes an opposing stance, proposing that vocabulary knowledge contributes to performance on the nonword repetition task (Snowling et al., 1991). Because the nonword repetition stimuli and the word-learning stimuli employed in most of the previous studies were from the same language (i.e., the children's native language), it is plausible that the relationship between phonological memory and word learning might have been mediated by children's existing lexical knowledge. However, in the present study the phonological memory task (though slightly different from the typical nonword repetition task) involved nonwords that were characteristic of Mandarin Chinese, the children's native language, rather than characteristic of English, the FL to be learned. Thus, even if lexical knowledge had intruded on performance in the phonological memory task of the present study, the lexical knowledge should have been the knowledge of the native language, rather than the knowledge of the FL. This lexical knowledge is not expected to intrude on the learning of English-sounding words, given that the words to be learned differ from those in the children's native language in terms of phonological and morphophonological structures. Thus phonological memory may be specifically related to FL word learning, and the relationship cannot be simply reduced to a result of mediation by vocabulary knowledge.

One may question the conclusions drawn because the phonological memory task used in the present study is not an exact copy of the typical nonword repetition task (i.e., the typical task used in English), which requires the child to repeat, one at a time, nonwords varying in length and complexity (e.g., words of increasing syllable length; nonwords without clusters—*sep, pennel, doppelate, woogalamic*; nonwords with clusters—*grall, hampent, glistering, contramponist*). In addition, one might question the fact that in contrast to Gathercole and Baddeley's (1989) findings with English-speaking children, for example, the phonological memory measure in the present study did not correlate with the children's native vocabulary scores. However, a close examination of the phonological memory task in the present study reveals that the task may be a purer measure of phonological memory capacity than the typical nonword repetition task. First, the child had to repeat three nonwords at a time rather than one nonword at a time; this may have made larger demands on phonological memory. Second, to perform the phonological memory task in the present study, the child did not have to decompose the nonwords into their smaller subsyllabic segments or assemble unfamiliar articulatory motor programs for each component syllable, because the nonwords were created with syllables that were real and existent in Mandarin Chinese. The typical nonword repetition task has been criticized as a nonpure measure of phonological memory because children might perform poorly on it as a result of difficulties with phoneme segmentation or assembly of articulatory instructions, in addition to difficulties with phonological memory (Snowling et al., 1991). In a well-designed study, Metsala (1999) found that the robust relationship between vocabulary and nonword repetition was not a result of the common variance due to short-term memory but was mediated by the phoneme segmentation ability. In the present study, the lack of correlation between the measure of phonological memory and the children's native vocabulary might be a result of the phonological memory task's being a purer measure of phonological memory capacity than the traditional nonword repetition task, with minimal involvement of phoneme segmentation ability.

In contrast to those for phonological memory, none of the phonological awareness measures predicted children's ability to learn novel FL words at T3. Research has shown that preliterate children are aware of sublexical units such as syllables and rimes to a certain extent, but their awareness of phonemes is poorly developed (e.g., Liberman, Shankweiler, Fischer, & Carter, 1974). That is, preliterate children can be successful on phonological awareness measures that require analysis with larger sublexical units (e.g., onset-rime) yet be much less proficient when successful analysis requires isolation of individual phonemes in words (e.g., segmenting words into individual sounds). The findings of the present study were consistent with this observation; children's performance on the vowel substitution task, requiring analysis at the individual phoneme level, revealed substantial floor effects. The lack of correlation between the measure of vowel substitution and the learning of novel FL words at T3 could be at least partially attributed to the floor effects observed in the present study. However, floor effects were not evident on either vowel detection or syllable substitution at T3. The lack of correlation between these two measures of phonological awareness and the FL-WRP learning scores at T3 requires further consideration.

Though not related to the FL-WRP learning scores at T3, the measures of phonological awareness at T3 were significantly correlated with the FL-WRP learning scores at T4. Specifically, vowel detection and syllable substitution measured at T3 and T4 were related to the FL-ERP learning scores at T4, but not to those at T3. Vowel substitution measured at T4 was related to FL-WRP learning at T4. The specific association between the phonological awareness measures and the FL-WRP learning scores at T4 was further supported by the results of multiple regression analyses. After controlling for the FL-WRP learning scores at T3, the *school* differences, the *Zhuyin fuhao* word-reading scores, and the differences in phonological memory, each of the three phonological awareness measures at T4 predicted a significant portion of the variance in FL-WRP learning at T4. At the same time, phonological memory did not predict a significant portion of the variance in FL-WRP learning at T4 after the variance on either syllable substitution or vowel substitution and the variance on other control variables were allowed for. Thus at T4, the measures of phonological awareness not only emerged as significant predictors of the FL-WRP learning scores but also predicted a significant portion of the FL-WRP learning variance not accounted for by phonological memory.

The question remains as to why the phonological awareness measures were associated with the FL-WRP learning scores at T4 but not with those at T3. There are two possible explanations. First, it is possible that phonological awareness has an effect on FL word learning only when the holistic shape of the word to be learned has been established. In the present study, children learned the same set of foreign words at T3 and T4. In principle, when the three words are encountered at T3, they should be less familiar than when encountered at T4. It has been suggested that an unfamiliar word may be perceived, encoded, stored, and reproduced as a holistic whole even by children who have developed awareness of phonemes (Walley, 1993). Given that FL words differ from native words not only in individual phonemes, but also in their overall phonological shape, the attentional demands of learning foreign words just encountered may be so great that children who are phonologically aware nevertheless cannot effortlessly and immediately extract the phonemic details of the FL words. Instead, they rely on their capacity to store the overall shape of an unfamiliar representation temporarily as a satisfactory approximation of the word to be learned. The attentional demands may be reduced considerably for the young FL learners after some gestalt features of the words are established. At that point, children are able to make use of their phonological awareness ability to learn or produce the target words. But until that familiarity is achieved, children who have developed the ability to attend to the internal structure of a word from the acquisition process of their native language cannot extract the internal structure of a foreign word, which is unfamiliar at all levels of phonological information.

Second, the uniqueness of phonological awareness may well be developmental, bearing little relation to the familiarity of individual words. It is possible that the ability to use the knowledge of the intrasyllabic structure of a word to learn unfamiliar words does not emerge automatically with an increase in phonological awareness. In the present study, vowel detection and syllable substitution at T3 predicted the FL-WRP learning scores at T4 but were not concurrently related to the FL-WRP learning scores at T3. The time lag relationship may reflect the time lag between the development of phonological awareness and the use of that awareness to succeed on the FL-WRP learning task.

One way to determine the plausibility of these two explanations is to reexamine the relation separately for the children who successfully had learned the three FL words on the FL-WRP task at T3 and those who demonstrated no evidence of having learned all three words. It is assumed that the children who had learned the three words at T3 had more successfully created and established the phonological representations of the words in memory for reproduction, at least at the holistic level, as compared to the children who demonstrated no evidence of having learned all three words. If phonological awareness plays a role in FL word recall and pronunciation learning after the word shape has been established, then we would expect to find that those who have learned the three words take advantage of their phonological awareness skills to a greater extent than those who have not successfully learned the words. In this case, the uniqueness of phonological awareness should be observed among children who had successfully learned the FL words at T3 but not among those who had not. On the other hand, if the unique relationship between phonological awareness and FL-WRP learning at T4 is a result of a time lag between the development of phonological awareness and the use of that awareness to cope with the word recall and pronunciation-learning task, the uniqueness of phonological awareness should be observed in both groups of children.

The results of the regression analyses show that for the children who had successfully learned the words at T3, the three measures of phonological awareness predicted a substantial portion (59%) of the variance in the FL-WRP learning scores at T4 after the differences in the FL-WRP learning scores at T3, *school, Zhuyin fuhao* word-reading scores, and phonological memory were controlled for. Phonological memory was not a significant predictor of the FL word recall and pronunciation-learning scores either with or without phonological awareness's being forced into the equation. For the less successful learners, phonological memory predicted an extra portion of the variance in the FL-WRP learning scores at T4 before phonological awareness was entered into the equation. Phonological awareness did not predict an extra portion of the variance either with or without the variance in phonological memory being controlled for. Given that the successful learners, as a group, performed better than the less successful learners on the phonological memory measure but not on any one of the phonological awareness measures at either T3 or at T4, the differential association of phonological awareness with FL word recall and pronunciation learning cannot be attributed to one group's having more advanced phonological awareness skills than the other. These results seem to suggest that the specific association of phonological awareness with FL-WRP learning scores at T4 may be a result of the words' being not completely novel at all levels of representations rather than a time lag between the development of phonological awareness and the use of that awareness. Children who successfully have learned the words at a given time are likely to perform better in the word-relearning task if they have better phonological awareness skills than if their phonological awareness skills are poorly developed. Children who have not successfully learned the words at a gven time are likely to perform better in the relearning task if they have better phonological memory capacity. For these children, the variance in phonological awareness does not predict their performance in FL word recall and pronunciation learning, presumably because their relatively poor phonological memory capacity is still engaged with creating a holistic representation for the word to be learned.

In sum, the study findings provide initial evidence that the phonological processing skills of young FL learners' native language may be good predictors of the FL word recall and pronunciation-learning ability of an FL in those learners in spite of the differences in the phonological structure and the phonemic composition of the two languages. Phonological memory appears to be a strong predictor of the ability to learn FL words in young Chinese-speaking FL learners regardless of whether the words to be learned are completely new. The results favor the interpretation that phonological short-term memory supports vocabulary acquisition, rather than the reverse, because the relationship is less likely to have been mediated by lexical knowledge in the present study than in previous studies. Phonological awareness does not appear to be a good predictor of the ability in young FL learners to learn FL words just encountered for the first time, presumably because with novel words, children devote cognitive resources to the processing of the overall shape of the novel words. However, when some level of familiarity with the words is achieved, phonological awareness ability may become a significant factor in word relearning.

One limitation of the study is that FL vocabulary knowledge (against FL word recall and pronunciation-learning ability) was not assessed for individual children. Time constraints in testing each child prevented this assessment, and further, no standardized English vocabulary tests are available in Taiwan. Future studies will want to address this limitation. Words to be learned in this study were chosen from rather obscure English words, with which children were unlikely to have had experience. Indeed, initial testing revealed that the participants did not have expressive production of the words to be learned. However, it is still plausible that the relationship between native phonological processing skills and FL word recall and pronunciation learning was mediated broadly by children's FL vocabulary knowledge. Under the pressure to discriminate between two phonological systems and to sort out the phoneme constancy of different languages, children who knew more FL words (i.e., English) might have developed a deeper insight into the phonological structure of a language, be it specific to the FL or language in general. This awareness, arising from experience with FL vocabulary, may in turn have facilitated the development of phonological awareness and FL word recall and pronunciation-learning ability. This possibility, emphasizing the critical experience with FL but playing down the effect of native language, deserves further investigation. Nonetheless, the results of another study by this author (Hu, 2002) revealed that Chinese-speaking 3rd graders with better phonological awareness of the native language were better FL (English) vocabulary learners than those with poorer phonological awareness, even after the variance was controlled for, in an experimental measure of English vocabulary knowledge.

Finally, the findings of the present study have several implications and lead to several recommendations for FL vocabulary teaching in young FL learners. It is not uncommon to find children who have difficulty with tasks requiring phonological awareness but who have no apparent difficulty in speech perception and production of their native language. This is not surprising given that children can usually manage their ambient language(s) by attending to the gestalt features of the language. However, although a holistic phonological representation with all or several of the segments underspecified may serve the purpose of everyday communication perfectly well, such a representation may become very inefficient when storage, access, or reproduction of phonological representations becomes demanding, particularly in the case of FL acquisition. The identification of phonological memory as a major limiting factor in FL word learning is theoretically interesting. Yet clinically, it suggests no avenues for intervention, because training studies have not been shown to improve phonological memory. In contrast, phonological awareness is very trainable (e.g., Blachman, Ball, Black, & Tangel, 1994; see Troia, 1999, for meta-analyses of relevant research), and the training of phonological awareness supports the acquisition of novel words in one's native language (de Jong et al., 2000). The findings from the phonological awareness training studies, together with the results of the present study, suggest that phonological awareness training perhaps could be incorporated into classroom activities to help young FL learners enhance word recall and pronunciation-learning ability or to ameliorate word-learning problems in FL.

Revised version accepted 20 January 2003

Note

[1]One of the more widely employed tasks of phonological memory is nonword repetition, developed and used by Gathercole and Baddeley (1989, 1990). In a nonword repetition task, the child is required to repeat a list of nonwords ranging from two to five syllables in length. However, the task is difficult to adapt directly in Mandarin Chinese because words consisting of three or four syllables are not common in the language, and words consisting of five syllables are quite rare (Tang, 1988). Bisyllabic words in Mandarin are usually processed as a unit (Hoosain, 1991). The preference for bisyllabic words is evident among adult Chinese learners of English, who are more likely to insert schwa into monosyllabic English words (CCV or CCVC) than into bisyllabic words (CCVCV; Lin, 2001). In pilot testing, a set of trisyllabic nonwords was devised, but the trisyllabic nonwords were judged by two graduate students and one college student to be like strings of three separate syllables. Thus, three-syllable nonwords were discarded as potential test items.

References

Avons, S. E., Wragg, C. A., Cupples, L., & Lovegrove, W. J. (1998). Measures of phonological short-term memory and their relationship to vocabulary development. *Applied Psycholinguistics*, *19*, 5843–5601.

Baddeley, A., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review*, *105*, 158–173.

Blachman, B. A., Ball, E. W., Black, R. S., & Tangel, D. M. (1994). Kindergarten teachers develop phoneme awareness in low-income, inner-city classrooms: Does it make a difference? *Reading and Writing: An Interdisciplinary Journal*, *6*, 1–18.

Bowey, J. A. (1996). On the association between phonological memory and receptive vocabulary in five-year-olds. *Journal of Experimental Child Psychology*, *63*, 44–78.

Catts, H. W. (1989). Phonological processing deficits and reading disabilities. In A. Kamhi and H. Catts (Eds.), *Reading disabilities: A developmental language perspective* (pp. 101–132). Boston: College-Hill.

Chen, T.-Y. (1999). A case study of a Chinese student with English learning disabilities. In J. Katchen & Y.-N. Leung (Eds.), *Proceedings of the Eighth International Symposium on English Teaching* (pp. 271–282). Taipei, Taiwan: Crane.

Cheung, H. (1996). Nonword span as a unique predictor of second-language vocabulary learning. *Developmental Psychology*, *32*, 867–873.

Clark, E. V. (1993). *The lexicon in acquisition*. New York: Cambridge University Press.

Cornelissen, P. L., Hansen, P. C., Bradley, L., & Stein, J. F. (1996). Analysis of perceptual confusions between nine sets of consonant-vowel sounds in normal and dyslexic adults. *Cognition*, *59*, 275–306.

de Groot, A. M. B., & Keijzer, R. (2000). What is hard to learn is easy to forget: The roles of word concreteness, cognate status, and word frequency in foreign-language vocabulary learning and forgetting. *Language Learning*, *50*, 1–56.

de Jong, P. F., Seveke, M.-J., & van Veen, M. (2000). Phonological sensitivity and the acquisition of new words in children. *Journal of Experimental Child Psychology*, *76*, 275–301.

Dollaghan, C., Biber, M., & Campbell, T. F. (1995). Lexical influences on nonword repetition. *Applied Psycholinguistics*, *16*, 211–222.

Elbro, C. (1996). Early linguistic abilities and reading development: A review and a hypothesis. *Reading and Writing: An Interdisciplinary Journal*, *8*, 453–458.

Fazio, B. B. (1997). Learning a new poem: Memory for connected speech and phonological awareness in low-income children with and without specific language impairment. *Journal of Speech, Language, and Hearing Research*, *40*, 1285–1297.

Ferguson, C. A. (1986). Discovering sound units and constructing sound systems. In J. S. Perkell & D. H. Klatt (Eds.), *Invariance and variability in speech processes* (pp. 36–51). Hillsdale, NJ: Erlbaum.

Fowler, A. E. (1991). How early phonological development might set the stage for phoneme awareness. In S. A. Brady & D. P. Shankweiler (Eds.), *Phonological processes in literacy* (pp. 97–117). Hillsdale, NJ: Erlbaum.

Ganschow, L., Sparks, R. L., Javorsky, J., Pohlman, J., & Bisho-Marbury, A. (1991). Identifying native language difficulties among foreign language learners in college: A "foreign" language learning disability? *Journal of Learning Disabilities*, *24*, 530–541.

Gathercole, S. E., & Baddeley, A. D. (1989). Evaluation of the role of phonological STM in the development of vocabulary in children: A longitudinal study. *Journal of Memory and Language*, *28*, 200–213.

Gathercole, S. E., & Baddeley, A. D. (1990). The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology*, *81*, 439–454.

Gathercole, S. E., Hitch, G., Service, E., & Martin, A. J. (1997). Phonological short-term memory and new word learning in children. *Developmental Psychology*, *33*, 966–979.

Gathercole, S. E., Willis, C., & Baddeley, A. D. (1991). Differentiating phonological memory and awareness of rhyme: Reading and vocabulary development in children. *British Journal of Psychology*, *82*, 387–406.

Glushko, R. J. (1979). The organization and activation of orthographic knowledge in reading aloud. *Journal of Experimental Psychology: Human Perception and Performance*, *5*, 674–691.

Harm, W. M., & Seidenberg, M. S. (1999). Phonology, reading acquisition, and dyslexia: Insights from connectionist models. *Psychological Review*, *106*, 491–528.

Hoosain, R. (1991). *Psycholinguistic implications for linguistic relativity: A case study of Chinese*. Hillsdale, NJ: Erlbaum.

Hu, C. F. (2002, December). *Segmented phonological representation and L2 vocabulary learning*. Paper presented at 13th World Congress of Applied Linguistics (AILA 2002), Singapore.

Hu, C. F., & Catts, H. W. (1998). The role of phonological processing in early reading ability: What we can learn from Chinese. *Scientific Studies of Reading*, *2*, 55–79.

Katz, R. B. (1986). Phonological deficiencies in children with reading disability: Evidence from an object-naming task. *Cognition*, *22*, 225–257.

Liberman, I. Y., Shankweiler, D., Fischer, M. F., & Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology*, *18*, 201–212.

Lin, Y.-H. (2001). Chinese EFL syllable simplification—The effect of Mandarin disyllabicity. In Department of Applied English, Ming Chuan University (Eds.), *Proceedings of the Eighteenth Conference on English Teaching and Learning in the Republic of China* (pp. 174–185). Taipei, Taiwan: Crane.

Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology*, *91*, 3–19.

Michas, I. C., & Henry, L. (1994). The link between phonological memory and vocabulary acquisition. *British Journal of Developmental Psychology*, *12*, 147–163.

Munson, B. (2001). Phonological pattern frequency and speech production in adults and children. *Journal of Speech, Language, and Hearing Research*, *44*, 778–792.

Oakhill, J., & Kyle, F. (2000). The relation between phonological awareness and working memory. *Journal of Experimental Child Psychology*, *75*, 152–164.

Read, C., Zhang, Y. F., Nie, H. Y., & Ding, B. Q. (1986). The ability to manipulate speech sounds depends on knowing alphabetic writing. *Cognition*, *24*, 31–44.

Segalowitz, S. J., Segalowitz, N. S., & Woods, A. G. (1998). Assessing the development of automaticity in second language word recognition. *Applied Psycholinguistics*, *19*, 53–67.

Service, E., & Craik, F. I. M. (1993). Differences between young and older adults in learning a foreign vocabulary. *Journal of Memory and Language*, *32*, 608–623.

Service, E., & Kohonen, V. (1995). Is the relation between phonological memory and foreign language learning accounted for by vocabulary acquisition? *Applied Psycholinguistics*, *16*, 155–172.

Snowling, M., Chiat, S., & Hulme, C. (1991). Words, nonwords, and phonological processes: Some comments on Gathercole, Willis, Emslie, and Baddeley. *Applied Psycholinguistics*, *12*, 369–373.

Snowling, M., Goulandris, N., Bowlby, M., & Howell, P. (1986). Segmentation and speech perception in relation to reading skill: A developmental analysis. *Journal of Experimental Child Psychology*, *41*, 489–507.

Sparks, R., & Ganschow, L. (1993a). The impact of native language learning problems on foreign language learning: Case study illustrations of the linguistic coding deficit hypothesis. *Modern Language Journal*, *77*, 58–74.

Sparks, R., & Ganschow, L. (1993b). Searching for the cognitive locus of foreign language learning difficulties: Linking first and second language learning. *Modern Language Journal*, *77*, 289–302.

Sparks, R., & Ganschow, L. (1995). A strong inference approach to causal factors in foreign language learning: A response to MacIntyre. *Modern Language Journal*, *79*, 235–248.

Storkel, H. L. (2001). Learning new words: Phonotactic probability in language development. *Journal of Speech, Language, and Hearing Research*, *44*, 1321–1337.

Studdert-Kennedy, M. (1987). The phoneme as a perceptumotor structure. In A. Allport, D. Mackay, W. Prinz, & E. Scheerer (Eds.), *Language perception and production* (pp. 67–84). London: Academic Press.

Studdert-Kennedy, M., & Goodell, E. W. (1995). Gestures, features and segments in early child speech. In B. de Gelder & J. Morais (Eds.), *Speech and reading: A comparative approach* (pp. 65–88). East Sussex, England: Erlbaum and Taylor & Francis.

Swan, D., & Goswami, U. (1997). Phonemic awareness deficits in developmental dyslexia and the phonological representations hypothesis. *Journal of Experimental Child Psychology*, *68*, 18–41.

Tang, T.-C. (1988). *Studies on Chinese morphology and syntax*. Taipei, Taiwan: Student Books.

Taraban, R., & McClelland, J. L. (1987). Conspiracy effects in word pronunciation. *Journal of Memory and Language*, *26*, 608–631.

Troia, G. A. (1999). Phonological awareness intervention research: A critical review of the experimental methodology. *Reading Research Quarterly*, *34*, 28–52.

Walley, A. C. (1993). The role of vocabulary development in children's spoken word recognition and segmentation ability. *Developmental Review*, *13*, 286–350.

Wimmer, H., Landerl, K., Linortner, R., & Hummer, P. (1991). The relationship of phonemic awareness to reading acquisition: More consequence than precondition but still important. *Cognition*, *40*, 219–249.