

Phonological Short-term Memory and Foreign Language Learning

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This study investigated links between short-term memory skills and children's abilities to learn the vocabulary of a foreign language taught in school. Forty-five Greek children who were learning English as a foreign language were assessed on their short-term memory in both languages, and on their knowledge of both native and foreign vocabulary. Knowledge of native and foreign vocabulary shared highly significant associations with the phonological short-term memory measures. However, vocabulary scores in the two languages shared a close relationship that could not be explained exclusively in terms of phonological loop capacity. Implications of these findings for theoretical accounts of how words are learned in the native and foreign language are considered.

Cette étude explore les liens entre les habiletés de mémoire à court terme et la capacité des enfants à apprendre le vocabulaire d'une langue étrangère. Quarante-cinq enfants grecs ont été évalués au plan de leur mémoire à court terme et de leur connaissance du vocabulaire dans les deux langues (grec et anglais). La connaissance du vocabulaire dans les deux langues est fortement associée aux mesures de mémoire à court terme phonologique. Cependant, même si la relation entre les deux scores de connaissance du vocabulaire est très forte, celle-ci ne peut être expliquée exclusivement en terme de capacité de la boucle phonologique. La discussion porte sur les implications de ces résultats pour des hypothèses théoriques expliquant l'apprentissage des mots dans une langue maternelle et dans une langue étrangère.

Recent research has revealed a close link between language acquisition and the capacity of the verbal component of working memory, the phonological loop (see Baddeley, Gathercole, & Papagno, 1998, for review). There is evidence indicating that the phonological loop plays an important role in supporting the long-term learning of the phonological forms of previously unfamiliar words in the acquisition of vocabulary in foreign as in native languages. Service (1992) found that the single best predictor of success in learning English at school was the children's accuracy in repeating unfamiliar nonwords and established that nonword repetition was specifically associated with foreign language vocabulary acquisition rather than with other aspects of foreign language learning (Service & Kohonen, 1995). Learning of foreign words has found to be benefited by repetition at initial presentation in several studies (Ellis & Beaton, 1993a; Ellis & Sinclair, 1996).

Evidence that phonological short-term memory representations contribute significantly to native vocabulary learning is provided by both longitudinal and experimental studies with children. Gathercole and Baddeley (1989) reported that children's abilities to repeat unfamiliar nonwords at 4 years of age significantly predicts their vocabulary a year later, at age 5. In a further study, it was found that children with relatively good phono-

logical short-term memory skills for their age were also better and faster at learning previously unfamiliar names of toy animals (Gathercole & Baddeley, 1990).

Recent investigations indicate that long-term knowledge of the structure of the language may also influence ease of learning new lexical material. The predictors of success in learning new foreign words in an experimental task were found to vary with the amount of vocabulary children had already acquired in that language (Cheung, 1996). However, new word learning ability in children with low vocabulary scores in their second language was best predicted by their phonological short-term memory skills. The same dependency upon short-term memory was not detected for children who had already acquired an extensive vocabulary in their foreign language (Chen & Leung, 1989). A decreasing reliance of vocabulary learning upon short-term memory, possibly due to a concomitant increase in support from the substantial base of existent word knowledge, has been found also in development of native vocabulary. Gathercole, Willis, Emslie, and Baddeley (1992) studied the native vocabulary acquisition of a cohort of children aged between 4 and 8 years of age, and found beyond 5 years of age clear evidence that existing vocabulary determines both phonological memory performance and further vocabulary development.

Another indication that long-term memory contributes to immediate memory is provided by the findings that memory span is greater for lists composed of native than foreign words (Hulme, Maughan, & Brown, 1991), a phenomenon that seems likely to reflect the lack of phonological lexical representations for unfamiliar words (Brown & Hulme, 1992). Long-term knowledge may also contribute to the recall of nonwords. Gathercole, Frankish, Pickering, and Peaker (1999) found that children recalled nonword sequences more accurately if the nonwords contain high than low-probability phonotactic segments, suggesting that knowledge of the probabilistic structure of the language may support memory performance (see also Gathercole, Willis, Emslie, & Baddeley, 1991; Vitevitch, Luce, Charles-Luce, & Kemmerer, 1997). Those findings suggest that the children's knowledge about rules and constraints of the phonological system of the native language can be used to enhance short-term memory performance.

The relationship between short-term memory and long-term knowledge therefore appears to be reciprocal: Phonological loop capacity promotes learning of phonological patterns of new words, and stored knowledge of the phonological structure of the language supplements the phonological loop. One implication of this analysis is that existing vocabulary knowledge will itself indirectly contribute to the learning of new vocabulary.

The possible trade-off between long-term vocabulary knowledge and phonological short-term memory is investigated in the present study of a group of Greek children learning English as a foreign language in school. The children were aged between 9 and 11 years, and had been studying English on a regular basis for 3 years on average. Previous investigations of the relationship between short-term memory and vocabulary acquisition have investigated either native vocabulary (e.g. Gathercole & Baddeley, 1989; Michas & Henry, 1994) or foreign vocabulary (e.g. Papagno, Valentine, & Baddeley, 1991; Papagno & Vallar, 1995; Service & Kohonen, 1995). A novel feature of the present study was that vocabulary knowledge of both languages was assessed, enabling us to make direct comparisons of the degree of dependency upon phonological short-term memory of native and foreign vocabulary acquisition.

Phonological short-term memory skills were also measured in both languages: The children were tested on their immediate repetition of both Greek (native) and English (foreign) nonwords. Three other factors that may contribute to ease of learning foreign vocabulary were also assessed: chronological age, nonverbal ability, and period of study of the foreign language.

In the present report, an additional focus concerned the association between knowledge of native and foreign vocabulary. We aimed to assess whether vocabulary knowledge was strongly related across the two languages and if so, whether this relationship could be accounted for simply in terms of the mediating influence of phonological short-term memory skills.

METHOD

Participants

Forty-five children attending a public primary school in Greece participated in this experiment. The mean age of the group was 10 years 3 months (range: 8 years 8 months to 11 years 8 months). All children were being taught English as a foreign language by the same teacher at their school. The mean period of study of English was 3 academic years (range from 1 to 5 years). The time children had spent learning English was estimated by a short interview with the parents, and confirmed by checking the school records. Every full academic year the child had been taught English was counted as 1 year of study, and children who had dropped the English classes for more than 5 months considered as having missed a year.

Design and Materials

Phonological Short-term Memory Measures

Repetition of English nonwords was assessed using the Children's Test of Nonword Repetition (CNRep; Gathercole & Baddeley, 1996). The test was administered by a Greek native speaker experimenter. Each of the 40 nonwords was scored as either correct or incorrect, with no penalty for the characteristic prosody of a Greek accent provided that the phonemes were correct. The total number of correct repetition attempts (maximum = 40) was scored for each child. *Wordlikeness* measures were obtained for all test items by a small group of 20 Greek adults who were asked to rate each spoken nonword on a 5-point scale ranging from 1 (very likely to pass for a real word in Greek) to 5 (very unlikely to pass for a real word in Greek). The instructions emphasized that the rating should not be based on how similar the nonword is with a particular word, but on the extent to which its sound structure would pass for a real Greek word. The mean rating for each nonword was calculated; the mean value was 1.88 (*SD* 0.50).

In order to test the repetition of Greek nonwords, a Greek version of the CNRep was constructed. The test contained 50 nonwords, 10 each containing 2, 3, 4, 5, and 6 syllables. Examples of nonwords are *lalmæ* and *vokrietan*. All the test items were also assessed for *wordlikeness* by Greek adults (mean value 2.78, *SD* 0.71). The stimuli of the test were phonotactically legal in Greek and followed the dominant stress patterns of the language. The Greek nonwords were presented to the children following the procedure developed for the CNRep (Gathercole & Baddeley, 1996).

Nonverbal Ability

The revised booklet edition of the Coloured Progressive Matrices (Raven, 1986) was administered to each child. The total number of items correct was scored for each child.

Native Vocabulary Measures

Native vocabulary knowledge was assessed using two measures, a receptive and a productive test. Receptive vocabulary knowledge was tested using a Greek translation of the short form of the British Picture Vocabulary Scale (Dunn, Dunn, Whetton, & Pintilie, 1982). On each trial of this test, the child is shown a page containing four line drawings. The test administrator speaks a single word to the child, whose task is to point to the drawing that corresponds to the spoken word. The test was translated into Greek by a native Greek speaker (EM). It was necessary to replace a small number of test stimuli that were judged likely to be unfamiliar to Greek children. For example, the word *socket* was replaced because the drawing does not correspond to the Greek electric sockets.

Productive vocabulary was assessed using the Word Definition subtest of the WISC III-UK (Wechsler, 1974). The test was translated into Greek. In this test, 30 words are presented for definition by the child. Two credits are given for every response that indicates good understanding of the word, one credit for every response that shows poverty of content, and zero for every incorrect definition of the word. The total sum of credits was scored for each child.

Foreign Vocabulary Measures

Two tests of the children's knowledge of English vocabulary were given, both involving translation between the spoken English and Greek forms of words. In the native-to-foreign translation test, the children were asked to provide the best English translation for 60 Greek words. In the foreign-to-native test, the children attempted to provide the best Greek equivalent to 60 different English words. The items were presented auditorily by a native Greek experimenter with good knowledge of English. The vocabulary items included in both tests were selected from the English textbooks used by the children in school (Triandafellou, 1996). The items were arranged in order of difficulty, with words that had been taught at the initial stages of learning appearing earlier in the tests than the words introduced later in tuition. Translation attempts were counted as correct only if both meaning and part of speech were accurately represented. That is, for the Greek word *ksafneka*, the English translation *suddenly* would count as correct, but not the English word *sudden*. One credit for every correct translation and zero for every incorrect translation of the word were given to each child. The total number of correct translation attempts of each child in each test was scored (maximum = 60).

Procedure

Children were tested individually in a single session lasting for about 1 hour. The order of the tests was held constant across all children. The order of administration

of the tasks was as follows: nonverbal ability, Greek nonword repetition, English nonword repetition, translation foreign-to-native, translation native-to-foreign, native vocabulary receptive, native vocabulary productive.

RESULTS

Descriptive statistics for each measure are provided in Table 1. Repetition accuracy scores for the native and foreign nonwords were compared by calculating the number of correct responses on each test for the 40 items containing 2, 3, 4, and 5 syllables. A two-way analysis of variance with language and length as the within-subject variables established highly significant effects of both language [$F(1,45) = 86.6, P < .001$] and length [$F(1,45) = 73.72, P < .001$], replicating the frequent finding that phonological memory performance is better for familiar rather than unfamiliar lexical material. The children performed comparably on translating between Greek and English words regardless of the direction of the translation, with the two translation measures correlated highly with one another [$r(45) = .95, P < .001$].

The lower triangle of Table 2 shows the correlation coefficients between all principal test scores. A Greek (native) vocabulary composite score was obtained by averaging the *z*-scores of the two vocabulary tests. The same procedure was followed to obtain a composite foreign vocabulary score from the two word translation tasks.

The English (foreign) vocabulary measure was significantly correlated with both foreign and native nonword repetition measures. Similarly, the composite Greek

TABLE 1
Means, Standard Deviations, and Ranges for all Measures

<i>Measures</i>	<i>Mean</i>	<i>SD</i>	<i>Range</i>
<i>English nonword repetition</i>			
2-syllable nonwords	5.58	1.63	2–9
3-syllable nonwords	5.73	1.48	2–8
4-syllable nonwords	3.89	2.07	0–10
5-syllable nonwords	3.36	1.81	0–7
Total	18.56	4.73	6–26
<i>Greek nonword repetition</i>			
2-syllable nonwords	7.22	1.62	3–10
3-syllable nonwords	7.92	1.51	3–10
4-syllable nonwords	5.27	1.47	2–8
5-syllable nonwords	5.38	1.67	1–8
6-syllable nonwords	3.29	1.38	0–6
Total	29.09	5.33	11–37
<i>Native vocabulary measures</i>			
Productive vocabulary	29.45	7.74	13–52
Receptive vocabulary	20.44	5.5	4–29
<i>Foreign vocabulary measures</i>			
Translation foreign-to-native	22.78	15.87	0–54
Translation native-to-foreign	21.09	11.90	0–48
Translation total	43.57	27.27	0–120
<i>General measures</i>			
Nonverbal ability	24.71	5.41	12–35
Length of study	3.30	2.19	1–5
Chronological age (months)	123.87	12.11	106–142

TABLE 2
Correlations between Principal Measures

Measures	1	2	3	4	5	6	7
1 Greek nonword repetition total		.47**	.43**	.44**			
2 English nonword repetition total	.48**		.31*	.43*			
3 Greek (native) vocabulary	.50**	.35*		.56**			
4 English (foreign) vocabulary	.36*	.39**	.66**				
5 Nonverbal ability	.24	.24	.40**	.34*			
6 Length of study	.04	.16	.03	.73**	.05		
7 Chronological age (months)	.03	.31*	.36*	.32*	.34*	.43**	

Lower triangle presents simple correlations coefficients, $df = 45$; upper triangle presents partial correlations after nonverbal ability, length of study and age partialled out, $df = 39$.

* $P < .05$; ** $P < .001$; all others nonsignificant.

(native) vocabulary score was significantly correlated with both native and foreign nonword repetition. Composite Greek and English vocabulary scores were strongly associated with one another.

In order to explore the specific relationship between nonword repetition and vocabulary in both languages, the potentially confounding influences of chronological age, nonverbal ability, and length of study were partialled out. The partial correlations are shown in the upper triangle of Table 2. Both native and foreign vocabulary scores remained significantly correlated with the nonword repetition measures after age, nonverbal ability and length of study had been partialled out. No significant differences were found between these correlation coefficients ($P > .05$, in all cases), indicating comparable associations between nonword repetition accuracy and both native and foreign vocabulary knowledge. The partial correlation between native and foreign vocabulary scores remained highly significant.

Finally, we wished to establish whether the close association between native and foreign vocabulary is mediated by the common link shared with performance on nonword repetition task. In order to test this possibility, a composite repetition score was computed for each child, based on the mean z -score for each of the Greek and English nonword repetition scores. Combining these measures in this way was judged to be appropriate, as both individual measures had been shown to share equivalent strengths of association with the two measures of vocabulary knowledge. The unique associations between each of the three composite scores (nonword repetition, native vocabulary, and foreign vocabulary) were then explored by partialling out the third variable in each case by controlling at the same time for chronological age, nonverbal ability, and length of English study. Foreign and native vocabulary scores remained highly associated with each other after repetition scores had been partialled out [$r(43) = .42$, $P < .05$]. Foreign vocabulary scores remained significantly associated with repetition scores after native vocabulary had been taken into account [$r(43) = .32$, $P < .05$]. However, when foreign vocabulary scores were partialled out, native vocabulary scores no longer maintained a significant link with nonword repetition [$r(43) = .30$, $P > .05$].

DISCUSSION

Highly significant links were found between children's phonological memory skills, as assessed by nonword repetition accuracy, and their knowledge of vocabulary in both native and foreign languages. These findings confirm and extend previous studies charting associations between short-term memory and vocabulary knowledge in both the native language (e.g. Gathercole & Baddeley, 1990; Michas & Henry, 1994) and in foreign languages (Cheung, 1996; Service, 1992; Service & Kohonen, 1995). The relationship between phonological short-term memory and foreign vocabulary was found to be independent of more general factors such as chronological age, nonverbal ability, and length of time spent studying the foreign language.

A unique feature of the present study was that both phonological memory skills and vocabulary knowledge were assessed in both languages, enabling us to make direct comparisons of the strengths of the associations across languages. Two features of the findings are notable. First, there was evidence for language specificity in the link between scores on the nonword repetition and vocabulary knowledge tests. Knowledge of foreign but not of native vocabulary was associated with nonword repetition independently both of general factors (age and nonverbal ability) and also of vocabulary competence in the native language. That children's learning of foreign vocabulary may be particularly highly dependent upon temporary phonological memory rather than native vocabulary acquisition may be due to the greater unfamiliarity of foreign words. There is more opportunity for support from lexical phonological knowledge in the learning of native words, and this may reduce the dependency on phonological short-term memory. On the basis of previous evidence that long-term knowledge of the structure of the language boosts immediate memory performance for nonwords (Gathercole et al., 1991; Gathercole et al., 1999; Vitevitch et al., 1997), this feature of the data is not surprising. It should be also noted that the superior levels of repetition accuracy in all syllable lengths for native than foreign nonwords does lend further weight to previous evidence of language specificity in memory for nonwords (Thorn & Gathercole, 1999).

Second, it was found that knowledge of native and foreign vocabulary shared extremely close links, which cannot be accounted for simply in terms of shared contributions of phonological short-term memory to long-term learning in the two cases. An implication of this finding is that an individual's capacity to learn the sound system of a language is strongly influenced by factors other than phonological short-term memory and any full account of vocabulary acquisition needs to identify what these factors may be. One possible explanation for the present finding is that the children participating in this study had learned many of the foreign words by direct association with the equivalent native words, in line with the dominant method of foreign language teaching employed in Greek schools. This account is certainly consistent with previous evidence that in the initial stages of foreign language acquisition, new words are learned via associations with native words (Chen & Leung, 1989; Kolers, 1966). In later stages, in contrast, children appear to be able to acquire foreign words directly, without associating them with the corresponding native words (Horst, Cobb, & Meara, 1998).

In summary, the present study both supplies further evidence of close associations between phonological memory and vocabulary knowledge in both native and foreign languages, and demonstrates that factors other than short-term memory place important constraints on an individual's capacity to learn new words. The findings suggest that in a second language, new vocabulary can be acquired by a process of bootstrapping onto the secure knowledge base already established for the native language and, as a consequence, the ease of learning new words in a foreign language is strongly influenced by the stability and extent of representations of native vocabulary. For individuals learning new languages in different contexts such as total immersion, however, this degree of dependency of foreign vocabulary acquisition on native language may be significantly diminished.

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