PHONOLOGICAL SHORT-TERM MEMORY CONTRIBUTIONS TO VOCABULARY ACQUISITION

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A dissertation submitted to the University of Bristol
in accordance with the requirements of the degree of Doctor of Philosophy in the Faculty of Social Sciences.

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August, 1999

ABSTRACT

The series of studies presented in this thesis investigate the contributions of phonological short-term memory to vocabulary acquisition. Findings in the area of verbal memory suggest that phonological memory plays a crucial role in the learning of novel phonological forms of words. Nevertheless, little is known about strength of the relationship between short-term memory and vocabulary learning at different levels of familiarity with a language.

The first study assessed the phonological short-term memory abilities of a group of young Greek children. A strong link was found between their vocabulary knowledge and their verbal short-term memory capacity. The remaining three studies assessed the phonological memory abilities of various groups of Greek children who were learning English as a second language and had differing degrees of familiarity with their second language. In all cases a close association was found between existing Greek and English vocabulary knowledge and phonological memory skills. However, while learning new vocabulary was found to be strongly associated with phonological memory skills and moderately associated with existing vocabulary knowledge among beginner learners, a distinct pattern was revealed for advanced learners. Ease to learn new words in their second language found to associate significantly with existing vocabulary but not with phonological short-term memory efficiency among children who had extent familiarity with this language. The findings suggest that while there is clear involvement of immediate memory in native and foreign vocabulary acquisition, contributions of this cognitive system differ with differing levels of familiarity with the language. In the initial stages of language learning phonological memory plays an important role in vocabulary acquisition. In the later stages of learning when lexical phonological knowledge of a language has been established, support from long-term knowledge becomes most important.

The theoretical and practical implications of the findings together with suggestions for future research are discussed.

DEDICATION AND ACKNOWLEDGEMENTS

This work was been supported by the State Institute of Scholarships, Athens, Greece. However, without the help of several people this thesis would not have been possible.
I would like to thank all the children who so willingly participated in the studies; magically they managed to make the long hours of testing enjoyable. Also, the Headmaster and the teachers of the Primary School of Grekochori for their co-operation during the data collection.
I owe special thanks to my supervisor Professor Susan Gathercole for her invaluable ideas, guidance and support; she never failed to give me inspiration and motivation. I also thank my second advisor Dr. Chris Jarrold for his valuable comments, support and encouragement.
I am grateful to my parents and my family in Greece for all their love and support and for never giving up on me.
I am indebted to my friends Annabel, Josie, Chris and Sue who gave me solutions to numerous problems and made my staying in England so pleasant.
My grateful thanks go to Kostas for protecting me from despair and never letting me lose my bearings.

This work is devoted to my beloved brother Christo Masoura.

AUTHOR'S DECLARATION

I declare that the work contained in this thesis was carried out in accordance with the Regulations of the University of Bristol. The work is original except where indicated by special reference in the text and no part of the thesis has been submitted for any other degree.
Any views expressed in the thesis are those of the author and in no way represent those of the University of Bristol.
This thesis has not been presented to any other University for examination either in the United Kingdom or overseas.

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DATE: 30.9.'99

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CHAPTER 1

INTRODUCTION

The primary aim of this chapter is to provide an overview of the theoretical background of native and foreign vocabulary acquisition tracing the connections that the vocabulary learning process share with the phonological loop component of the working memory model. Research evidence and theoretical explanations of findings in memory contributions to vocabulary acquisition in both native and foreign languages are critically evaluated.

Before attempting to explore the specific contributions of phonological short-term memory skills to vocabulary acquisition, factors known to play a significant role in acquisition of native and foreign vocabulary are discussed. As the approach adopted in this thesis focuses on memory mechanisms rather than the acquisition of the vocabulary *per se*, the emphasis is on those theories and studies that are relevant to the contribution of memory to language learning. The function of a particular component of working memory the phonological loop, is explored in detail together with the long-term memory contributions to phonological loop performance.

Note that the terms "foreign language", "non-native language" and "second language" are used interchangeably here; all refer to language which is learnt after the native language has been acquired to a certain degree.

Also, no distinction is made between implicit and explicit learning, the term "learning" is simply used to describe the process by which knowledge is internalised.

1.1 PHONOLOGICAL SHORT-TERM MEMORY

The existence of a specific memory system responsible to deal with temporal retention of speech-based material have been well established in the literature (Atkinson & Shiffrin, 1968; Baddeley & Liberman, 1980; Logie, 1986 Neisser, 1967; Hebb, 1961;). The cognitive role that verbal short-term memory system appears to serve is the human ability to accurately retain verbal information over short periods of time. This functional operation of verbal short-term memory to temporally store verbal information, led in the past to an emphasis on the dedication of this system merely to the memory of sequences of digits or words. The principal everyday activity in which such a temporal memory system involved in, was simply dealing with telephone numbers. Consistent with this view are findings suggesting that individuals with deficits in short-term memory appear to have few problems in coping with everyday life cognitive demands (Vallar & Salice, 1990).

Recent findings in the area of human cognition though, suggest that short-term memory system may be involved in several more complex cognitive activities. According to this view, the function of a phonological short-term memory system is not simply to retain sequences of familiar words but to aid a very important human ability: the learning of new words.

1.1.1 Working memory model

The model of short-term memory that has been most useful in accounting for several phenomena of human memory and language acquisition is the working memory model (Baddeley & Hitch, 1974). Working memory systems can be defined as the cognitive process that are responsible for both the temporary storage of material needed in active information processing and the cognitive functions involved in manipulating this

material (Baddeley, 1986). This theory postulates several independent sub-systems of short-term memory. The connection with language learning is that working memory also seems to be involved in processing any new language input and may therefore play a part in learning novel language material.

In its current form the model consists of a *central executive* and two independent slave systems. (Baddeley, 1986 Baddeley; & Hitch,1974). *The phonological loop* handles verbal, speech-based material, and the *visuo-spatial sketchpad* deals with visual images. The independence of the two slave systems has been suggested by several findings. For example, visual tasks do not seem to interfere with verbal memory tasks and vice versa (Baddeley & Lieberman, 1980; Brandimonte, Hitch & Bishop, 1992; Logie, Zucco & Baddeley, 1990; Logie, 1986). An attentional control system, the central executive, integrates information from different working memory slave systems and long-term memory, allocates resources, and generally organises working memory operations.

The component of working memory that is especially involved in learning new words is the phonological loop. Its primary purpose is to store unfamiliar sound patterns while more durable memory records are being constructed. Recent studies have shown that phonological short-term memory plays an important role in the acquisition and development of language. Significant links have been found between an individual's phonological loop capacity and their ability to perform language-based tasks such as reading (Ellis & Large, 1988; Gathercole & Baddeley, 1993), language comprehension (Baddeley & Lewis, 1981; Mann, Shankweiler & Smith, 1984; Martin, 1990) and speech production (Adams & Gathercole, 1996; Blake, Austin, Cannon, Lisuss & Vaughan, 1994). In particular, learning of new words has been found to benefit crucially from

phonological loop capacity (Gathercole & Adams, 1993; Gathercole & Baddeley, 1989; Michas & Henry, 1994) and evidence for this close association come from various sources. This issue has attracted an increasing interest. The relationship between phonological short-term memory and vocabulary knowledge has been investigated lately in numerous studies of several populations. It gradually became clear that the main human cognitive process that the phonological loop serves is the acquisition of new vocabulary (Baddeley, Gathercole & Papagno, 1998).

1.1.2 Assessment of phonological short-term memory

Most of the batteries that include assessment of temporal storage of verbal material in the phonological short-term memory system, have used digit span as a measure to assess short-term memory capacity (Elliot, 1983; Wechsler, 1974, 1981). This test measures the maximum length of sequence of digits an individual can correctly recall immediately after auditory presentation and thus, provides an indication of the maximum number of items can store in phonological memory. In contrast, many of the recent studies examining phonological memory skills have used a nonword repetition task as a measure to assess phonological loop capacity. In this paradigm a child listens to a made-up spoken item such as "woogalamic" and is asked to repeat it aloud immediately. The accuracy with which the child can repeat these unfamiliar phonological forms provides an indication of the efficiency of child's phonological loop. Although the task is simple and takes a short time to be completed it seems to accurately tap the capacity of the phonological loop (Gathercole & Baddeley, 1989, 1990; Gathercole, 1995a, Gathercole, Willis, Emslie & Baddeley, 1991; Gathercole, Willis, Baddeley & Emslie, 1994). However, it is important to identify the cognitive process that takes place in the repetition of nonwords in order to understand the sensitivity of the task towards individual differences in phonological short-term memory.

What are the exact mechanisms that children engage when they repeat nonwords? In the first place, the absence of lexical support for these unfamiliar sound patterns may force the child to rely heavily on the representation of the nonword in the phonological loop as a means of supporting its repetition (Gathercole & Baddeley, 1998, 1990). As a phonological memory measure the nonword repetition paradigm has been shown to correlate significantly with conventional measures of short-term memory such as digit span. The strong correlations observed between the two measures are attributable to the common reliance of the two tasks on verbal short-term memory. These data initially substantiated the validity of the nonword repetition paradigm. Nonword repetition though, has been shown to link more closely to children's vocabulary knowledge than digit span (Gathercole, Willis, Emslie & Baddeley, 1992; Gathercole, Willis & Baddeley, 1991). This finding has been explained by the greater lexical support for familiar digits and thus, a lesser demand on the phonological loop for the recall of digits. Nonword repetition seems to provide a purer measure of phonological loop capacity as it allows for minimal support from long-term representations. Nevertheless, this task has been suggested to reflect different psycholinguistic abilities apart from phonological short-term memory, such as language output skills (Kamhi & Catts, 1996; Wells,1995) and phonological segmentation ability (Bardy Shakweiler & Mann,1983; Brown & Hulme,1996).

The suggestion that the nonword repetition task reflects the child's ability to analyse and articulate phonological structures (Brown & Hulme, 1996; Snowling, Chiat & Hulme,1991) seems reasonable. Repetition of nonwords requires not only phonological memory skills but also the process of phonological segmentation and the assembly of articulatory instructions (see also Snowling , Goulandris, Bowldy & Howell, 1986). Indeed, repetition of unknown nonwords whose spoken form has never been practised by the child may involve speech output abilities. The digit span measure overcomes the possible influence of articulatory output skills by asking children to repeat familiar words items. On this account, children with poor articulatory function will perform at a low level on nonword repetition tasks simply because such a task requires good articulatory skills. In this case, though, low repetition accuracy levels should not

necessarily reflect poor phonological memory skills. The possibility that repetition of nonwords loads not merely children's phonological loop but also some other abilities leads to the assumption that the link between vocabulary acquisition and performance on nonword repetition tasks does not imply a link between phonological memory and vocabulary knowledge. This seems to be unlikely. In most of the studies that employed repetition of nonwords as means to assess phonological memory, children with articulatory difficulties and problems with the spoken language were carefully excluded from testing. Although low phonological memory capacity is unlikely to be spotted without specific testing, poor phonological segmentation and articulatory skills are easily noticed in schools. Indeed, individuals with specific deficits in short-term phonological memory appear to cope well with everyday cognition (Shallice & Butterworth,1977; Vallar & Shallice, 1990) while difficulties in speech production are easily noticed. Also, studies with specific language impairment children (Gathercole & Baddeley, 1990b) and patients with short-term memory deficit (Baddeley, Papagno & Vallar, 1988), have shown that phonological memory impairment can observed despite normal articulation rate. Thus, it is unlikely that the children who participated in the studies examining phonological loop capacity performed poorly on nonword repetition as a result of output difficulties. Secondly, the judgement of repetition accuracy takes into account children's typical pronunciation. Consistent deviations from the received pronunciation and consistent replacements are not scored as errors. This method of scoring the nonword repetition tasks acts as a safety valve against penalising children for articulation difficulties. Finally, studies involving children learning novel verbal items, have shown that children with poor nonword repetition abilities are slower at learning novel items, although all the children were able to repeat back the unfamiliar forms before the learning trials began (Gathercole & Baddeley, 1990). Thus, it seems unlikely that speech output constraints on nonword repetition may mediate the association with vocabulary knowledge.

1.1.3 The components of the phonological loop

At present the phonological loop is seen as a combination of two components: a passive *phonological store* holding verbal material and an active *articulatory rehearsal* process. There is now considerable evidence that items are represented in the phonological store in a speech-based code (Baddeley, 1986; Conrad & Hull, 1964). This manner of storing information in the phonological loop is suggested to give rise to the phonological similarity effect: sequences of words that sound very similarly to one another are recalled much less well than sequences in which each word has a very distinctive sound pattern (Conrad, 1964; Conrad & Hull, 1964). As the information represented in the phonological store is held in terms of the sound based characteristics, when it decays with time, the loss of a single phoneme from an acoustically similar list will be much more disruptive than the loss of a single phoneme from a acoustically distinctive list. Studies of memory for visual information suggest that visually presented material does not have automatic access to the phonological store but can enter it by being silently articulated (Hitch, Halliday, Schaafstan, & Schraagen, 1988; Walker, Hitch, Doyle and Poter, 1994).

Heard verbal material is thought to be automatically registered in the phonological store; but the contents of the store fade. Findings suggest that the maintenance of the material is achieved by refreshing the phonological trace through rehearsal in the loop by articulating the items-to-be-remembered subvocally (Baddeley, 1986). The articulator rehearsal function has approximately 1.5-2.00 sec to refresh the trace before it fades. So, the exact amount of material that can be maintained by rehearsal depends on individual's speech rate. This limitation of resources in the phonological loop may produce the word-length effect: people's memory for sequences of 1-syllable words is much better than for 5-syllable words (Baddeley, Thomson and Buchannan, 1975). Rehearsal is thought to be a covert form of articulation, so that the frequency with which memory traces can be refreshed will depend on how fast they can be spoken. Short words can be

spoken faster than lengthy words and thus they can be rehearsed more rapidly than lengthy words. This also produces consistent differences in digit span across different languages, depending on how long digits take to articulate in that language (Chincotta & Underwood, 1997 Hoosain, 1982; Naveh-Benjamin & Ayrs, 1986). Consistent with this view are findings showing that articulatory suppression, which interrupts rehearsal, eliminates length effects, because when subjects are not subvocally rehearsing, it does not matter how long the words are (Baddeley, Lewis, Vallar, 1984; Murray, 1986; Gupta & MacWhinney, 1995). Nevertheless, recent findings suggest that the rehearsal process is not necessary to account for the effects of words length on memory performance. Decay during the output process which is greater for long than short words and not slower rehearsal, can account for length effects (Brown & Hulme, 1995; Neath & Nairne, 1995). An alternative suggestion is that the length effect arises not from the articulatory duration of the words but rather from the phonological complexity (Service, 1998; Caplan & Waters, 1994).

In recent years, detailed computational models of the phonological store have begun to be developed. Although these models are distinctive from one other, they are typically based on connectionist principles and describe phonological storage as the activation of a structure or network of phonological units. The starting point for most of these models is the observation that despite the success of the working memory model to accommodate several empirical phenomena, it does not explain some aspects of the phonological short-term storage process, such as serial nature or typical patterns of order errors (Burgess & Hitch, 1996; Glasspoll, 1995; Hartley & Houton1994). Some more recent models attempt to account for phenomena in verbal short-term memory and

word learning and to relate these two domains (Brown & Hulme, 1996; Gupta & MacWhinney, 1997).

The suggestion that short-term memory performance is indeed related with long-term stored knowledge about the words of a language is supported by several lines of experimental evidence. It has became increasingly apparent that verbal short-term memory performance is not only affected by physical characteristics -i.e. length and phonological similarity (see section 1.1.3) but also by non-physical characteristics of memory stimuli such as lexicality of the material. Memory span has found to be greater for lists composed of words than nonwords, -the lexicality effect (Hulme, Maughan & Brown, 1991). Also, word frequency (Hulme, Roodenrys, Schweikert, Brown, Martin and Stuart,1997) imageability (Bourassa & Besner,1994) concreteness (Walker & Hulme, submitted) and morphological form (Service, submitted) have been shown to affect phonological memory accuracy. Even the nonword repetition task which is supposed to be a "nonlexical" task has been found to be influenced by lexical knowledge. Children appear to be better at repeating nonwords which are judged by adults to be high rather than low in wordlikness (Gathercole, 1995; Grant, Karmiloff-Smith, Gathercole et al, 1997; Gathercole, Willis, Baddeley & Emslie,1991). Furthermore, Gathercole, Frankish, Pickering, & Peaker (1999) found that children recalled nonword sequences more accurately if the nonwords contained high rather than low probability phonotactic segments.

These findings suggest a link between short-term memory mechanisms and more permanent stored knowledge. One theoretical explanation for this body of evidence concerns the possible support that the long-term knowledge of the verbal material gives

to the temporal storage of this material. It appears that long-term knowledge is somehow integrated with temporary phonological loop representations. Although the demonstrations of such integration of prior knowledge are compelling, the exact mechanisms that underpin such a process are unclear.

One suggestion is that long-term knowledge is used to reconstruct the incomplete traces in the phonological loop in a process of redintegration. According to this account the specific stored phonological representations for the familiar words can be used to fill-in incomplete traces in phonological short-term memory traces (Hulme et al., 1991). Thus, for example, as there are stored representations available to "redintegrate" partial traces for words the recall is more accurate for words than for nonwords. This explanation though, can not account for the "lexicality" effects shown in nonlexical material (Vitevitch, Luce, Charles-Luce, & Kemmerer,1997; see also Gathercole, 1995; Grant, Karmiloff-Smith & Gathercole, 1996; Gathercole, Willis, Baddeley & Emslie, 1991) because there is no stored lexical knowledge for any made-up nonword (i.e. a specific representation of this item in long-term memory). It seems that the beneficial contribution from long-term knowledge to immediate recall tasks is not restricted to a simple lexical level support but also extends to a sub-lexical level. It seems possible that knowledge about the phonological distributions of the language may be used to "guess" the missing phonemes in representations in the loop (Gathercole et al.,1999). This suggests that each language has its own distribution of phoneme patterns and restrictions about phoneme combinations. Some of those combinations appear more frequently in the language than others. Probabilities of phonotactic patterns and knowledge about those patterns can benefit temporal storage in the loop by filling-in incomplete traces. In the case of recall of unfamiliar items, although no specific representation are available in long-term memory, the items that consist of more frequent phonemic combinations

have a greater probability of being to filled up successfully. In all cases, it appears that the stored knowledge of the structure of the language supplements the fading phonological loop traces, either at a lexical or a sublexical level.

An alternative explanation for lexicality and phonotactic probability effects is that they do not arise from the usage of different kinds of long-term knowledge during or after storage in phonological memory but from processing of information during perception. On this account, perceptual representations are superior for words than nonwords and for high than low wordlikness nonwords, before they are stored in phonological memory. The differences lie at the distinctive levels of perceptual analysis: words can benefit from contact with stored lexical knowledge, while nonwords that are high in phonotactic probability benefit from activation of shared segments. Note that according to this account, support from long-term knowledge occurs in the recognition of the phonological forms and before phonological storage in short-term memory (Vitevitch et al., 1997; Vitevitch & Luce, in press).

Before examining in detail the evidence which suggest a close relationship between vocabulary knowledge and phonological loop capacity, it worth considering the nature of vocabulary acquisition process itself. In the next section of this thesis certain phenomena of vocabulary acquisition are reviewed in order to consider how the phonological loop functions as system responsible for acquiring vocabulary can account for each of these phenomena. Also, different aspects of vocabulary are distinguished in order to specify which particular aspect of word learning is linked with phonological memory.

1.2 VOCABULARY LEARNING AND VOCABULARY GROWTH

Learning new words is a very crucial processes in a child's development. Vocabulary knowledge has been shown to be the most important determinant of intellectual and educational achievements (Aderson & Febody, 1981; Sterneberg, 1987). Also, vocabulary assessment forms a part of many well used intelligence tests such as WISC-R (1974), McCarthy Scales (1970) British Ability Scales (Elliot, 1983). In addition, vocabulary assessment has gained an increasing interest and several tests have been specially designed to assess vocabulary among children (see Curtis, 1987).

Most children learn their native language easily and efficiently. During the pre-school years children learn many new words and first language acquisition happens in the natural course of things as children try to communicate with the outside world. Even children with limited intellectual capacity can develop some aspects of the language and can acquire some vocabulary knowledge (Cromer, 1991). Children seem able not only to pick up new words readily and without instruction but also to do so at an impressive rate as well. The average 5-year-old child has a vocabulary of more than 2,000 words and is expected to learn up to 3,000 per year during the school years. Thus, the average high school senior has a vocabulary of 40,000 words (Nagy, Anderson & Herman,1987). These estimates suggest that children between the ages of six and eight pick up an average of fourteen basic words a day (Miller, 1977). How do they learn so many words? A large part of this vocabulary must be acquired incidentally in order to account for the remarkable gains of lexical items. Indeed, recent evidence has shown that children learn most of their vocabulary through everyday life activities and are able to derive word meanings from context (Nagy, Herman & Anderson, 1985). There are approximately 600,000 words in the English language (Ellis, 1994) and children learn the majority of these words without specific teaching and without looking these up in a dictionary.

Listening to stories and reading books has been shown to be an effective activity for building vocabulary. Robbins and Ehri (1994) read a storybook individually to kindergartens and measured their knowledge of the meaning of 22 unfamiliar words, half of which had appeared in the story. Children recognised the meanings of significantly more words from the story than words not in the story, thus indicating that storybook reading was effective for building vocabulary. Also, Senechall and Cornell (1993) has shown that 3-year-olds can successfully extract word meaning from listening to storybooks being read. The same way of building up vocabulary has been shown to hold true for older children as well (Elley, 1989). During normal reading children gain reliable knowledge of words from the passage being read. (Nagy, Anderson & Herman 1987).

Together with incidental learning, vocabulary growth can occur by intentional training e.g. instructions on morphological knowledge, where children are taught to derive meaning of words through morphological analysis (White, Power & White,1989). Although this technique has been shown to be beneficial for vocabulary growth, inevitably it can only be used with older children who have already acquired a substantial vocabulary. Intentional word learning can occur with younger children in situations when an adult names an object in a manner that contrasts the new word with a known word. Carey (1978) experimentally introduced a "new" word *chromium*, for olive-coloured objects to 3- and 4-olds. In this paradigm children's attention was directed to a display containing objects of two already known colours such as blue or red and some olive-coloured objects. Children were told "Bring me the chromium tray, not the blue one, the chromium one" or "Bring me the chromium cap, not the red one, the

chromium one". Over the next few months children introduced the new word into their lexicons and learned that olive was a colour that has its own name.

This paradigm, known as *"fast mapping"* reflects the child's partial mapping of the conceptual properties of a word. It is hypothesised that children quickly recognise a word as a word and have a partial sense of the sets of things or events to which the word refers before they will be able to fully master the word's meaning. As Carey (1978) suggested when young children first notice a new lexical item they are able to create a representation of the new form and associate it with its referent before they can use the phonological form of the new word.

Further experiments used the fast mapping paradigm to investigate children's memory for the label of the new word. A constant finding is that children are more reliable in demonstrating comprehension of a novel word introduced in this way than they are at reproducing its novel referent (Dollaghan,1985,1987). Therefore, the acquisition of the conceptual components of the words can occur before any learning of phonological properties has taken place.

Evidence for the reverse direction of dissociation between phonological and conceptual acquisition of vocabulary is also available. Children may fail to comprehend a language that they can correctly produce (Chapman & Miller,1975) and correct production can often coexist with incorrect comprehension (Rice,1984). In the same paper Rice underlines the natural way children learn their language: "they listen to the speech of others and gradually come to understand what the words mean. Later on they begin to produce their own words" (Rice,1984 pp.146). But no matter what the details of the

processes of vocabulary acquisition might be (when infants engage in fast-mapping or when older children read) conceptual properties seem to be learnt independently from the phonological properties of words. Thus, the distinction between conceptual learning and phonological learning is crucial for studies of vocabulary acquisition.

Before suggesting any association between phonological loop and vocabulary knowledge, one should consider such a distinction and identify carefully which aspect of word learning taxes the phonological loop.

1.2.1 Individual differences in vocabulary acquisition

So far the research findings that have been reviewed in this thesis consider the rate of vocabulary growth among children, together with some variables affecting this vocabulary gain. Not all children though manage to achieve the same speed of vocabulary growth. Some children learn vocabulary very rapidly and some are much slower than their peers. One group that fails to acquire vocabulary efficiently is children with specific language impairment (SLI). This condition is diagnosed when a child fails to develop language at a normal rate for no obvious reasons and despite adequate progress in other aspects of development. Specially problems with syntax and morphology are common and expressive language is usually more impaired than receptive language (Bishop, 1992). In line with this profile are findings suggesting that those children are more impaired in learning the labels of new words than in comprehending the meanings of the words (Dollaghan, 1987; Ellis, Weismer & Hesketh,1996). Vocabulary development is particularly impaired among children with SLI (Stark & Tallal,1981) and their performance on vocabulary tasks typically falls short of what is expected for their age. Besides this specific developmental disorder children's

vocabulary acquisition can become impaired for various environmental or genetic reasons (see Bishop and Mogford, 1993, for review of several factors affecting vocabulary development).

Individual differences are also found in vocabulary knowledge for children with no known language pathology (Becker, 1980). In general, most of the studies involved in assessing children's vocabulary identified groups that differ considerably in their vocabulary knowledge. No matter what aspect of vocabulary acquisition was under consideration in several areas of vocabulary growth, researchers have always managed to divide their samples to subgroups with low and high vocabulary knowledge.

Indeed, the ability to learn a novel phonological structure varies between individuals in every cohort of children, (i.e. some fall below the expected for their age vocabulary levels and some go beyond those levels) (Nagy, Anderson and Herman, 1987). To explain individual variation, we should consider first the factors that may contribute to vocabulary acquisition. Chronological age is a determinant of performance in most cognitive tasks such as vocabulary learning and thus vocabulary gain is as liable to age effects as is any other developmental task. (Dickinson,1984). Also, general intellectual ability has been shown to correlate significantly with vocabulary growth (Moulden,1996). Furthermore, environmental factors contribute significantly to vocabulary growth. Naturally, children learn words from their parents, their caretakers and teachers, and also from TV programs, books, comics, magazines and so forth. All those factors constitute a language environment that is unique for each individual child. Inevitably, with so many factors linking closely to learning of new words there are

many possible interactions among components that contribute to vocabulary acquisition.

In summary, vocabulary acquisition is an important cognitive achievement that most children appear to fulfil easily and naturally without any particular instruction. Several environmental and developmental factors can affect vocabulary growth. Individuals differ considerably in both the ease with which they acquire new words and the extent of their vocabulary knowledge. Finally, the phonological and conceptual components of vocabulary learning can be acquired independently from each other. Thus, any model suggesting shared mechanism underling verbal short-short term memory and vocabulary acquisition should account for these phenomena of vocabulary development.

1.2.2 Phonological memory and native vocabulary growth

Recent research suggests an important phonological memory involvement in vocabulary acquisition. Individual differences in short-term memory performance appears to plays a crucial role in determining long-term vocabulary acquisition. This finding has been consistently observed across several populations of children and adults. The first suggestion that the phonological loop, component of working memory plays a crucial role in learning the phonological aspects of new words came from neuropsychological studies. Baddeley, Papagno and Vallar (1988) investigated the learning capacity of a patient, P.V., with a very pure deficit in short-term memory. P.V. had a selective impairment of auditory memory span and was unable to repeat sequences longer than two or three digits. Across a series of experiments (Vallar & Baddeley 1984; Baddeley et al 1988) it was found that P.V. could learn pairs of meaningful words but she was completely unable to learn to associate a familiar word with an unfamiliar item from a

foreign language. For example, she could learn the pair *spada-grano* in her native language of Italian, but she could not learn the pair *rosa-svieti* where the word *svieti* is Russian. It was suggested that short-term phonological storage is not essential for forming associations between meaningful items that are already known but is important for learning words in a foreign language.

A range of correlational studies with normal children have also shown that children's ability to repeat novel phonological patterns is strongly related to their native vocabulary knowledge, at least in early and middle childhood years. Children who perform well on tests of verbal STM (such as digit span and nonword repetition) typically have good native vocabulary knowledge. Specifically, in several studies, the correlations between scores on nonword repetition and receptive vocabulary tests have been found to be highly significant: At age three r=.42 (Adams & Gathercole, 1995). At age four, r=.49; at age five, r=.34 (Gathercole and Adams,1994). At age four, r=.56; at age five, r=.52; at age six, r=.56 (Gathercole, Willis, Emslie and Baddeley,1992). At age five,r=.48 (Michas and Henri,1994). One concern about these results is the possibility that differences in children's vocabulary knowledge may be attributed to individual differences in their general intelligence and not to differences in their STM skill. According to this assumption the children with better general intellectual skills will learn vocabulary more easily than children with low intellectual abilities, independent of differences in phonological short-term memory skills. Furthermore, it is crucially important to disentangle general intelligence and phonological short-term memory in vocabulary studies, as there is a close link between working memory measures and performance on conventional measures of intelligence (Kyllonen and Christal, 1990). This strong interaction between the two factors may overshadow the independent

contribution each one makes to vocabulary acquisition. Clearly, before making any statement or drawing any conclusion about the relationship between children's learning of words and their phonological memory skills, general confounding factors which might contribute to vocabulary must be carefully ruled out.

This limitation has been ruled out in at least some of the recent studies of native vocabulary acquisition and phonological STM. Together with the STM scores and vocabulary measures a general non-verbal ability score was obtained for each child and then partialled out of correlations between phonological memory and vocabulary knowledge. In all cases, the partial correlations coefficients between phonological short term memory as assessed by of nonwords and vocabulary knowledge were significant: at age four, $r=.47$; at age five, $r=.36$ (Gathercole and Adams,1994). At age four, $r=.46$; at age five, $r=.50$; at age six, $r=.48$ (Gathercole, Willis, Emslie and Baddeley,1992). Children with high phonological memory skills have better vocabulary knowledge that children with low phonological skills even when the effects of general intellectual abilities have been removed. Therefore, the relationship between STM and vocabulary does not seem to be mediated simply by differences in the general intellectual abilities of individual children. It seems that the link between children's performance on verbal STM tasks and their abilities to learn words there is a strong, direct relationship.

One other concern, namely the possible effects of environmental factors on the relationship between vocabulary knowledge and phonological memory, still remains open. It can be hypothesised that children who are exposed to rich linguistic environments at home develop their vocabulary mainly from their extensive linguistic experience with less contributions from their phonological abilities. Their extensive

vocabulary together with the variety of linguistic forms they experience can boost all language-related abilities. Experimental studies of vocabulary learning in children where children are exposed to the novel items under controlled conditions have ruled out this possibility. Gathercole and Baddeley (1990) tested the abilities of 5-year-old children of high or low nonword repetition ability to learn new names of toy animals. Across 15 learning trials, the experimenter named four toys and tested the children's memory for these names. The toys were either given familiar names such as Peter and Michael or phonologically unfamiliar names such as *Pyemass* and *Meeton*. The findings showed that the children with the low nonword repetition scores were significantly poorer at learning the phonological unfamiliar names than the high-repetition children. In contrast there was no reliable difference in the rates at which the two groups of children learned the familiar names. Similar results are reported by Gathercole, Hitch, Service and Martin, (1997) in an experimental study of 5-year-old children learning of pairs of familiar words or word-nonword pairs. The children's phonological short term memory abilities relate to their word-nonword learning but not to their word-word learning.

However, a simple linear relationship between STM performance and vocabulary knowledge, no matter how strong it is, does not necessarily imply causality. The opposite direction of causality may hold: children with more extensive vocabularies are more likely to hold a phonological specification that resembles closely any particular nonword in their long-term memory (Snowling, Chiat, and Hulme, 1991). By having a broad range of words, they can easily identify a close phonological neighbour of any nonword and use this as a facilitator to repeat the nonword (Dollaghan, 1994). Certainly, to make any claims about a cause-and-effect relationship between the ability to retain verbal material in STM and learning of new words, further data are needed. A

study carried out by Gathercole, Willis, Emslie and Baddeley (1992) provide such evidence. These authors applied a cross-lagged correlational analysis to data obtain in a longitudinal study of 80 children tested on three occasions between 4 and 8 years of age. Such an analysis compares the correlation between two measures across a particular time period in the two possible causal directions and assumes that the correlation is stronger in the causal than in the noncausal direction (Crano & Mellon, 1978). In particular, correlations compared between early phonological short term memory abilities and later vocabulary and early vocabulary and later phonological memory found that repetition of nonwords at age of 4 was significantly associated with vocabulary knowledge 1 year later, whilst native vocabulary knowledge at age 4 was not a significant predictor of nonword repetition scores at age 5. These results indicate that ability to repeat nonwords at some age can predict later vocabulary learning. Similar results have been reported in a study of 104 young children participating in a longitudinal study (Gathercole and Baddeley, 1989). Children between the ages of 4 and 5 were tested and retested after one year on their vocabulary skills and on phonological memory. Gathercole and Baddeley (1989) found that phonological memory at age 4 accounted for a significant amount of variance in vocabulary score at age 5, over and above that accounted for by the vocabulary score the previous year. These data provide direct evidence for the direction of causality: children's phonological loop abilities contribute to natural acquisition of native vocabulary. What is the reason for this contribution and how exactly does it happen? The answer to this question is discussed to the next part of this chapter.

In summary, it has been illustrated firstly, that children's cognitive abilities to hold lexical material in memory for short a time determines their learning of the

phonological forms of new native words. Secondly, that their long term knowledge of their native language determines their performance on verbal memory tasks.

Also, various findings suggest that short-term memory plays an important role in the acquisition of the phonological sound patterns of new words. In particular, a verbal component of working memory, the phonological loop, meditates learning of new lexical material. Evidence from a range of studies indicates that the ability to create representations in the phonological loop determines the learning of new words independently of individual differences in linguistic environment and non-verbal abilities.

1.3 FOREIGN LANGUAGE VOCABULARY ACQUISITION

While all children learn their own native language since the first years or infancy, most of the children educated in the modern word learn also a second or even a third language as well. In many countries children start learning a foreign language at the very early stages of their development and most of the modern schools include teaching of at least one foreign language in their educational curricula. Clearly, there is an expanding need for communication amongst nations and thus, a necessity for individuals to learn foreign languages. Several teaching methods have been developed to meet this need (see Healy, Barshi, Crutcher, et al., 1998). As a consequence, considerable attention has been given to the pragmatic aspects of this task and research into foreign language acquisition has been governed for several years by the effort to define the optimal way of teaching a foreign language. That has lead to several controversies and no general accepted teaching method has been as yet identified. Besides the practical issues which relate mainly to improving foreign language training programs, some theoretical issues arise as well.

Foreign language learning is a highly complex process that involves multiple cognitive operations. In such a demanding and multilevel task, learners of a foreign language have to depend on and exploit all the available resources and possible techniques in order to acquire the second language. The ways to approach such a demanding task appear to be numerous, providing fruitful ground for research investigations.

The acquisition and retention of vocabulary has been examined more thoroughly than any other aspect of foreign-language-training in applied psycholinguistics research. Improving the efficiency and effectiveness of acquiring new vocabulary is an important component of improving foreign language learning.

Before establishing an extensive vocabulary second language learners can not successfully communicate in this language. Laufer (1990) highlights this fact (which is well known among foreign language teachers and students) by noting that "foreign language learners do not carry grammar books around in their pockets. They carry dictionaries"(p. 293). Although it is argued that language perception and production in fluent speakers are dominated by semantically or conceptually driven processes (processes which do not depend directly on lexical skills) Kirsner (1994) suggests that that these processes can not be introduced until a sufficient and effective vocabulary is established and exercised.

Having considered the significant role of the phonological loop component of working memory in acquiring native vocabulary, it appears tempting to examine whether the same association holds also for the acquisition of foreign vocabulary. Evidence from the early neuropsychological studies reviewed earlier (see section 1.2.2) are in line with this assumption (Vallar & Baddeley 1984; Baddeley et al 1988). Patient P.V. was unable to learn foreign words suggesting an involvement of phonological memory to foreign word

learning. Papagno, Valentine and Baddeley (1991) replicated the experiments that they had run with P.V., with normal, Italian-speaking subjects. They prevented participants from using their short-term phonological store by asking them constantly to repeat a nonsense syllable during stimulus presentation (articulatory suppression). In this respect, participants were assumed to resemble P.V. who had an impaired short-term memory store and had also the same mother tongue (Italian). The authors showed that articulatory suppression disrupts the learning of foreign vocabulary, but not native language paired association. A similar relationship between phonological store capacity and ability to learn vocabulary in a second language, was reported by Service (1992) in a group of Finnish children learning English as a foreign language in school. Service studied the children in a longitudinal study over three academic years. Their accuracy to repeat meaningless nonwords before instruction in English had began was an accurate predictor of future success in learning English. In a second study Service and Kohonen (1995) found a strong relationship between repetition of nonwords and foreign language learning, even when general academic achievement had been partial out. No any other aspect of foreign language -e.g. essay writing, grammar- could be accounted for by nonword repetition. These authors conclude that phonological memory specifically relate to foreign vocabulary learning.

One interesting aspect of foreign vocabulary acquisition is that it appears to be associated with intelligence less strongly than native vocabulary does. Although it correlates moderately with intelligence, the individuals who learn foreign languages most easily are not necessarily especially intelligent people. On the contrary, extremely intelligent people may have difficulties in foreign language learning. Genesse (1976) failed to find a consistent association between IQ level and performance on any measure of foreign language interpersonal communication skills -either listening, pronunciation,

vocabulary, grammar or communicativeness- in students learning French as a second-language. Similarly, children with mental retardation as a result of a chromosomal disorder, may talk excessively and have very good language function with impressive vocabularies and ability to learn fluently a second language. Barisnikov et al (1996) presented a case study of a girl with Williams syndrome, C.S., who despite very profound retardation in non-language skills and deficient visuospatial cognition had a high level language system and a very good knowledge of two additional languages. She was polyglot with fluency in English, French and German. She demonstrated phonological short-term memory skills at a very good level and shown normal levels of unfamiliar nonword learning. Her ability to learn associations between familiar words was impaired. Such studies provide evidence that foreign language learning is relatively independent from intelligence and the crucial cognitive factor that uniquely links to foreign language learning is phonological memory ability (see also Rondal, 1995).

Taken as a whole, these foreign vocabulary studies indicate that the representations stored temporarily in the phonological loop mediate the long-term learning of words in native as in foreign languages. Accordingly, anything that benefits the accuracy of those representations will promote new word learning and anything that interrupts phonological temporal storage will diminish novel learning . Repeating aloud the to-be learned words for example, could boost the phonological representations of those words. Indeed, foreign language learners who rehearse words by repetition, learn more words that controls who remained silent. Ellis and Sinclair (1996) demonstrated that learning of Welsh words benefited from repetition. They also showed that participants who were encouraged to rehearse the foreign language utterances were superior to silent controls

and participants who were prevented from rehearsal by articulatory suppression on a translation task.

Consistent with this view is the finding that people who find it easy to learn a foreign language have excellent phonological loop capacities. Papagno and Vallar (1995) compared two groups of students: one with exceptional foreign language abilities that could speak fluently at least three languages (polyglots) and one with usual foreign language learning abilities who had learnt one second language at school (non-polyglots). The two groups were closely matched on academic achievements, non-verbal intelligence and visuo-spatial short-term memory. Polyglots and non-polyglots differed considerably in their phonological working memory skills and in their abilities to learn new foreign words. Polyglots had superior phonological short-term memory skills and learned significantly more foreign words in a new language (Russian). The superior performance of polyglots in the learning of words in a foreign language can not readily be attributed to a general superiority in verbal learning tasks: the two groups did not differ in their ability to arbitrary associations between pairs of native words.

But what is it to learn a new word in a foreign language? As in a native language, in order to learn a new word we must initially enter it in our mental lexicon, categorise the novel sound and be able to pronounce it, recognise the new sound pattern and be able to use it appropriately. We must also learn the semantic and syntactic properties of the new word and be able to relate it with other words and place it correctly in a lexical structure.

1.3.1 Acquisition of the phonological properties of foreign words

In the case of the foreign word learning, some properties of the word learning processes appear to be particularly difficult. Acquiring in particular the sound patterns of foreign vocabulary seems a hard process for most second language learners (Desrochers and Begg, 1987). The root of this difficulty lies possibly in the distinctive articulatory features of languages. Different languages make use of different sound patterns, have different phonetic repertoires, different phonotactic rules and frequencies. Foreign language learners frequently have to articulate phonemes that are not present in their native language. When the sound features of the foreign language are very distinctive from the native sound repertoire the difficulty increases (Feldman and Healy,1998). So, languages that have relatively little overlap between their articulatory features are harder to learn. Articulating phonemes that do not exist in native language presents the learner with further difficulties. For example, English words with the sound "*h*" at the beginning such as *house* or *huge* are more difficult for Italian students of English than words like *pretty* or *norm*, because this sound pattern is not part of their native sound system. Similarly, words like *shift, shake* are more difficult when pronounced by Greek learners of English than words like *kennel* or *press (*Nation, 1987; Rogers, 1969). Ellis and Beaton (1993b) have demonstrated that foreign words which are difficult to pronounce are more difficult to learn even when word length, frequency, part-of-speech, and imageability are controlled for. Although the sound patterns may vary even within the native language across speakers, dialects, characteristic prosodic patterns and so on, the sound properties of a foreign language can be extremely unfamiliar to the learner.

Consistent with the view that the acquisition of a foreign phonology is particularly difficult, are findings suggesting that the correct pronunciation of foreign words can

remain impaired even when fluency in several functional and communicative aspects of the language can be achieved (Anderson & Graham, 1994). The phenomenon of acquiring a foreign language proficiency while remaining an accent is well recognised and established in literature (Brown, 1987). It therefore appears that the acquisition of the phonological and conceptual components of a foreign words are independent from one another so that it is possible for learners to acquire the one without learning the other. Although the same independence between acquisition of the conceptual and phonological properties holds for the learning of native words (see section 1.2), in foreign vocabulary the evidence for such a dissociation is more robust. Typically, the reproduction of the phonological form of a foreign word is more difficult that the conceptual understanding of this form. Ellis and Beaton (1993a) found that translation is easier when one is asked to translate from a foreign to one's own language. Translation is also slower and influenced by conceptual variables from native-to-second but not from second-to-native language (Kroll & Sholl, 1992; Chen and Leung, 1989). Surely, vocabulary acquisition in a second language consists not only of the learning of the sounds of foreign words but also of the acquisition of the conceptual referents of the words. Nevertheless, in the case of foreign language learning the acquisition of the conceptual meanings of most words appears to be an easy task. An adult learner or a child who has a substantial vocabulary knowledge in the native language has to associate the phonological sound of the foreign word with a conceptual meaning already existing in the native lexicon. Translation from a foreign to a native language is a task that requires the learner to reconstruct this association between the novel sound and the existing conceptual knowledge. On the other hand, translation from a native to foreign language requires the learner not only to reconstruct the association but also to produce

the novel sound. On those grounds, translation seems to have distinctive phonological demands according to its direction (Ellis & Beaton, 1993a).

Further indications for this dissociation, together with evidence for the crucial role of the phonological loop in the learning of phonological properties of foreign vocabulary, comes from studies with both bilingual and monolingual children. Speidel (1993) studied two bilingual siblings, Sally and Mark. The children were raised in the United States by their German speaking family and experienced German as their first language. Over their early childhood they encountered an increasing amount of English via their English-speaking kindergarten, schools and through playing with peers. Although the two children had equivalent levels of comprehension in both languages, they differed dramatically in the production and articulation of the languages: Mark, who suffered from impaired hearing, showed poor articulatory control in both languages, difficulties with word order and a strong tendency to mix English and German sounds within words. Sally had good, fast production of both languages and she rarely mixed the two languages. Assessment of Mark's cognitive abilities revealed significant impairments in phonological short-term skills. Apparently, although Mark had good comprehension he failed to successfully acquire the phonological components of the language. Speidel (1989) suggested that speech production may be restricted by poor phonological immediate memory capacity.

Vallar and Papagno (1993) report a case of dissociation between ability to acquire phonological properties of foreign words and ability to learn the conceptual meanings of words. They investigated the abilities of a young woman with Down syndrome, F.F., who had good language abilities for her condition in her native language (French) and

also a good level of communication in a second language (English). F.F. performed at levels equivalent to controls in learning new words in Russian, but she was very poor at learning pairs of familiar French words that were associated randomly. Clearly, she had a difficulty in learning the conceptual components of words, due to her condition, but her ability to learn new phonological material was efficient. Interestingly, F.F. had phonological loop capacities within the normal range and possibly foreign vocabulary benefited directly from her ability to store phonological material. Vallar and Papagno (1993) proposed that her low level of general mental functioning reflected a general conceptual learning deficit, while her abilities to learn phonological material were intact.

In summary, these findings point to a double dissociation in abilities to learn phonological or conceptual properties in a second language. Acquisition of a second language can be achieved despite general intelligence limitations, providing that phonological loop function is intact. Impairments in phonological loop on the other hand, are associated with difficulties in second language production but comprehension of language may remain normal. It appears that the phonological and conceptual aspects of foreign vocabulary rely on independent cognitive mechanisms. Also, it appears that the phonological aspect of learning foreign vocabulary can benefit from good phonological loop skills.

1.3.2 Why is it difficult to acquire the foreign phonology?

The findings reviewed so far in this thesis suggest that the phonological loop, component of working memory plays a crucial role in acquiring the phonological forms of native and foreign words. Also, it appears that in the long-term phonological learning of the native words is easier and a perfect phonology can acquired by the speakers of any

language. The learning of foreign words though, is more difficult and the acquisition of the accurate phonology can remain impaired even after several years of learning (Ioup, 1984; Scovel, 1981; Cutler and Otake, 1994). Furthermore, learning of familiar phonological forms is easier than learning for unfamiliar forms within one language as well. Children perform better at learning familiar than unfamiliar native-like phonological forms (Gathercole, Hitch, Service and Martin, 1997; Gathercole, Frankish, Pickering and Peaker, 1999). What are the exact mechanisms that underline this distinction between native and foreign phonology? Although it is difficult to distinguish between vocabulary learning in native language and vocabulary learning in a second language, some important differentiations can be made. A child who learns a new native word has to understand the conceptual meaning and to acquire the sound pattern of the new word. As argued earlier, a child can acquire one aspect of words without or before acquiring the other (see section 1.3.1). In second language learning though, acquisition of conceptual meanings of words is less involved. A typical second language learner who has knowledge of his native language to a certain degree, learns new words in the second language mainly by associating the new phonological form with the conceptual specification of the equivalent native word. For words that do not have direct translation in the native language, a learner can associate the new phonological form with multiple conceptual referents that are already established in the native language. In both cases, acquisition of conceptual properties is reduced while acquisition of new phonological forms is increased.

Consider the phonological learning of native words: words within a particular language have a highly characteristic distribution of phonological structures. Words within one language draw on a restricted pool of phonemes, and the phonemes are combined into

syllables according to the phonotactic rules of the language. Knowledge about these distributional properties of sound combinations accumulates in long-term memory with time. Over time an individual has considerable experience with the native language and extensive knowledge about the frequencies of the sound combinations in this language. So, sound patterns of unknown native words are easy to learn because they are composed of familiar phonemes combined in a phonotactically familiar manner.

Research suggests that sensitivity to phonological characteristic for each language emerges from the first year of life (Jusczyk, Luce, &Charles-Luce, 1994; De Boysson-Bardies & Vihman,1991). One possible explanation for this ease at acquiring new phonological forms in native language is that individuals draw upon their stored knowledge about the language to support new learning of verbal input.

The knowledge an individual has about the probabilistic frequencies of the sound combinations of their own native language is extensive: such a knowledge starts being stored from the very early years of life and increases with exposure to spoken language. There is now evidence suggesting that this accumulative knowledge leads to a specialisation of the perceptual system toward native-like sounds (Thorn and Gathercole, 1999). Thus, acquisition of novel phonological forms in one's native language can benefit from such specialisation of the perception system. The same beneficial support is less possible to be available for foreign sound combinations. One possible reason for this difficulty may be the fact that the structural and distributional properties of the foreign language are distinctive from the native ones and the phonological learning of new forms is more likely to impede rather to benefit from previous probabilistic knowledge. Clearly, relying upon phonotactic rules of a particular language to acquire new phonological forms within this language may be beneficial but the same strategy can

prove catastrophic for word learning in a second language. Often second language errors are due to overgeneralisation or due to native language-specific procedures that applied to second language (Ho, 1986). Indeed, language-specific procedures (i.e. typical of one particular language) are applied to foreign language output even when they are not appropriate (Cutler and Otake, 1994).

Earlier in this thesis two features of the phonological loop function reviewed (section1.2 and 2.3), namely: first, the phonological loop plays a crucial role in learning of phonological properties of words and second, temporal representations in the loop are influenced by long-term knowledge. These important features of the loop can possibly account for people s' difficulties in acquiring foreign phonology. Long-term knowledge is used to fill in incomplete or decaying representations in the phonological loop, possibly by using a process of redintegration. Native and native-like words are more likely to equalised successfully because the knowledge about the frequencies of phoneme combinations is more extensive. This increased possibility on enhancing phonological loop representation results eventually in better long-term storage of the new phonological form. The possibility for successful reinstatement is less for foreign words and words with uncommon sound combinations simply because the support from long-term knowledge is less available. In other words, phonological loop appears to be specially tailored to store words in one's native language.

In summary, children storing knowledge about the probabilistic structure of their native language since they start experiencing the spoken language. This accumulative knowledge leads to an increasingly specialised temporary memory system. A mature perceptual system appears highly specialised to the probabilistic structure of the native

language. Although learning of words in the native language can benefit, foreign word learning appears to impede by such specialisation of the perceptual system.

1.3.3 Chronological age and foreign language learning

Consistent with the view that perceptual system over time becomes specialised towards the distributional properties of the phonology of the native language is evidence showing that acquiring the accurate pronunciation of a second language becomes increasingly difficult with age. Lenneberg (1967) hypothesised that native language could be optimally acquired only within a critical period which extends from early infancy until puberty. The critical period hypothesis has been lately extended to second language acquisition as well. Young children appear to be better second language learners than adults and that they reach higher levels of final proficiency in second language (Johson & Newport, 1989). Nevertheless, children seem to be very efficient and competent foreign language learners, especially when they acquire the language before of the age of seven because then the foreign language can be native-like (Johson & Newport, 1989). Service and Craik (1993) studied younger and older English speaking subjects learning Finnish words and English meaningless made-up words. They found that age interacts with learning as the younger participants learnt more items and learnt more accurately. Although there is little agreement about the exact age at which a foreign language can be acquired perfectly, most opinions converge around the age of six. This advandage which children have over adults in acquiring a foreign language extends to most aspects of language like phonology, grammar and vocabulary (Long, 1990). As Long notes " starting after the age of 6 appears to make it impossible for many learners (and after the age of 12 for the remainder) to achieve native-like competence in phonology; starting later that the early teens, more precisely after the age of 15, seems to create the same

problems in morphology and syntax" Long (1990, p.274). Even if, as Long believes, there are maturational constraints on all aspects of foreign language acquisition, they appear much earlier for phonology than they do for the other cognitive aspects of vocabulary acquisition.

It is possible that this maturational factor in learning the phonological forms of foreign words reflects the increasing knowledge of native phonology over time. The phonological loop becomes specialised towards the native phonology with the accumulative experience of the native sounds. A mature phonological system is possibly more prune to errors by applying native phonological rules to the decaying representations of the unfamiliar material (Crutcher, 1998); while a phonological system with lesser knowledge of the phonological distributional of a native language is more possible to depend on the accuracy of the loop traces as means to create more durable representation of the new input.

1.3.4 Level of proficiency in foreign language

The view that the children and adults use different approaches to acquire foreign vocabulary also holds for the acquisition of aspects other than the phonological components of vocabulary, such as lexical and conceptual aspects (Kroll and Curley, 1987). The differences in strategies individuals use in acquiring foreign vocabulary seems to depend on the degree of familiarity with language. Beginner learners are more likely to depend on their native language knowledge to mediate learning of foreign vocabulary. Level of proficiency in a foreign language interacts with first language mediation, such that with increasing proficiency there is a transition from lexical mediation to more direct acquisition. One possible explanation for this transformation could be the way

people store and process words in a non-native language. Three different hypotheses have being suggested about the processing of foreign words (see Potter, So, Von Eckardt and Feldman, 1984). These different processing hypotheses are based on a general model that includes both modality-specific and amodal stores for picture and word processing (see Chen & Leung, 1989). The first hypothesis, the word association hypothesis, postulates that words in the foreign language are connected directly to corresponding words in the native language rather than with their underlying, amodal concepts. These connections are activated when the learner uses their non-native language (MacLeod, 1976). The second hypothesis, the concept-mediation hypothesis, postulates that the native and non-native languages operate independently so that words in the two languages are not directly associated but are linked through an amodal conceptual system (Kirsner, Smith, Lockhart, King, & Jain,1984; Potter, So, Von Eckardt & Feldman,1984; Scarborough, Gerrard, & Cortese, 1984). The third hypothesis, the intermediate hypothesis, concerns the lexical processing of beginning and proficient learners. It proposes that beginning and proficient learners use different methods to process words in the two languages. According to this hypothesis, at the first stage of the foreign language acquisition, the new language is operated through the native language, but the new language gradually develops into a stage of independent operation as the learning process continues. This third hypothesis has been supported by subsequent evidence (Altarriba, 1992; Chen & Ho, 1986).Chen and Leung (1989) explored the patterns of lexical processing for beginning and proficient learners of a non-native language and found that proficient participants could directly access the meanings of words in the non-native language, whereas beginners tended to use corresponding words in their native language as a media for such a goal. Kroll and Curley (1988) compared translation and picture naming in a group of students leaning German, with the group

including students who had studied for less than two years. They found support for a shift from word association to concept mediation with increasing expertise. Individuals though, who acquired the two languages more or less in parallel from birth (referred as native bilinguals) have neither separate nor shared memories: some information is restricted to the language of encoding while some is accessible to both linguistic systems (Kolers, 1996). Nevertheless, research with bilinguals who have acquired the second language before the age of three with different levels of proficiency has shown that only bilinguals at higher levels of proficiency can benefit from semantic cues in a foreign-sentence learning task (Opoku, 1992).

In summary, these results suggest that the increasing familiarity with a second language affects the way the foreign vocabulary is proceed. Initially, the learning of foreign words is facilitated dependence on knowledge about the native language. At later stages of the second language learning process, acquisition of new foreign words is achieved directly without mediation of native vocabulary.

1.3.5 Mediational techniques for vocabulary learning

The usage of existing knowledge to achieve acquisition of foreign vocabulary is well established. Learners of foreign languages appear to use a variety of memory-boosting strategies in their attempts to acquire and retain vocabulary (Paivio and Desrochers, 1981). Learners may apply metacognitive strategies in order to remember new vocabulary such as associations (i.e. make semantic associations to link the new form to existing lexical items) or mediation techniques (i.e. trying to infer the meaning of the new word from the context). Papagno et al. (1991) found that participants would spontaneously associate foreign words with words in their native language and this mediated learning of foreign words. The authors conclude that the extent to which a

new foreign word can be semantically or acoustically associated with one native word can facilitate learning of this word. For example, English students of German could associate the German word *Fleisch* (meat) with the English flesh. Similar findings are reported by Service and Craik (1993) who found that English-speaking adults learnt Finish words with high association value more easily that words with low association value. It appears that semantic long-term memory can be used to mediate new words learning.

Therefore, they may be several kinds of memory mediation of foreign language learning. Some of these strategies which make use of old knowledge to enhance vocabulary learning, have been shown to be quite effective (Crutcher and Ericsson, 1992). Most of these techniques consists of creating an acoustic or semantic link between the new word and an existing native word. One such technique is the keywords method, in which the learner creates a bridge between the word-to-be-learnt and its translation, using a peg word (Crucher, 1990). So, the French word *couteau(*=knife) can be easily learnt by an English learner by using the word *toe* as a keyword because it sounds like the last syllable of *couteau* and can be easily imaged in a meaningful interaction with a knife (e.g. a knife cutting someone's toe). Although such associations may be very beneficial for learning, second language learners may in fact learn only small portions of their vocabulary through successful associations between the new foreign word a similar native one. Not all the words of a language can be readily available to be semantically associated with a familiar word. Research evidence suggests that when semantic associations are not available (and usually they are not), learning of phonological patterns of foreign words depends heavily on short-term memory. Papagno, Valentine and Baddeley (1991) found, in a final experiment, that when the English participants

were asked to learn Finnish words -that were selected to be very dissimilar to English- the original finding was replicated: articulatory suppression disrupted learning of foreign words. So once again, it appeared that phonological short-term memory skills are used in foreign language vocabulary acquisition.

Although numerous studies have suggested that the use of keyword imagery mediates foreign-vocabulary learning, the benefits of this technique appear to be quite limited. Ellis and Beaton(1993b) evaluated keyword techniques and found that the mediation of those strategies are effective mainly for receptive vocabulary learning. Considering that "...people learn foreign languages as much to utter and write as to understand and read..." (Ellis & Beaton, 1993b pp 534) it appears that such a technique which is simply mediating vocabulary understanding, is of little benefit for spoken language. Although imagery techniques and key word techniques appear effective in foreign language learning, their effectiveness depends on several variables and limitations of the success of the techniques have been suggested (Paivio & Desrochers, 1981). The techniques seem to be effective in certain experimental situations rather than in real learning settings (Willerman & Melvin, 1979), can be used more easily by adults than by children (Pressley, Samuel, Hershey, Bishop, & Dickinson, 1981; Morris, 1981), and only a restricted minority of foreign words can be learnt by using mnemonic techniques -for example nouns are more easily to create links to than proverbs (Paivio, 1968; Delaney, 1978). Thus, these techniques appear to make only a small contribution to foreign vocabulary learning.

One other technique, which can be useful in supporting foreign language learning is transferring knowledge from one's native language to the second language (Hancin-Bhatt

& Nagy, 1994). Some languages share important structural similarities in the lexicon and in morphology. Some languages include loan-words from other languages (Arakawa, 1978) For example, academic English is filled with Spanish-English cognates: that is, words that have similar or identical spellings and meanings in the two languages (e.g. family-*familia*, animal-*animal*); these relationships could be helpful for the learners of the new words. Indeed, Hancin-Bhatt and Nagy (1994) suggest that instructions on relationships between the derivational morphology of languages may be helpful in promoting foreign language vocabulary growth. Reading can prove very beneficial to new word learning (Jenkins et al, 1989) and is actually a well-used method of learning foreign language vocabulary, as not all of the words in a foreign language are taught by giving the specific word meaning and many words are learnt by deriving a word's meaning from context (Jenkins et al, 1989). Foreign language learners often use guessing to find the meanings of unknown words when they read foreign texts. Although effective in some cases, this approach might prove unsuccessful when learners rely on their native language syntactic cues to interpret a word. McDonald and Heileman (1991) found that speakers of different languages vary in their reliance on syntactic and semantic cues in sentence interpretation process. Errors in second language may possibly occur because of a transfer from native language to target language. For example, if forced to choose between the cues of word order or verb agreement in a sentence-interpretation task, native Italians will rely on verb agreement and native English speakers will follow word order. (MacWhinney, Bates, & Kliegl, 1984). On the other hand, native French speakers prefer to rely on clitic pronoun agreement when they interpret sentences and ignore word order (McDonald & Heileman, 1991) because the French language does not have strict word order and has richer clitic agreement. If a native English speaker who learns French as a second language uses word order (which is

strict in English) as a means to derive word meanings from a French text he will possibly misinterpret sentences. Thus, the usage of the same cues across different languages may lead to misinterpretation of sentences and word meanings.

In these cases though, when an association is hard or impossible to make, then the need to approach the new word in a more suitable way arises. Clearly, only a limited amount of foreign vocabulary can be learned through direct semantic or acoustic associations. Foreign language learners must depend on a more flexible system which is able to accommodate any kind of new verbal material independently of association availability or particular specifications. In order to be effective such a system needs to both store an unlimited variety of sound combinations and to make use of prior knowledge so that the more durable records of these combinations are based on consistent features over several exposures. The concept of the phonological loop as language promoting system is compatible with such suggestions. The main features of the operation of the phonological loop are consistent with phenomena of foreign vocabulary acquisition reviewed here. Thus, the working memory model appears as a useful theoretical framework to investigate memory involvement in vocabulary learning.

In summary, the findings reviewed so far provide substantial evidence for semantic memory contributions to second language learning. Usage of mnemonics techniques and semantic memory involvement can mediate acquisition of limited number of words. In contrast, an involvement of verbal short-term memory in the learning of foreign vocabulary can accommodate a wide range of empirical and experimental phenomena in the area of second language acquisition.

1.4 OVERVIEW OF THE THESIS

The term verbal short-term memory refers to the capacity of both children and adults to retain sequences of verbal material over short periods of time. The current most broadly developed specification of short-term memory, the working memory model, provides a comprehensive account of several phenomena of phonological memory functioning. According to this model, a specialised verbal component of short-term memory, the phonological loop, serves to maintain representations of memory items in a speech-based form.

The primary function that the phonological loop appears to fulfil is the acquisition of vocabulary. In particular, it mediates the learning of the phonological forms of new words rather than the acquisition of contextual or semantic aspects. This mediation is thought to be achieved by the storage of unfamiliar patterns while more permanent memory records are being constructed. The function of the phonological loop as a word learning mediator is now well-documented in the literature.

However, less is known about phonological loop contributions to learning of non-native vocabularies. A thorough investigation of the cognitive abilities involved in the acquisition of vocabulary in a second language is important considering the increasing need for foreign language learning. This is specially true as the processes involved in learning new words in a foreign language puts more constraints on the phonological aspects of learning.

Although the phonological loop supports language learning, little is known about the specific contributions it makes to various levels of learning. The process of acquisition of new words in native and second languages are not constant, but vary both as a function of the differing learning demands of the foreign phonology and their interaction with age and level of proficiency in a foreign language.

The series of experiments in this thesis were therefore designed to provide a systematic investigation of phonological short-term memory contributions to both native and foreign vocabulary acquisition among individuals with various degrees of familiarity with a foreign language.

Study 1 (Chapter 2) examined the association between phonological short-term memory efficiency and native vocabulary knowledge in a group of young Greek children. In Study 2 (Chapter 3) the same association with both native and foreign vocabulary knowledge was assessed for a group of Greek children who were beginner learners of English as a foreign language. The remaining two Studies examined the contribution of phonological short-term memory and existing vocabulary knowledge to the learning of novel words. Study 3 (Chapter 4) examined the learning of new native and foreign words and assessed whether the ease of learning new items could be attributed to phonological short-term memory efficiency or vocabulary knowledge. Study 4 (Chapter 5) built on the findings from Study 3 and assessed advanced second language learners performance on learning new words in their second language.

The findings indicated that an involvement of phonological short-term memory in native and foreign vocabulary acquisition, while these involvement differs with differing levels of familiarity with the language.

CHAPTER 2

PHONOLOGICAL SHORT TERM MEMORY AND NATIVE VOCABULARY KNOWLEDGE

It was argued in chapter 1 that a specialised component of working memory, the phonological loop, contributes to the learning of new words in both native and foreign languages. Specifically, contributions of the phonological loop to native vocabulary acquisition are well established in the literature. Much is already known about the association between phonological loop capacity and vocabulary learning in normal children, children with language impairments, adults, and patients with cognitive deficits. Most of the evidence for this close link comes from studies of English speaking populations. A few studies have investigated the phonological loop's involvement in the learning of a second language. According to these studies, the same association between phonological loop efficiency and the learning of new words holds for second language acquisition. This evidence comes from several populations such as English, Italian, Chinese and Finish participants who learnt either English or an other language as a second language and also from bilingual and multilingual participants.

It appears however, that there has been little systematic examination of the relationship between phonological loop capacity and native vocabulary acquisition in populations who are not English-speaking with the result that little is known about the working memory contributions to native vocabulary acquisition in other languages apart from English. Accordingly, study 1 was designed to investigate the contributions of phonological short-term memory to native vocabulary acquisition in a different

population. A group of non- English speaking (in this case Greek speaking) children were examined for their phonological short-term memory skills and their native vocabulary knowledge. The answer to the question of whether the relationship between phonological memory and word learning holds when children of any language acquire their native vocabulary is important for the generalizability of this relationship.

2.1 DEVELOPMENT OF A NONWORD REPETITON TEST IN GREEK

Recent research has found an involvement of phonological short term memory in a number of psycholinguistic skills such as vocabulary acquisition (Gathercole, Willis Emslie, and Baddeley, 1992) reading ability (Crain, Shankweiler, Macaruso and Bar-Shalom, 1990), speech production (Adams and Gathercole, 1995) and language comprehension (Mann, Shankwieler &Smith,1984). As a consequence, the construction of appropriate tasks to assess phonological memory accurately and sufficiently has recently became an issue of considerable interest.

A number of tasks such as digit span, word span, nonword repetition and serial recall have been proposed as assessment tools to measure children's phonological loop capacity (Gathercole and Baddeley, 1993). The most well-used measure is digit span, a measure that also has been present in many ability test batteries (Wechsler, 1974, Wechsler, 1981, Elliot, 1983). In this task, the maximum length of sequence of digits that an individual can correctly recall is counted and the score on this task reflects the capacity of verbal short-term memory (see chapter 1 paragraph 1.2). A less conventional measure of verbal immediate memory is a task which requires the repetition of nonwords. In this task the accuracy with which a child can repeat unfamiliar spoken forms is assessed, and this is

thought to provide a pure measure of phonological loop capacity. Repetition of nonwords has been found to correlate highly with other conventional measures of verbal phonological memory such as digit span. In some cases repetition of nonwords has been shown to correlate more closely to children's vocabulary knowledge than digit span (Gathercole & Baddeley,1989,1990a). Thus, repetition of nonwords has suggested to be a simple and sensitive measure to individual differences in phonological short term memory. The test is widely used in psycholinguistic research. Nevertheless, very little evidence of Greek nonword repetition tasks exists in the literature.

One of the aims of the research reported in this thesis was to develop valid and reliable tools for the accurate assessment of immediate memory among Greek children. The suggested sensitivity of the task together with the lack of a Greek equivalent test motivated the construction of a new nonword repetition test in Greek.

2.1.1 The new Greek Nonword Repetition Test

A Greek nonword repetition task was constructed to assess Greek children's phonological short-term memory abilities. The test was modelled on the Children's test of Nonword Repetition CNRep (Gathercole & Baddeley, 1996) which purports to assess phonological immediate memory abilities of English children aged between four and nine years. A set of Greek nonwords was constructed which met the criteria set by the original CNRep (Gathercole et al., 1994). The main consideration was to construct items that are legal according to Greek phonotactic rules. Thus, all of the nonwords contained real syllables and were constructed so as to follow the phonotactic rules of the Greek language (Petrunias, 1984). In Greek, unlike English, stress patterns for each word length

are not consistent, with several stress patterns allowed at each word length and no single dominant stress pattern. This variability was reflected in the various stress patterns at all syllable lengths in the Greek nonwords.

A further consideration was to minimise the lexicality of the constituent stressed syllables of Greek nonwords. Dollaghan, Biber & Canbell (1993; 1995) found that nonwords with stressed syllables corresponding to real words (e.g., *BATHesis*) were repeated significantly more accurately than nonwords with non-lexical stressed syllables. Thus, in all of the nonwords, the syllable carrying primary stress did not correspond to a Greek word.

There were 48 Greek nonwords in the initial set, 12 each containing two, three, four and five syllables directly corresponding to the four syllable lengths comprising the English CNRep. Examples of Greek non-words are '*prosta*', '*sinafikos*' and '*pravagos*' (for a full list see appendix B). The initial set of nonwords consisted of two parallel forms, Form A and Form B, each one containing 24 stimuli. There were several reasons for this division. Firstly, the Greek nonword repetition test was intended to be simple, short to administer and easy for young children to repeat; for that reason a minimum number of test items was desirable. Secondly, at this initial stage the test needed to include as many stimuli as possible in order to check for possible variation among nonwords. Thus, the usage of several test items was essential. Finally, constructing two test versions provided the opportunity to test parallel forms for reliability (Anastasi & Urbina, 1997). The nonwords were randomly assigned by syllable length within each set so that the tests did not increase in difficulty as they proceeded.

2.1.2 Wordlikeness rating

The Greek nonword repetition test was constructed by taking real Greek words and making phonological substitutions to yield nonword forms that were nevertheless phonotactically legal. The 48 Greek nonwords were then recorded on a cassette by a female voice with a neutral Greek accent. On the recording, a three-second interval occurred between the end of one nonword and the onset of the next. Although the material developed for this test consisted of unfamiliar nonwords, previous findings indicate that even nonwords are not completely independent of lexical influences (Gathercole, 1995; Gathercole Willis, Emslie & Baddeley, 1991; Grant, Karmillof-Smith, Gathercole, Paterson, Davies & Udwin, 1997). In order to determine the extent to which the nonwords constructed for this new test were related to real Greek words, a group of twelve Greek native-speaking adults listened to each nonword and generated ratings of wordlikeness. A procedure developed by Gathercole et al (1991) was adopted here to obtain wordlikeness ratings for the Greek nonwords. The participants were told that they would hear some made up words that they should judge on the basis of how likely each item would be to pass for a real word in Greek. They were asked to rate each item on a five-point scale ranging from a minimum of 1(=not likely to pass for a real word in Greek) to a maximum of 5(=very likely to pass for a real word in Greek). It was emphasised that their rating should not be based on how similar the nonword was to a specific Greek word, but on an estimation of the extent to which its sound structure would pass for a real Greek word. The mean rating for each nonword was calculated and is summarised in table 2.1.

Table 2.1. Mean wordlikeness values as function of length in Greek and English nonwords

	Greek nonword repetition test			English nonword repetition test
Length	Form A	Form B	Full list	CNRep [a]
2 syllables	3.00 (0.59)	3.19 (0.63)	3.09 (0.59)	2.72 (0.75)
3 syllables	2.78 (0.73)	3.19 (0.59)	2.98 (0.71)	2.69 (0.61)
4 syllables	3.03 (0.70)	3.24 (0.58)	3.13 (0.65)	2.22 (0.92)
5 syllables	2.39 (0.50)	2.81 (0.84)	2.60 (0.75)	2.80 (0.93)
Total	2.75 (1.0)	3.11 (1.14)	2.95 (1.04)	2.85 (0.85)

[a] Data are from Gathercole, 1995.

The two parallel Forms were equal in wordlikeness $t(23) = 1.86$; *ns* and the over-all wordlikeness scores (Form A and Form B) were comparable to the mean wordlikeness for the nonwords in the CNRep (Gathercole & Baddeley, 1996) $t(86) = 1.23$; *ns*. The procedure employed to obtain wordlikeness ratings for the Greek nonwords was similar to the one used by Gathercole (1995). This allows comparisons between over-all wordlikeness of English and Greek nonwords. Correlation coefficients were calculated between obtained wordlikeness and number of syllables in each nonword, number of phonemes in each nonword and number of consonant clusters. All three correlation coefficients were found to be nonsignificant $r = -.23$, $r = -.27$ and $r = .26$ respectively with $p > .05$; ($df = 48$ in all cases). Thus, phonological and lexical properties of these items appear to be unrelated.

2.1.3 Adult's performance

The new test was then administered to a group of 11 Greek adults in order to provide a preliminary evaluation of the difficulty of the new test. Performance was high with 93% accuracy and repetitions were nearly perfect (mean =22.3, SD=0.54). However, five of the items had unexpectedly low repetition accuracy.

These items were: *fnidos, fikolia, fomaleti, thriama, viro* with 33%, 40%, 70%, 75% and 12% accuracy rates, respectively. It is seems likely that the very low repetition performance for these items arose from difficulties in perceiving the initial phoneme of these nonwords: the fricative sounds *f* and *th* at the beginning of the nonwords are hard to distinguish, and repetition errors consisted mainly of substitutions of one for the other. These items remained in the test but the initial phoneme was either omitted or replaced by an other consonant: *Fnidos* was replaced by *nidos*, *fikolia* was replaced by *kolimia*, *fomaleti* was replaced by *tomaleti*, *thriama* was replaced by *xiama*, and *viro* was replaced by *rivo* .

Finally, the new test was administered to a group of English adults who had no previous contact with the Greek language (N=12). Two distinct verbal presentations of the test were used: the Greek nonwords were either spoken by a native English experimenter or by a native Greek experimenter. The mean repetition performance was 19.9 (SD = 2.09) and 19.05 (SD = 2.11) respectively, and there was no statistically significant difference in performance for the two presentations $t(19)=2.00$; $p>.05$. In both presentations though, accuracy by English adults was lower comparatively to that of Greek adults $t(11)=3.76$, $p<0.1$.

In summary, a new test of nonword repetition was developed to assess verbal memory among Greek children. The basic characteristics of the Greek nonword repetition test

were investigated before it was used with children. Comparable values of wordlikeness to the English CNRep were found for the Greek nonword repetition test. The connection between length as a function of number of syllables in the Greek nonwords and wordlikeness was not significant. Greek adults performed at high levels on the new test and English adults made more errors in repetition than Greek adults. Finally, adults errors were used to refine the test to exclude stimuli with perceptually difficult characteristics. In conclusion, the properties of the new Greek nonword repetition test favour the usage of the test as a phonological short-term memory measure for Greek children.

2.2 STUDY 1

It has been argued in Chapter one that vocabulary acquisition is a very crucial skill in children's language development. Vocabulary growth has been associated with a range of variables. One important determinant appears to be phonological memory ability. As it has been reviewed earlier (see chapter 1 paragraph 2.2), there is compelling evidence that the ability to create accurate phonological representations in working memory plays an important role in learning new words (Gathercole & Adams, 1993; Gathercole & Baddeley, 1989; Gathercole, Hitch, Service & Martin, 1997; Michas & Henry, 1994). Specifically, one particular aspect of word learning, namely the ease with which children learn the sound patterns of words, is affected considerably by phonological loop capacity. Phonological loop functioning itself (i.e. the quality of representations) benefits from accumulative knowledge about the sound patterns of words. Evidence for the beneficial contribution of prior knowledge to short-term memory tasks comes from several sources. Children repeat (Gathercole, 1995) and recall (Gathercole, Frankish, Pickering & Peaker, 1997) high wordlike nonwords more accurately than low wordlike

nonwords. Memory span for familiar words is better than for nonwords (Hulme, Maughan & Brown, 1991). Note that such a long term system represents prior knowledge of the structure of a language and children's knowledge of a language determines their ability to repeat nonwords that follow the phonotactic rules of that language (for more detailed discussion on this issue see Thorn & Gathercole, 1999).

One suggestion for this link is that a specialised but time limited system (i.e. the phonological loop) handles novel input over a short period. The accuracy of these temporary memory representations determines the formation of durable long-term records of the input. The quality of these temporal representations depends on accumulative knowledge about probabilistic properties of sound combinations. According to this suggestion, children should be able firstly, to create brief records of potential novel words and secondly, to link that input to a long term system in ordered to acquire their vocabulary.

In the natural process of vocabulary acquisition, children indeed show evidence of such processes. The ability to rapidly create representations of novel words appears early in infancy. Pre-school children are able to create "fast mappings" between a new word and its referent even after a single exposure to the word (Carey, 1978; Dollaghan, 1985). Within a few presentations children show the ability to refine and consolidate these representations (Carey, 1978) and are capable of lexical comprehension of the novel word (Keenan & MacWhinney,1987). Also, children appear to became sensitive phonological characteristics and to phonotactic probabilities of their own native language early in infancy (Werker & Trees, 1984; De-Boysson-Bardies &Vihman,1991; Juscyk, Luce, & Charles-Luce, 1994).

Much is already known about phonological short term memory involvement in vocabulary learning among children who's native language is English. Phonological loop capacity is closely related to vocabulary knowledge (Gathercole &Adams,1994; Michas &Heanry,1994), to new vocabulary learning (Gathercole & Baddeley, 1990a; Gathercole, Hitch, Service & Martin,1997) and can predict later learning of phonological forms of word (Gathercole, Willis, Emslie, and Bddeley,1992; Gathercole & Baddeley, 1989) among English speaking children. Also, phonological short-term memory ability links closely to English vocabulary learning among Finnish (Service1992; Service & Kohonen, 1995), Chinese (Cheung, 1996), French-English bilingual children (Thorn &Gathercole, 1999) and Italian adults (Papagno, Valentine &Baddeley, 1991). As yet, few studies have investigated the relationship between the phonological loop and native vocabulary acquisition in non-English speaking children. How do children who's native language is other than English learn words in their language? Whether or not they rely on their phonological loop capacity to acquire the sound patterns of words is an important issue for the generalisation of the relationship and for better understanding of vocabulary acquisition. Accordingly, the purpose of Study 1 was to investigate whether the same pattern of phonological loop involvement in vocabulary learning holds in a language other than English, in this case Greek. Is was assumed that if it is the operation of the phonological loop that accounts for the relationship, the same pattern should hold for Greek speaking children as well. If it is an language factor *per se* that accounts for the observed relationship between verbal memory and vocabulary knowledge in English speaking children, the link may be different in a language that is considerably different to English.

Every language has its own phonological rules and distributional characteristics of sound combinations. Clearly, differences in phonology are present in any pair of languages. In particular, languages that make use of very distinctive sound combinations and have different alphabets to each other, are more likely to differ considerably in their phonological features. This suggestion is consistent with findings that show that some languages are easier to learn in every group of native speakers (Ellis, 1994; Laufer, 1990; Nation, 1987). Typically, second language learners acquire foreign words that contain sound patterns that are similar to their own native language more easily than foreign words that are different from their native language (Feldman & Healy, 1998; Rodgers, 1969; Ellis & Beaton, 1993a). An example of languages that differ considerably in phonology is the pair Greek-English (see Efstathiades, 1974). The Greek language typically has longer words than English and more clusters of consonants are allowed in the Greek phonotactic system (Petrunias, 1984). For example, clusters of more than three consecutive consonants are allowed in Greek words.

The distinctive characteristics of Greek and English phonology make Greek speaking children an interesting population to investigate possible contributions of phonological memory to native vocabulary acquisition. The differences between the English and Greek languages, might lead to two contradictory hypotheses: Firstly, due to practice at maintaining lengthy multisyllabic stimuli Greek children's phonological loop capacities may be greater, and so may represent a lesser constraint on the long term leaning of the phonological properties of vocabulary. Secondly, the greater length of Greek words may make temporary storage more prone to error, in which case children with relatively poor phonological loop capacities should find it particularly difficult to construct long-term phonological representations.

Evidence from other languages is important for a better understanding of phonological loop functioning. Previous research indicates that differences in word length between languages affects performance on phonological short-term memory tasks (Naveh-Benjamin & Ayres, 1986). Digit span is larger for languages in which speech rate is faster (Chincotta & Hoosain, 1995; Chinccota & Underwood, 1996). One possible explanation for these findings is that in languages with short digit names articulatory duration is also shorter and less demands are made on the phonological loop than in languages with longer articulatory duration.

In one of the few studies that investigated phonological loop involvement in language related tasks among Greek speaking children, a close link between phonological memory skills and reading ability was found. Maridaki-Kassotaki (in press) examined the relationship between nonword repetition ability and reading achievement in Greek-speaking children and found strong links between reading performance during early school years and repetition of Greek nonwords ($r = .63$ for 6-year-olds and $r = .81$ for 7-year-olds). In order to extend this link to some other language skills, the current study investigated Greek speaking children's phonological short-term memory abilities and its possible links with their vocabulary knowledge.

Study 1 investigated phonological short-term memory abilities and vocabulary knowledge in a Greek speaking group of children. Three assessments of phonological short-term memory were made: digit span, repetition of native nonwords and repetition of foreign nonwords. Repetition of foreign nonwords is not a conventional task to employ in order to assess phonological memory capacity especially with children who

have no knowledge of foreign languages. It is assumed though to represent a more stringent phonological short-term memory test. Repetition of extremely unfamiliar items such as nonwords in a foreign language may force the child to rely very heavily on the representation in the phonological loop to support repetition. It was assumed that usage of two tasks (repetition of native and foreign nonwords) could provide a sensitive measure to assess phonological memory skills. Thus, the English CNRep (Gathercole & Baddeley, 1996) was used together with the Greek nonword repetition test to assess the phonological memory skills of participants in Study 1.

In summary, possible contributions of phonological short-term memory to vocabulary knowledge were investigated in a group of Greek speaking children. An prediction was made: if the same pattern observed among English speaking children emerges also among Greek children, phonological loop contributes to word learning independently of characteristics of the language to-be-acquired. If the link between phonological memory and vocabulary knowledge does not hold for Greek speaking children, the observed relation is an inner language phenomenon dependent strongly of the typical characteristics of the English language.

2.2.1 Method

Participants

The participants were pupils in two Greek primary schools who had entered the school 7 or 12 months before testing and who were attending the first or the second stage of primary education, respectively. There were 47 subjects available for all the measurements. The mean age of the pupils at the time of testing was 80 months (6.6

years), ranging from 62 month to 93 months (SD =5.7 months). 19 girls and 28 boys were tested. Parents of all children were aware that their children are taking part in a memory experiment.

Design and procedure

A within-subjects design was employed for this experiment. Each child completed all five tests in a single session lasting about 40 minutes. The children were tested individually in a quiet room in the school. The order in which the tests were given was kept constant across children. The order of the administration of the tests was as follows: Raven's progressive Matrices, Digit Span, Greek nonword repetition test, British Picture Vocabulary Scale, English CNRep. In order to counterbalance the presentation of the two forms of the Greek nonword repetition test, a Latin square design was employed for this task: half of the children were given the form A of the Greek nonwords and the other half the parallel form B.

Measures

Phonological short-term memory

Children's phonological memory abilities were assessed by three different means: repetition of Greek nonwords, English nonwords and digit span

Greek nonwords

The new Greek nonword repetition test described above (section 2.1.1), was administered. The stimuli were recorded onto an acoustic tape with a native Greek speaker reading out the stimuli at a rate of one stimuli per 3 seconds. The stimuli were

presented to the child by means of a tape recorder. Before the test began, the children were told that they would hear some funny made-up words that do not mean anything. They were asked to listen to the cassette and to try to repeat these funny words as accurately as possible. Responses were scored as incorrect if the experimenter judged that the child produced a sound that differed from the target nonword by one or more phonemes, and were judged as correct if the stimuli was accurately repeated. For cases in which it was apparent from a child's spontaneous speech that a specific phoneme was consistently misarticulated, credit was given for the consistent substitution. The responses were scored by a native Greek speaking experimenter, twice: at the time of testing and a second time later based on the recorded responses. The agreement between these two ratings was 98%. Reliability of the two ratings was examined with Cohen's Kappa (Cohen, 1960) and found to be high ($k = 62$).

English nonwords

The children's Test of Nonword Repetition (CNRep), (Gathercole, Willis, Baddeley & Emslie, 1994) was given to each subject. The test contains 40 nonwords, ten each containing two, three, four and five syllables. Examples of stimuli are '*rubid*' and *'contramponist'* (for a full list of stimuli see appendix A). The items are presented in a constant randomised sequence for all subjects. The nonwords were recorded onto a good-quality tape by a female English speaker, and presented to the children using a good-quality tape recorder. The procedure employed to administer the Greek nonword repetition test, and described above, was adopted for the administration of CNRep. Emphasis was given on the accurate reproduction of the sound sequence and less on imitation of the distinctive English accent. Children who repeated accurately but with a strong Greek accent were not penalised. The responses were scored by a trained

experimenter who speaks English as a foreign language. Repetition accuracy was scored twice: at the time of testing and a second time later based on the recorded responses. The agreement between these two scorings was 91% to each other (k=59).

In order to estimate the difficulty of the task for young children who had no previous knowledge of English, part of the English CNRep test was administered to a small group of children before being used with children who participated in this study. Twenty four Greek-speaking six-years olds (mean age = 6.5 years, SD=0.9 months) were asked to repeat 20 items from the English CNRep. Mean performance was relatively low but not discouraging (28.7% correct repetitions) with mean accuarancy=5.4 and SD=2.8. The test appeared sensitive to individual differences in phonological memory abilities with children showing a wide range of performance on the task. It was decided to give the full range of the English CNRep to Greek children as young as six years old

Digit Span

Digit span was assessed in Greek. The experimenter spoke aloud sequences of random digits, with an interval of 1 second separating each item. The child was required to repeat back the digits, in the original sequence immediately after presentation. The accuracy of recall was scored by the experimenter. This basic procedure was employed for all digit sequences. At each list length, starting at length two, three sequences of random digits of equal length were presented. The criterion for moving on to the next list length was correct repetition of three sequences at a particular list length. If all three attempts were correct, the digit sequence was increased by one item on the next trial, and a further three lists at the next length were presented. If more than one error was

made on the three trials at any length, testing stopped after the third list at that length. If the subject recalled two lists correctly at one length and made one incorrect recall, a further (fourth) list at that length was presented. If the final list was correctly recalled, a further three lists at the next length were presented. If the forth list was incorrectly recalled, testing was terminated. Two separate scores were calculated for this task: a) span, calculated as the maximum list length at which the child made a correct response and b) the total number of correct recalls through all sequences. Although the conventional scoring of this task is to count the maximum digit sequence length accurately repeated, the second score is thought to be more sensitive. This is because it counts all correct responses the child gives irrespective of possible incorrect responses within the same length. It also corresponds to the raw score used in the digit span test of the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974). This second scoring was used for data analysis.

Vocabulary

The Short Form of the British Picture vocabulary scale (Dunn & Dunn, 1983) was translated and adapted to Greek by a native speaking experimenter and a Greek teacher. A small number of the test items were replaced. The item *claw* was replaced by the word *beak* as the Greek equivalent for "claw" is not a single word but a periphrasis (nail-of-a-wild-animal). The item *socket* was replaced by *cord* because the drawing did not correspond to the Greek electric sockets. The Greek translated form of the BPVS was used to provide a picture-word matching assessment of the child's receptive vocabulary knowledge. In this test the child is shown a series of pages, each containing four line drawings. The child's task for each page is to point to the picture that corresponds to a single word spoken by the test administrator. Test administration proceeds until an

error criterion is reached, The measure used for the purposes of analysis was the total number of correct responses made by each child.

Non-verbal ability

The Raven's Coloured Progressive Matrices (Raven,1986) was used to asses children's general intellectual abilities. In this test a booklet is shown to the child in which each page displays a two-dimensional geometric pattern with a missing part. Six patterned parts are displayed beneath the incomplete pattern, and the child's task is to point to the segment which he or she considers will complete the large pattern perfectly. All patterns in the test are completed by each child. The total number of correct responses was scored for each child (maximum=36).

2.2.2 Results

The mean performance on the assessments are shown in Table 1. The mean raw score on the vocabulary task corresponded to a standardised score of 130 if the English norms are applied. This score is relatively high for this sample age. Possibly, using the English norms is not appropriate for this Greek sample and there are not any standardised norms for the British Picture Vocabulary Scales for a Greek population. Nevertheless, the test was used to reveal individual and not group differences. The raw scores were used to analyse the data.

Table 2.2. Mean performance profiles and standard deviations on all assessments

Measure	Mean	SD	Range	Standardised scores*	Mean % correct
Phonological Memory					
Greek nonword repetition					
2-syllable nonwords	4.68	7.80	5	-	78
3-syllable nonwords	5.30	8.83	5	-	88
4-syllable nonwords	5.68	9.47	3	-	95
5-syllable nonwords	4.62	7.70	5	-	77
Total	20.25	1.95	9	-	84
English nonword repetition					
2-syllable nonwords	3.60	2.02	10	7.8a	36
3-syllable nonwords	3.87	1.68	8	6.4a	39
4-syllable nonwords	2.19	1.42	7	5.1a	22
5-syllable nonwords	1.51	1.38	6	5.3a	15
Total	11.17	4.91	24	64 (10)	28
Digit Span	11.33	3.18	5	-	-
Vocabulary Knowledge	20.57	3.47	18	130 (90)	-
Non verbal ability	19.36	5.16	22	(63)	54
Chronological age (months)	80.17	5.76	32		

*Standardised scores equivalents and percentile ranks in parenthesis if the English norms are applied.
a Mean repetition subscores by English 6-year-olds. Data are from Gathercole et al (1994)

The mean score on the Raven Coloured Progressive Matrices test was 19.36 for this group of Greek children. Although the scale does not provide exact standardised scores corresponding to each raw score, the percentile rank corresponding to the mean score of children's performance is 63 that is expected for this age group if the English norms are applied. Children performed at an age-appropriate level for this non-verbal ability task, considering also that their English peers showed comparable performance (mean = 21.4, SD=4.6) on this task in the Gathercole et al (1992) study.

Children's mean digit span was 4.43 (SD =1.04). This score is comparable to the performance of English peers on this task: English 6-years olds showed a mean digit spans of 5.7 (SD =1.1) (Gathercole et al 1992). The alternative scoring of children's protocols, in which the number of lists correct was calculated at each length also revealed expected for this age group scores: the mean raw score was 11.33 (SD=3.18) while the English peers mean score was comparable on this task 12.6(SD=3.2) (Gathercole et al 1992). The raw scores of the number of lists correct were used to analyse the data.

Nonword repetition

The mean score on the Greek nonword repetition task was unexpectedly high (84% correct) in comparison with their English peer's performance on the equivalent task. English 6-years -olds score on average 62% correct on an equivalent task where they are asked to repeat nonwords in their native language (Gathercole et al., 1994). The high performance for this age group is possibly due to the small number of items included in the test (maximum 24).

Internal reliability of the Greek nonword repetition task was assessed by dividing the test into equivalent halves and applying the Spearman-Brown formula (Anastasi & Urbina, 1997) to determine split-half reliability. The correlation coefficient was non significant (r=0.17) indicating unsatisfactory levels of internal reliability for the Greek nonword repetition test. It is possible that the low reliability level reflects the low sensitivity of the measure resulting from ceiling effects in performance on the task.

Subtest scores at each of the four syllable lengths of the Greek nonword repetition test were obtained for each child. These data are summarised in table 2.2. Repetition accuracy for Greek nonwords was almost equal at all four lengths with a slight decline between syllable lengths four and five. The high performance of children on this task and the relatively small number of items at each length (maximum 6) possibly disguise further properties of this data, such as length effects and wordlikeness effects. The mean score on the English nonword repetition task was considerably lower (28% correct) than on the Greek test. The difference between performance on the two nonword repetition tasks (Greek and English) was highly significant $t(46) = 14.01$, $p < .001$. Greek children scored lower on this task than their English peers who scored 64% correct (Gathercole et al,1994).

English subtest scores at the four syllable lengths of the English nonword repetition (CNRep) test were obtained for each child (see table 2.2). Repetition accuracy for English nonwords declined as a function of the number of syllables between syllable lengths three and five. This linear function corresponds to what is found on the English nonword repetition task with English children (Gathercole et al, 1994). However, repetition performance was slightly better for the three-syllable than the two-syllable nonwords. This may be due to the distinctive phonology of the two syllable nonwords that makes them difficult for Greek children to pronounce. Some of the endings of the two syllable English items consist of two consecutive vowel sounds e.g. *bannow, glistow,* a combination that does not appear as an ending in any Greek word. This ending does not appear in any other item of the test either, which makes the two syllables items uniquely difficult for Greek children to repeat correctly.

Reliability

Internal reliability of the English nonword repetition task was assessed firstly, by dividing the test into equivalent halves and applying the Spearman-Brown formula (Anastasi & Urbina, 1997) to determine reliability by the split-half method. The observed correlation was significant ($r = .50$ at $p < .05$). Secondly, internal reliability was assessed by considering the correlations between the four syllable length subscores (each with a maximum score of 10). Subscores at all syllable lengths correlated with one an other significantly (correlations are summarised in table 2.3). Hence, the internal reliability of the English nonword repetition test appears to be satisfactory.

Table 2.3. Correlations between the four-syllable length subscores in CNRep

Length	Two syllables	Three syllables	Four syllables
Two syllables	-		
Three syllables	**.45**	-	
Four syllables	**.55**	**.49**	-
Five syllables	**.33**	**.34**	**.37**

Correlations printed in bold are significant at the 5% level

The same procedure was employed to assess internal reliability of the Greek nonword repetition test. The correlations between the subscores at all syllable lengths are summarised in table 2.4. Only the four syllable Greek nonwords correlate significantly with two and three syllable nonwords. The remaining correlations were found to be non-significant. The internal reliability of the Greek nonword repetition test appears to be rather low.

Table 2.4. Correlations between the four-syllable length subscores in Greek nonword repetition test

Length	Two syllables	Three syllables	Four syllables
Two syllables	-		
Three syllables	.06	-	
Four syllables	**.28**	**.32**	-
Five syllables	.08	.06	.03

Correlations printed in bold are significant at the 5% level

Association between STM and vocabulary knowledge

Correlation coefficients were computed between the three phonological short-term memory measures (digit span, repetition of Greek nonwords, repetition of English nonwords) and were found to be significant (see table 2.5). Validity of the Greek nonword repetition measure was assessed by calculating the correlations between performance on the Greek nonword repetition task with digit span and English CNRep performance. These were $r=.53$, $p<.001$ and $r=.43$, $p<.05$ respectively ($df=47$). The high correlations between these measures and the new constructed Greek nonword repetition test imply a satisfactory validity of the Greek nonword repetition measure. The correlation between digit span and English nonword repetition was also highly significant ($r=.47$, of $p<.001$).

Previous research has consistently found close links between measures of phonological short-term memory and vocabulary knowledge. These links appear in the current data too and the same pattern of association between vocabulary and short-term memory seems to apply to this group of young Greek children (see table 2.5). Digit span, Greek

nonword repetition and English nonword repetition scores were all significantly correlated with vocabulary knowledge. Digit span scores were more highly associated with vocabulary knowledge than nonword repetition scores did. However, there were no significant differences between the digit span and nonword repetition measures in the extent to which they relate to the vocabulary test ($r = 2.01$, $p > 0.5$).

Table 2.5. Correlation matrix for all principal measures

Measure	1	2	3	4	5
1. Greek nonword repetition	-				
2. English nonword repetition	**.43**	-			
3. Digit span	**.53**	**.47**	-		
4. Vocabulary knowledge	**.34**	**.37**	**.45**	-	
5. Non-verbal ability	.29	.13	**.30**	**.42**	-
6. Chronological age (months)	.15	.26	**.32**	**.34**	.26

Correlations printed in bold are significant at the 5% level
df = 47 in all cases.

The links between each of the three phonological short-term memory measures (digit span, Greek nonword repetition and English nonword repetition) and vocabulary knowledge were further explored in a series of partial correlational analyses. In the analyses, the partial correlations between the memory measures and vocabulary knowledge were computed after the potentially confounding influences of chronological age, in one set of the analyses, and of chronological age and non-verbal ability, in the other set of analyses, were partialled out (see table 2.6).

Table 2.6. Partial Correlation Coefficients Between individual short-term memory and vocabulary knowledge

Measures		
	Vocabulary knowledge	
	Variables partialled out	
Phonological memory measure	Chronological age	Chronological age and non-verbal ability
1. Greek nonword repetition	**.31**	**.24**
2. English nonword repetition	**.30**	**.31**
3. Digit span	**.38**	**.33**
4. Non-verbal ability	**.37**	

Correlations printed in bold are significant at the 5% level
df=44

All three phonological short-term memory scores remained significantly correlated with vocabulary knowledge when chronological age was partialled out. Digit span and English nonword repetition remained significantly correlated with vocabulary scores when both variance attributable to chronological age and non-verbal ability scores had been partialled out . The relationship, though, between Greek nonword repetition and vocabulary scores was not so specific. The partial correlation between Greek nonword repetition and vocabulary scores was nonsignificant when variance associated with age and non-verbal ability scores was partialled out . This may have been due to ceiling effects in the Greek nonword repetition test.

In summary, all three phonological short-term memory measures used here were found to be significantly linked to vocabulary knowledge in this group of young Greek children. Nevertheless, repetition of English (foreign) nonwords appeared to correlate more strongly with vocabulary knowledge here than repetition of Greek (native)

nonwords did. This may have been also due to ceiling effects on the Greek nonword repetition test.

Wordlikeness

Using the wordlikeness ratings for the Greek nonword repetition test reported in the methods section (see paragraph 2.1.2), the association between the wordlikeness of the Greek nonwords and repetition accuracy was investigated. No significant correlation was found ($r = .19, p > .05$) possibly due to the relatively high repetition accuracy shown on the nonword repetition test.

2.2.3 Item analysis

One possible explanation for children's high performance on the Greek nonword repetition task is that some of the test's items were far too easy for children to repeat. These items needed to be identified and removed from the list in order to improve the sensitivity of the test . In an item analysis, the difficulty of each test item was estimated. The percentage of participants who correctly repeated each item was calculated with the score indicating the difficulty of each item (see table 2.7). Another consideration of item difficulty relates to the intercorelations among the items. Even items with moderate difficulty level can not differentiate individuals if they correlate very highly with other items in the test. Ideally, a test should consist of items that have average difficulty around .50 and intercorrelate moderately with the total score (Anastasi & Urbina. 1997). In order to identify those items in the Greek nonword repetition test which intercorrelated moderately with the total score, the inter-item correlations were calculated. Each item's scores were correlated with the total scores in a participants-by-items table and a correlation was estimated for each item separately (see table 2.7). The

scores from the item being correlated each time were removed from the list of totals before the correlation was calculated.

Most of the Greek nonwords included in the test, were found to have a difficulty of close to 1.00. Some items such as *nakonidisto* and *kolimia* had a difficulty of 1.00. Apparently, these items do not discriminate between the participants, and so need to be either eliminated or modified. A small proportion of the items such as *lolminadiko* and *lavirigikos* had a difficulty of around .50 and significantly differentiated among participants. A few items, such as *lolminadiko* and *athoniditos* were found to have both, difficulty around .50, and to correlate moderately with the total score. These items can be retained in the test.

Table 2.7 Mean performances and Intercorelations of individual items in the Greek nonword repetition test

Form A			Form B		
Items	Mean performance	Correlation with mean	Items	Mean performance	Correlation with mean
prosta	0.76	0.11	lalma	0.73	0.34
sinafikos	0.92	0.36	aligea	0.95	-0.44
akainatizo	0.84	0.40	paremofora	0.91	0.05
dolatos	0.84	0.34	planero	0.86	0.69
alkotita	1.00	0.19	nistomia	0.95	-0.09
mopado	0.80	-0.07	kavotos	0.95	-0.21
fere	0.72	0.01	nidos	0.55	0.19
kourma	0.80	-0.25	kamos	0.86	-0.15
epnasi	0.92	-0.01	harostikos	0.91	-0.13
kalthamotita	0.80	0.19	lavirigikos	0.68	0.14
almahis	0.92	0.21	atrovo	0.91	0.80
krotinaki	0.92	-0.09	kolimia	1.00	0.36
nakonidisto	1.00	-0.14	thimopilia	0.82	0.25
nilagia	0.88	0.08	kastalono	1.00	0.18
athoiditos	0.68	0.04	kanilaniso	0.73	-0.29
natalo	0.92	0.21	miniktos	0.77	0.27
midra	0.96	-0.06	tida	0.86	0.00
pravagos	0.72	0.29	edonas	1.00	0.23
lolminadiko	0.56	0.10	stonipilia	0.68	-0.19
tomaleti	0.96	0.04	fonorizo	0.86	0.41
xiama	0.88	-0.22	magratos	0.91	0.66
volsi	0.96	-0.16	thati	0.27	0.22
nireftolaso	0.68	0.28	imnosalono	1.00	0.08
rivo	0.88	0.27	aros	1.00	-0.27

2.2.4 Discussion

The relationship between the children's ability to repeat back unfamiliar nonwords in native and in foreign languages and their vocabulary knowledge was investigated in a group of Greek speaking children. Evidence was found that phonological short-term memory skills, as assessed by nonword repetition are related to vocabulary knowledge in this group of five-years-olds. The extent of vocabulary knowledge gained by the age of five remained strongly linked to immediate memory abilities even when the general factors of non-verbal ability and chronological age, were taken into account.

These findings replicate the well established link between vocabulary and phonological short-term memory found in previous studies with English speaking children (Gathercole & Adams, 1993; 1994; Gathercole & Baddeley,1989; Gathercole, Hitch, Service, & Martin,1997; Gathercole, Willis, & Baddeley,1991; Gathercole, Willis, Emslie & Baddeley,1992; Michas & Henry,1994). However, the group of children who participated here were distinct in terms of their native language: they were Greek speaking children with no previous knowledge of foreign languages. It is worth noting that although the Greek language has a different phonology and average longer word length from English, the relationship between vocabulary knowledge and short-term memory ability remains strong. It can therefore be suggested that this relationship can be found in other populations, irrespective of the language spoken, and that the link between vocabulary and phonological short-term memory exists in a more general, language-free manner.

A correlational relationship between vocabulary knowledge and phonological memory does not of course, address the causal issue of whether phonological memory plays a

central role in vocabulary acquisition. One alternative account for this relationship could be that vocabulary knowledge supports accurate nonword repetition rather than depending on phonological short-term memory skills. On these grounds, children with good vocabulary can better repeat nonwords by relying on their long-term knowledge. One possible mechanism that integrates long-term knowledge with short-term storage is redintegration (see Chapter 1 paragraph 1.3). Children may draw upon their lexical knowledge to retrieve vocabulary items which are similar in phonological structure to a specific nonword. The greater the vocabulary knowledge, the greater the possibility that a child will be able to activate a phonological neighbour of the spoken item to-be-repeated. The current results allow one to make an assumption about the causality of the relationship. In Study 1 a link was found between repetition of English nonwords and Greek vocabulary knowledge. There are two possible directions of causality for this link.

Firstly, good Greek vocabulary knowledge supports repetition of English nonwords. In this case, long-term knowledge supports accurate repetition of nonwords. Indeed, this support seems to be available for repetition of lexical material, and is consistent with the considerable body of research indicating lexical (Hulme, Roodenrys, Brown & Mercer,1995) or sublexical (Gathercole,1995; Gathercole et al., 1997) knowledge influences on immediate memory for unfamiliar phonological material.

Secondly, ability to repeat English nonwords helps children to build up vocabulary. In this case, phonological memory abilities contribute to vocabulary acquisition. This hypothetical causal path is also consistent with the plethora of evidence indicating that

the efficient operation of phonological memory is crucial to the learning of words (Baddeley et al, 1998).

The familiarity that children have with their native language appears to have beneficial effects on the short-term storage of lexical material resembling the phonotactic properties of this language. It appears that young children as young as five years old who are at the initial stages of language competence when vocabulary knowledge is relatively restricted and reading ability hasn't developed yet, already hold information about the phonological properties of their native language. This knowledge appears to be effective enough to determine the quality of phonological loop representations. In line with this view are findings suggesting that the sensitivity to phonotactic probabilities of the native language emerges early in infancy (Werker & Tees, 1984; De Boysson-Bardies & Vihnam, 1991). The use of long-term knowledge to enhance phonological loop representations indicates a close relationship between language knowledge and memory performance. Sensitivity to a language's phonotactic probabilities though, is unlikely to hold for unfamiliar languages. Assuming that the structural and distributional properties of any pair of languages are distinctive, specialisation of the conceptual system to the properties of one's own language impedes learning of sounds in an unfamiliar language. This restriction may be particularly strong for languages that have different phonemes and highly distinctive phonologies, as the Greek and English languages do (Efstathiades, 1976).

The lack of familiarity that the Greek children participating in Study 1 had with the English language makes it less likely that they relied on long-term knowledge as a means to repeat the English nonwords. English nonwords represent an extremely unfamiliar

material for this group of children. Children of both high and low vocabulary knowledge in Greek had no prior knowledge of the English language. Assuming that support for repeating this material comes from long term sublexical knowledge, such a knowledge is limited here and thus, less likely to prove beneficial. By this account, the children who repeated English nonwords accurately relied more on their short-term phonological representations and less on their long-term knowledge of the language.

The link found between repetition of English nonwords and Greek vocabulary knowledge suggests a contribution of phonological memory abilities to vocabulary acquisition rather than support from long-term knowledge to repeat these particular nonwords accurately.

Nevertheless, the extent of vocabulary knowledge that children have in their native language can possibly facilitate repetitions of both foreign and native nonwords. There is evidence for transfer of first language knowledge to second language learning (Papagno, Valentine & Baddeley, 1991; Tao & Healy, 1998) particularly when two languages share the same alphabet (Buck-Gengler, Romeo, Healy and Bourne, 1998). This assumed facilitation, although perhaps present in every language, is effective and substantial in ones native language but restricted and less beneficial in an unfamiliar language.

An other aspect of the results is consistent with this view. Children were poorer at repeating foreign (English) nonwords than native (Greek) nonwords. Although nonwords are unfamiliar lexical items in both native and foreign languages, repetition of foreign nonwords is a task that puts a heavy load on the phonological loop.

Performance for native nonwords may be supported by long-term knowledge but this support decreases for foreign nonwords.

Similarly, performance for foreign (English) nonwords was poorer and significantly lower than performance of English children of this age on the same task. The results suggest that the lack of familiarity with the English language affects the short-term storage of material conforming to the phonotactic properties of this foreign language to Greek children. As long-term knowledge was not present to enhance phonological representations, children depended more on the quality of the representation to repeat the unfamiliar material (Gathercole, Frankish, Pickering & Peaker, 1997).

The assumed heavy reliance on phonological short-term memory to support repetition of foreign nonwords may lie at the root of the particularly strong association between performance on this task and vocabulary knowledge. Also, repetition of foreign nonwords correlates strongly with other measures of phonological short-term memory capacity such digit span and native nonword repetition. Assuming that foreign nonwords are very low in wordlikeness, repetition of such items appears to provide a pure and reliable measure of phonological loop capacity.

Repetition of native nonwords was also associated with vocabulary knowledge but the association diminished when other general factors such as chronological age and non-verbal ability were controlled. This result is not thought to reflect a possible shared contribution of a non-verbal ability factor to both short-term memory performance and vocabulary knowledge but rather a failure of the particular task to tap accurately phonological memory capacity. The high wordlikeness scores of the Greek nonwords

together with the children's high performance on this task, may have made the task less sensitive and thus inappropriate to assess children's phonological loop capacity.

The high levels of repetition accuracy on the Greek nonword repetition task may have masked the usual sensitivity to item length. Children's accuracy was not found to be sensitive to the length of native-like nonwords but performance on repetition of foreign nonwords declined as a function of number of syllables. Further properties of nonword repetition, such as the distinction between repetition performance on high and low wordlike Greek nonwords was not shown here, due to ceiling effects on the task.

The present findings show evidence of particularly close links between foreign nonword repetition and native vocabulary knowledge. These findings strongly favour the view that phonological short-term memory plays a crucial role in acquiring vocabulary knowledge rather than vocabulary knowledge supporting temporary storage in the phonological loop. The verbal memory contribution to vocabulary acquisition that has been established among English-speaking children appears to emerge in Greek five-years olds as well. Furthermore, performance on repetition of native nonwords was significantly better than repetition of foreign nonwords in Study 1 suggesting that the phonological loop component of working memory is responsible for storing unfamiliar spoken information and the system can use prior knowledge in order to enhance the quality of the stored representations. The implication of such a finding is that the association between the phonological loop and long-term learning of native words is not uni-directional but rather reciprocal. Long-term knowledge is used to improve the quality of temporary representations (Hulme, Maughan &Brown, 1991; Hulme, Roodenrys, Schweikert, Brown, Martin & Stuart, 1997; Gathercole, 1995;Gathercole,

Frankish, Pickering & Peaker, 1999). Consequently, the more extensive this knowledge is, for example in one's native language, the more ready the system is to support phonological loop representations.

Some limitations of the present experiment should be noted. Scores on the Greek nonword repetition test were positively skewed indicating that performance was approaching maximum levels. The difficulty level of this test therefore requires modification in order to reduce overall test scores while maintaining items with maximal discriminability. Items with low discrimination value should be excluded from a possible revised version of the test and replaced by new more sensitive items. A further means of increasing the test's sensitivity is to increase the length of the test by adding more items. A longer test of Greek nonword repetition should be more valid and reliable than a shorter one (Anastasi & Urbina,1997).

In summary, a new test of nonword repetition in Greek was developed and used with young Greek children. The high levels of performance on the test suggested that future modification of the items used may be necessary. Links between nonword repetition and vocabulary knowledge were shown, particularly for foreign nonword repetition. The findings of Study 1 support and extend to a new population the view that phonological short-term-memory is involved in supporting phonological learning of words, a relationship which probably becomes more bi-directional with increasing familiarity with a language.

CHAPTER 3

DO PHONOLOGICAL SHORT-TERM MEMORY SKILLS LINK TO FOREIGN-LANGUAGE VOCABULARY KNOLEDGE?

Study 1 established a close link between native vocabulary knowledge and phonological short-term memory capacity in young Greek speaking children. This association has been interpreted in terms of verbal short-term memory contributions to native vocabulary learning, but its generality needs testing. Does it also arise for words acquired in a foreign language? It is possible that this causal relationship does not arise in any vocabulary learning task but is be confined only to vocabulary acquisition in native language among Greek children. In this case, if phonological loop mediation is merely restricted to learning of native words, it is also possible that the link is not particularly restricted to learning the phonological properties of words but may also mark all aspects of verbal learning. In Study 1 children had achieved a mastery of their native language by learning both the conceptual and the phonological properties of the words in their native language (Greek). After children have achieved a mastery in discriminating sounds in their own language -and there is evidence suggesting that such a sensitivity to the phonotactic probabilities emerges early in infancy (De Boysson-Bardies & Vihman,1991; Jusczyk, Luce, & Charles-Luce,1994)- the phonological burden involved in acquiring vocabulary in the native language is comparatively limited. Words within a particular language are composed only of a restricted number of phonemes and phonemes are combined in a phonotactic manner which is typical for the language. Study 2 was designed to test whether the relationship between short-term memory and word learning is specific to the the acquisition of words within one's native language, or

extends to learning phonological patterns of words in a foreign language. The phonological short term memory skills of a group of children who were learning English as a second language after they had achieved a mastery in their native language were assessed. Children as foreign language learners have to acquire merely the new sound patterns of the words, as they have already acquired the conceptual meaning of words in native language. Thus, foreign language learning is a heavily phonological task because the structural and distributional properties of the foreign language are distinctive, and the learner can not rely on knowledge about the probabilistic structure of the language.

3.1 STUDY 2

The possibility that phonological short-term memory mediation is not restricted to native vocabulary acquisition and contributes also to learning vocabulary in a foreign language has been investigated in a number of studies (Chapter 1 paragraph 1.3). It was argued that there is now 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 native (Adams & Gathercole, 1995; Gathercole & Adams, 1994; Gathercole et al., 1992Michas and Henri, 1994;) as in foreign (Service & Kohonen, 1995; Papagno et al., 1991; Papagno & Vallar, 1995) languages. For instance, Service (1992) found that the single best predictor of success in learning English at school was the children's accuracy in repeating unfamiliar nonword and established that nonwords repetition was specifically associated with foreign language vocabulary acquisition rather than with other aspects of foreign language learning (Service and Kohonen 1995). Also learning of foreign words has been found to be benefited byrepetitions at initial presentation in several studies (Ellis and

Sinclair, 1996; Ellis and Beaton, 1993a), possibly due to repetition enhancing phonological memory representations.

Recent investigations indicate that long-term knowledge of the structure of the language may also influence ease of learning new lexical material in a foreign language. 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 & Baddeley (1992) studied the native vocabulary acquisition of a cohort of children aged between four and eight years of age, and found beyond five 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 which 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, too. Gathercole, Frankish, Pickering, and Peaker (1999) found that children recalled

nonword sequences more accurately if the nonwords contain high rather 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 was investigated in Study 2 in 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 three years on average. In Study 2, vocabulary knowledge of both languages was assessed, to enable one 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 which may contribute to the ease of learning foreign vocabulary were also assessed: chronological age, non-verbal ability and period of study of the foreign language.

Study 2 also provided the opportunity to investigate the association between knowledge of native and foreign vocabulary. We assessed 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.

3.2 Method

Participants

Forty-five children attending a public primary school in Greece participated in Study 2. 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 three 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 one year of study, and children who had dropped the English classes for more than 5 months were considered as having missed a year.

Materials

Phonological short-term memory

Children's phonological memory abilities were assessed by using two different means: repetition of Greek nonwords and repetition of English nonwords.

Greek nonwords

A revised version of the Greek nonword repetition test was constructed. The test had similar variation in phonological structure as the initial test described in Chapter 3. Only eight items from the initial list remained in the revised version of the test. Based on the results from Study 1 those items were found to discriminate highly among children and are *kamos, pravagos, athoniditos, lavirigikos, nidos* and *lolminadiko*. The new items were constructed by picking words from a Greek dictionary and modifying them by changing the order of the syllables. As a result the stimuli followed all the phonotactic rules and the dominant stress patterns of Greek language. Also, one extra nonword length was included and the revised version of the Greek nonword repetition test contained fifty nonwords, ten each of 2,3,4,5, and 6 syllables The items included in the test are shown in the Appendix. The Greek nonwords were presented to the children and the repetition accuracy scored, following the procedure described in Study 1.

English nonwords

The English nonword stimuli were taken from the Children's Test of Nonword Repetition Test (CNRep) as described in Study 1 (Gathercole, Willis, Baddeley & Emslie, 1994). Two repetition accuracy scores were again attained one at the time of testing and a second one based on the recorded responses of the children. The consistency of the scoring, inspected by calculating the correlation between the two scores, was extremely high $r = .98$, $p < .001$.

Native vocabulary

Vocabulary knowledge in native language was estimated by assessing both children's productive and receptive vocabulary.

Receptive Vocabulary

Children's current receptive vocabulary knowledge was assessed using the short form of the British Picture Vocabulary Scale (Dunn & Dunn, 1982) described in Study 1, Chapter 2. This test was translated and administered in Greek by a native Greek speaker (E.M.). It was found to be necessary to replace a small number of test stimuli which were judged likely to be unfamiliar to Greek children. For example, the word *socket* was replaced because the drawing does not corresponds to the Greek electric sockets.

Productive Vocabulary

The vocabulary subtest of the Wechsler's Intelligence Scale for Children Third Edition-UK (Wechsler, 1981) was used to assess children's productive vocabulary. In this subtest, a series of words (maximum 30) are presented orally which the child is asked to define. The subtest was translated into Greek and some Greek items replaced the more obviously anglicised ones. Each child was presented with thirty words, and 2 credits were given for every response that indicated good understanding of the word, 1 credit for every response that shows poverty of content and zero for every incorrect definition of the word. The total number of credits for each child was scored (maximum 60).

Non-verbal ability

Each child's non-verbal ability was assessed using the book form the Raven's Coloured Matrices (Raven, 1984) described in Study 1, Chapter 3.

Foreign vocabulary

A new test was developed to assess children's English vocabulary knowledge. Although the English test could have been used directly to Greek children who learn English, this was though to be an unreliable measure. These tests were designed to assess native vocabulary growth, when vocabulary is acquired in linguistic environments. Assuming that foreign vocabulary knowledge develops in a special manner, a different test was necessary. Thus, two tests of the children's knowledge of English vocabulary were given, involving translation between the spoken English and Greek forms of words.

Greek to English translation test

In the native-to-foreign translation test, the children were asked to provide the best English translation for 60 Greek words. The items were presented auditorily by a native Greek experimenter with good knowledge of English. The vocabulary items included in this test were selected from the English text books used by the children in school (Triandafellou, 1996). The items were arranged in order of difficulty, with words that were 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 this test was scored (maximum=60).

English to Greek translation test

In the foreign-to-native test, the children attempted to provide the best Greek equivalent to 60 different English words. The procedure employed for the native-to-foreign

translation test applied here. Children's responses were assessed by the same experimenter and again counted as correct only if both meaning and part of speech were accurately represented. In those cases where more that one Greek words could accurately express the meaning of the English words all satisfying translations counted as correct. For example, the English word *sad* can equally well be translated in Greek as *thlimenos*(=being in a bad mood) or *stenaxorimenos(*=being worried). 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 this test was scored (maximum=60).

Design and procedure

Children were tested individually in a single session lasting for about one hour. The order of the tests was held constant across all children. The order of administration of the tasks was as follows: non-verbal ability, Greek nonword repetition, English nonword repetition, translation foreign-to-native, translation native-to-foreign, native vocabulary receptive, native vocabulary productive.

3.3 Results

Mean performance profiles

Descriptive statistics for each measure are provided in Table 3.1. Using the English norms to find the standardised scores equivalents for this age group for the mean raw score on the British Picture Vocabulary Scale corresponds to a standardised score of 97, which converted to percentile rank gives a point of 42. This performance is within the expected range for this age sample. Applying the English norms again, the mean raw score on the WISC vocabulary subtest corresponds to the scale score of 10 which falls at the middle of the scale and suggests average performance for this age group. It appears

that children performed at age-appropriate levels for both vocabulary tasks and therefore, their scores reflect their actual vocabulary knowledge satisfyingly.

Table 3.1 .Means, Standard Deviations, Ranges and Standardised scores for all measures

Measures	Mean	S.D.	Range	Standardised scores
English nonword repetition				
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-sylable nonwords	3.36	1.81	0-7	-
Total	18.56	4.73	6-26	46(10)[a]
Greek nonword repetition				
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-sylable nonwords	5.38	1.67	1-8	-
6-syllable nonwords	3.29	1.38	0-6	-
Total	29.09	5.33	11-37	-
Native vocabulary measures				
Productive vocabulary	29.45	7.74	13-52	
Receptive vocabulary	20.44	5.5	4-29	97(42)
Foreign vocabulary measures				
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	-
General measures				
Non-verbal ability	24.71	5.41	12-35	(50)
Length of study	3.30	2.19	1-5	-
Chronological age (months)	123.87	12.11	106-142	-

Percentile points in parentheses.

[a] Equivalent for maximum(=9years) age interval in provided by the CNRep norms.

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 two, three, four, and five syllables. Scores were significantly greater for native nonwords than for foreign nonwords. 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 -$t(45)=1.05; p>.05$- on translating between Greek and English words regardless of the direction of the translation with the two translation measures correlated highly with one another, $r(45)=.95, p<.001$.

Table 2 shows the correlation coefficients between all principal test scores. For more robust results the scores from the two vocabulary scores were combined into a single score. 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.

Table 3.2 Correlation matrix for all principal measures

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

*Significant at level 5%.
** Significant at level 1%, df=45 in all cases.
Numbers without asterisk are nonsignificant correlations.

Table 3.2 shows that the English (foreign) vocabulary measure was significantly correlated with both English and Greek nonwords repetition measures. Similarly, the composite Greek (native) vocabulary score was significantly correlated with both Greek and English nonword repetition. The difference between these two correlation coefficients (Greek and English nonword repetition to Greek vocabulary) was not found to be significant, $t(45) = 1.98, p > .05$. Composite Greek and English vocabulary scores were strongly associated with one another, $r(45) = .66, p < .001$.

In order to explore the specific relationship between nonword repetition and vocabulary in both languages, the potentially confounding influences of chronological age, non-verbal ability and length of study were partialled out. The resulting partial correlations are shown in Table 3.3.

Table 3.3.Partial Correlation Coefficients between vocabulary tasks and short-term memory measures

Measures			
		Vocabulary tasks	
		Greek vocabulary	English vocabulary
	Variables partialled out		
Greek nonword repetition	age, non-verbal ability, length of study	.43	.44
English nonword repetition	age, non-verbal ability, length of study	.31	.43
Combined nonword repetition	age, non-verbal ability, length of study, Greek vocabulary	-	.32
	age, non-verbal ability, length of study, English vocabulary	.30	-
English vocabulary	age, non-verbal ability, length of study	.56	-
	age, non-verbal ability, length of study, nonword repetition	.42	-

Correlations printed in bold are significant at the 5% level

Both native and foreign vocabulary scores remained significantly correlated with the nonword repetition measures after age, non-verbal 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, addressing to establish whether the close association between native and foreign vocabulary is mediated by the common link shared with performance on nonword repetition task, further analysis was conducted. 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 partialing out the third variable in each case by controlling at the same time for chronological age, non-verbal ability and length of English study (see table 3.3). 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, $r(43) = .30$, $p > .05$.

3.4 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, 1990a; 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, non-verbal ability and length of time spent studying the foreign language. Clearly, findings from Study 2 suggest that phonological memory contribution is not merely restricted to vocabulary learning in native language but also expands to learning of a second language.

In Study 2 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 of general factors (age and non-verbal ability) and also of vocabulary competence in native language. That children's learning of foreign vocabulary may be particularly highly dependent upon temporary phonological memory than native vocabulary acquisition due to logical greater unfamiliarity of foreign words. There is more opportunity for support from lexical phonological knowledge in 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 then 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 2 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 (Kolers, 1966; Chen &Leung, 1989). 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, Study 2 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.

In conclusion, Study2 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 which could not be explained exclusively in terms of phonological loop capacity.

CHAPTER 4

THE ASSOCIATION BETWEEN PHONOLOGICAL SHORT-TERM MEMORY SKILLS AND NOVEL NEW NATIVE AND FOREIGN WORD LEARNING

The findings from Study 1 (Chapter 2) and Study 2 (Chapter 3) indicate a close relationship between young children's phonological memory abilities and both their native and foreign vocabulary knowledge. These findings are consistent with the notion that one component of working memory, the phonological loop, supports the learning of sound patterns of verbal items and enhances the construction of more permanent traces of words in long-term memory (Baddeley et al., 1998). The findings from Study 1 also suggest a reciprocal interaction between phonological memory skills and language competence, in which established knowledge about the language can be used to aid temporary representations in the phonological loop. The findings from Study 2 establish that the association between immediate memory and vocabulary knowledge is present even for words acquired in a foreign language.

One alternative explanation has not yet been considered, which is that children with higher vocabularies may have been exposed to richer linguistic environments and had more opportunities to develop their vocabularies independently of their phonological memory skills. By this account, children would be able to accurately repeat unfamiliar sound patterns simply because they have experienced a wider variety of sound combinations and not because they have good immediate memory skills. Study 3 was

designed to investigate the possibility that differences in learning opportunities accounts for differences in vocabulary knowledge among young children, by controlling the learning environment so that the amount of exposure to novel items was the same for all the children.

4.1 STUDY 3

The causal relationship between phonological short-term memory and native vocabulary knowledge (Baddeley et al. 1998) has already been extended to children's foreign vocabulary knowledge (Service, 1992; Service & Craik, 1993) and is discussed in Chapter 1, paragraph 1.3. It has also been established in a number of studies that the phonological loop plays a crucial role in the learning of new words in the native language (Gathercole & Baddeley 1990a; Gathercole et al 1997) and in foreign languages (Baddeley, Papagno & Vallar, 1988; Papagno & Vallar 1992, 1995). These studies have generated evidence mainly from English speaking populations and it is not clear if the same specific relationship between phonological memory and new vocabulary learning prevails in languages other than English. The particular focus of this thesis is on the Greek language, which encompasses phonological patterns and sounds that are not present in English (Efstathiades, 1974). Although there are differences in phonology between all languages, the extensive differences between Greek and English phonology make the investigation of the link between phonological memory tasks and word learning in a Greek population particularly interesting.

There is substantial evidence for individual variation in children's vocabulary knowledge (Dickinson, 1984; Rice, Buhr & Nemeth, 1991; Nagy, Anderson & Herman, 1987). Why do such large individual differences in vocabulary knowledge exist? Several factors have been suggested to account for individual differences in the abilities to acquire

vocabulary, such as variation in comprehension skills (Anderson & Feebody, 1981), variation in the ability to learn from context (Sternberg & Powell, 1983), intelligence (Wechsler,1974), or the existence of developmental disorders such as specific language impairment (Stark & Tallal, 1981). Individual differences in phonological short-term memory skills may be one substantial explanation for differences among children to acquire the phonological properties of vocabulary (Baddeley et al, 1998). The findings from Study 1 and 2 are consistent with this view.

Despite the wide variations in vocabulary knowledge and the root for those variations, children's vocabulary knowledge development can benefit from increased learning opportunities. During the course of one's life-span, a child is exposed to innumerable words through countless sources-textbooks, lectures, news papers, magazines, teachers, parents, movies, and so on. Even if children learn only a small proportion of the words encountered by context in which they are presented (Sternberg, 1987), a child can develop a vocabulary of many words through incidental learning (Nagy, Anderson & Herman, 1987). Certainly, children who live in environments that can supply multiple rich encounters for a number of words, can develop better vocabulary knowledge. This can support an alternative explanation to findings from Studies 1 and 2, which is that children's differences in vocabulary do not arise from individual differences in phonological loop capacity but from different learning opportunities. This possible explanation is tested in Study 3 where the variety of situations in which the words are encountered and the standards of performance are controlled experimentally.

A similar pattern of individual differences that appears among children who acquire their own native language, holds also for children who learn a second language. Children

differ considerably in the ease with which they learn new words in a foreign language. Some children learn foreign words easily and accurately while some children learn slowly and pronounce words with a strong native accent. Furthermore, the degree of variability in vocabulary among foreign language learners seems to be far greater than in native language speakers (Miyake & Friedman, 1998). For example, children after the same amount of exposure to a foreign language differ considerably in their vocabulary knowledge (Bialystok & Hakuta, 1994). In Study 3 the same procedure was used for native and foreign vocabulary to keep constant the learning opportunities and test directly the possibility that differences in phonological loop capacity account for individual differences in new word learning.

A laboratory word learning paradigm was employed in which children were asked to learn new native and foreign words named by the experimenter and depicted in pictorial form. On the basis of previous results it was predicted that ease of learning performance would be influenced by short-term memory skills. It was also predicted that children with larger native vocabularies would be better at learning the sound patters of new verbal items, based on previous findings suggesting that long-term knowledge facilitates further verbal learning (Gathercole & Baddeley 1990a; Gathercole et al 1997).

In order to make direct comparisons on children's abilities to store native and foreign verbal material in immediate memory, two phonological memory measures (one Greek and one English) were employed here. Superior performance was expected on the native rather than the foreign phonological memory task. One possible explanation for the ease with which participants remember native-like patterns of sounds (Hulme, Maugham & Brown, 1991; Jusczyk, Luce & Charls-Luce, 1994) is the contributions of long term

memory in immediate memory tasks suggesting that probabilistic distribution knowledge about the sound patterns in a language (Gathercole, Frankish, Pickering & Peaker, 1999) are used to support immediate memory performance. According to this account, the phonological loop interacts with long-term knowledge to provide a specialised device for the acquisition of native language. On the same grounds, acquisition of vocabulary in an unfamiliar language can not benefit from accumulated knowledge. More relevant to Study 3, English learning should be impeded by the Greek-language specialisation of children's perceptual systems.

Children's performance even on native-like nonword repetition tasks appears to be constrained by both long-term lexical knowledge (Gathercole at al.1991), the articulatory complexity of nonwords (Gathercole, 1995) and the frequency of phoneme combinations (Gathercole et al, 1999), in addition to basic phonological storage capacity. In Study 3, assessments of lexical properties of nonwords such as wordlikeness and phonological complexity were obtained in order to investigate the extent to which native-like nonword repetition accuracy depends on long-term lexical knowledge and is therefore less sensitive to phonological memory constraints.

A crucial factor other than phonological long-term learning in foreign language acquisition is the availability of semantic associations to link the new word to an existing lexical item (Paivio & Desrochers, 1981). Learning the sound patterns of new words in a foreign language is a task that imposes a heavy phonological load and is unlikely to be enhanced by the specialisation of the perceptual system (Thorn & Gathercole, 1999, Gathercole & Thorn, 1999). Mediation for such a difficult task as foreign vocabulary learning, seems to come from an other resource: when possible, foreign vocabulary

learners rely on semantic associations between the items to be learnt and native-language words and therefore they become less affected by the need to learn new phonological forms without the support of already existing knowledge about the structure of the language in long-term memory (Papagno et al,1991; Service & Craik, 1993).

In summary, Studies 1 and 2 revealed close links between phonological memory and both native and English vocabulary in a group of Greek children learning English as a foreign language at their schools. Study 3 tested whether this same relationship extends to new word learning in an experimentally controlled context in which learning opportunities are equated across all children. The relationship between phonological short-term memory, vocabulary knowledge and new word learning in both native and foreign languages was tested in a group of young Greek children, with the aim of establishing whether phonological memory skills contribute to the long-term phonological learning involved in acquiring both native and foreign lexical items.

4.2 Method

Participants

Forty Greek children, twenty-four boys and sixteen girls, took part in this Study. The children were pupils attending the first, second or third year of full-time education in a public primary school in Igoumenitsa, Greece. Their mean age was seven years and four months, ranging from five years and eleven months to nine years and one month (*SD*=10 months). Children whose first language was not Greek, or who had prior knowledge of English, or spoke any foreign language, were excluded from the Study.

Each child was tested individually in two thirty-minute sessions separated by a maximum of five days. The researcher was introduced to the pupils by the headmaster of the school and the testing took place in a quiet room in the school. No testing took place when children were at play. One of the children missed the second testing session due to illness and two more refused to complete the nonword repetition task. Those children were excluded from the sample and the final number of participants was thirty seven children.

Materials

Phonological short-term memory

Children's phonological memory abilities were assessed by using three different measures: repetition of Greek nonwords, repetition of English nonwords, and recall of series of digits.

Greek nonwords

The revised Greek nonword repetition test described in Chapters 2 and 3 was again used to assess children's phonological memory abilities. The items included in the test are shown in the Appendix. The same method for testing nonword repetition accuracy was adopted as in Studies 1 and 2.

English nonwords

The English nonword stimuli were taken from the Children's Test of Nonword Repetition test (CNRep) as described in Study 1 and Study 2 (Gathercole, Willis, Baddeley &, Emslie, 1994). Two repetition accuracy scores were again obtained one at the time of testing and a second one based on the recorded responses of the children.

The consistency of the scoring between the two scores was very high, $r = .98$, $p < .001$. The scores attained at the time of testing were used for the purpose of analysis.

Digit span

The auditory digit span procedure employed in Study 1(Chapter 2) was used to assess each child's short-memory span.

Vocabulary

Vocabulary knowledge was estimated by assessing children's productive and receptive vocabulary. Receptive vocabulary knowledge was assessed using the short form of the British Picture Vocabulary Scale (Dunn & Dunn, 1982), translated and adapted to Greek, used also in Studies 1 and 2. described in Chapter 2 and 3. This test was administered in Greek. Productive Vocabulary (word definition vocabulary), was assessed by using the vocabulary subtest of the Wechsler's Intelligence Scale for Children-III-UK described in Study 2, Chapter 3 (Wechsler, 1981)

Non-verbal ability

Each child's non-verbal ability was assessed using the book from the Raven's Coloured Matrices (Raven, 1984).

Experimental word learning

Two experimental word learning conditions were given to each child: a native learning task consisting of picture-Greek nonword pairs and a foreign learning task consisting of picture-English nonword pairs. All children were tested on both of the tasks in a single session. The order in which the children received the tasks was rotated across

participants. The number of stimuli presented on each learning task and the number of trials per item was determined on the basis of pilot data. Our purpose was to ensure that each task would yield a sensitive measure of the child's abilities to learn the new information. In each learning condition four items were presented on each of ten learning trials. The pictures were chosen from the Expressive One Word Vocabulary Test-R (Morrison 1990), a test of expressive vocabulary. The pictures were common objects or animals. The nonwords used were chosen from the CNRep (Gathercole & Baddeley, 1996) and from a large corpus of nonwords for which wordlikeness ratings were obtained. The nonwords contained either 2,3,4, or 5 syllables. The syllable lengths were arranged in two conditions, each one containing eight stimuli : four native and four foreign nonwords. In the picture-foreign nonword task, four items were presented to each child for learning. The items were: *Ratafilt*, *Stopogratic*, *Caddelondia* and *Rubit* matched with the pictures of a *pair of scissors*, a *kite*, a *piano*, and a *swan*, respectively.

In the native learning task the same amount of items were presented. In the picture-foreign nonword task, four items were presented to each child for learning. The items were: *Ahtoniditos*, *Pravagos*, *Epnoassi* and *Kourma* matched with the pictures of a *cup*, a *motor-bike*, a *crab*, and a *tie*, respectively.

Design and procedure

For the learning session the child was seated at a table and the experimenter asked the child to imagine that in some other country people speak a different language and have different names to describe objects. It was explained that this language sounds exactly like Greek but in reality the words mean nothing. The child was asked if he or she would like to learn four of those "funny, Greek-like" words.

For the foreign learning session the child was asked if he or she would like to learn four words in English. If agreed, the experimenter showed four pictures of common objects and said that each of them could be described by a "funny Greek-like" word, that the child should try to remember. In the foreign learning session the experimenter said that each of these is pictures could be described by an "English" word that the child should try to remember. The first trial then began. The experimenter placed each picture from the set in front of the child and named it aloud. The child was asked to repeat the funny word (nonword). If the child's repetition was incorrect, the experimenter repeated the label and asked the child to repeat it again. This procedure was repeated until the child made a repetition attempt judged by the experimenter to be correct. After the name had been correctly repeated by the child, the picture was removed from view and the same procedure followed for each of the remaining pictures in the set. All children attempted each item for a total of ten learning trials.

After the pictures had been named and correctly repeated ten times each, the experimenter placed on the table one plate where all the four pictures of the set appeared in a random order. The experimenter pointed to the one of the pictures and asked: "What is this one called?" The child's response was recorded in writing by the experimenter. Children were asked for the names of all four objects in this way.

The two learning tasks were counterbalanced across participants with half of the children learning first the Greek stimuli and then the English stimuli. Apart from the learning conditions, the rest of the tests were administered in a constant order to all children

4.3. Results

Mean performance profiles

Table 4.1 summarises the children's performance on all principle measures. The mean raw score on the WISC vocabulary subtest corresponds to the scale score of 10 for the chronological age of the sample, indicating age-appropriate level of performance on this vocabulary task for the group as a whole. The mean raw score on the British Picture Vocabulary Scale corresponds to a standardised score of 85 which is unexpectedly low for this sample. For this reason, the scores of this test were not included in subsequent statistical analysis. The children's mean score on the English CNRep corresponds to a standardised score of 63 for a normal English sample. Unsurprisingly, the performance is below the age-appropriate level according to the English norms. For the purpose of analysis, raw scores were used for both the English and the Greek nonword repetition measures. The mean score on the Greek Nonword Repetition test was 25.19 (50.38% correct repetitions). Split-half reliability (Anastasi & Urbina, 1997) of the test was satisfactory ($r=.76, p<.01$). Subtest scores at the different syllable lengths on each nonword repetition test were calculated for each child, and are summarised in Table 4.2. On both the Greek and the English nonword repetition tests, repetition accuracy declined as a function of the number of syllables between syllable lengths three and six or three and five respectively. However, repetition performance was slightly better for the three-syllable than the two-syllable nonwords on both repetition tasks. This may be due to the higher wordlikness rating for the three-syllable nonwords (see Table 4.2).

The children performed considerably more accurately in repeating Greek than English nonwords, $t(35) = 17.08, p<.0001$. Their performance on the English item learning task was relatively low (35% correct recalls). Performance levels across the two learning tasks

varied considerably. As expected the children achieved higher levels of correct responses in the Native Learning Task (Picture-Greek nonword pairs) than on the Foreign Learning Task (Picture-English nonword pairs). They recalled correctly 60% of the new Greek and 40% of the new English to-be-learned items $t(35) = 4.06$, $p < .0001$.

Table 4.1. Descriptive statistics for the individual differences measures

Measure	Mean	SD	Standardised scores	Mean % correct
Phonological Memory				
Greek nonword repetition				
2-syllable nonwords	6.54	1.48	-	65.4
3-syllable nonwords	7.30	1.41	-	73.0
4-syllable nonwords	4.76	2.00	-	47.6
5-syllable nonwords	4.32	1.59		43.2
6-syllable nonwords	2.27	1.52	-	22.7
Total	25.19	5.01	-	50.38
English nonword repetition				
2-syllable nonwords	4.46	1.74	9	44.6
3-syllable nonwords	4.95	1.87	7	49.5
4-syllable nonwords	2.57	1.59	6	25.7
5-syllable nonwords	2.16	1.28	6	21.6
Total	14.05	4.74	28.4 (63)	35.12
Digit span	13.95	2.81	12.6[a]	-
Vocabulary knowledge				
Receptive Vocabulary (BPVS)	13.41	5.40	85 (16)	-
Definitions (WISC vocabulary subtest)	19.16	6.66	(10)	
Learning Tasks				
Greek items correctly recalled	2.43	1.19	-	60.75
English items correctly recalled	1.61	1.05	-	40.25
Total learning (sum of Greek & English)	4.03	1.92	-	50.37
Non-verbal ability	19.38	4.39	(75)	53.83
Chronological age (years)	7.4	0.87		

[a]Data from Gathercole and Adams (1994)

Following the procedure described in Study 1, Chapter 2, wordlikeness values were obtained for all nonword items in both the Greek and English tests. A group of 12 native Greek speakers with very little knowledge of English were asked to rate on a five-point scale the extent to which each item would pass for a real Greek word. As expected, wordlikeness ratings were considerably higher for Greek (mean rating = 2.78, SD = 0.71)

than for English nonwords (mean rating=1.80, SD=0.50). Using the wordlikness ratings the relationship between wordlikeness and the children's repetition accuracy was estimated. A significant correlation was found for the Greek nonwords ($r=.32$, $p<.05$) but not for the English nonwords ($r=.23$, $p>.05$). It is possible that this is due to the restricted wordlikness range of values for English nonwords.

Table 4.2: Mean wordlikeness values and standard deviations in parentheses as function of length in Greek and English nonwords

	Greek nonwords			English nonwords
Length	Mean wordlikeness	Mean number of phonemes	Mean number of consonant clusters	Mean wordlikeness
2 syllables	2.63 (0.76)	5.8	1.1	2.17 (0.67)
3 syllables	3.07 (0.81)	8.1	1.3	2.04 (0.44)
4 syllables	2.87 (0.53)	9.9	1.3	1.75 (0.27)
5 syllables	2.71 (0.66)	11.4	1.2	1.57 (0.63)
6 syllables	2.64 (0.80)	13.5	1.3	-
Mean	2.78 (0.71)	9.74	1.24	1.80(0.50)

Additional measures of phonological complexity were also obtained for each of the Greek nonwords; number of phonemes and number of consonant clusters (see Table 4.2) in order to investigate the relationship between wordlikeness and nonword length. Clusters were identified on an intrasyllabic basis; clusters across syllable boundaries were not excluded from counts.

Clusters of more than two consonants are allowed in the Greek language and when they appeared in Greek nonwords they were counted as two separate clusters. For example, the cluster *str* in the nonword *epidestragon* counts as two separate clusters *st* and *tr* as an indication of the extra articulatory complexity of those multiple clusters. The correlation matrix for each of these measures within the 50-Greek nonwords set is shown in Table 4.3. Rated wordlikness did not correlate significantly with any other measure apart from repetition accuracy, possibly due to the way the nonwords were constructed. The nonwords were generated from real Greek words contained in the dictionary rather that constructed from random syllables. This method allows all nonwords to have high wordlikeness values. Although longer nonwords are more likely to contain familiar grammatical forms when nonwords are constructed from random syllables, even short nonwords can be very highly wordlike when generated from real words. Thus, the wordlikness value of a nonword depends on the phonotactic frequency of the particular word from which it has been generated and not from the phonological complexity of the word.

Table 4.3. Correlations Between Wordlikeness, Phonological Complexity Measures and Repetition Accuracy for the Greek Nonword Set.

	1	2	3	4
1. Wordlikeness				
2. Number of phonemes	-.06			
3. Number of consonant clusters	-.09	**.30**		
4. Number of syllables	-.07	**.95**	.06	
5. Repetition accuracy	**.32**	**-.61**	**-.60**	**-.63**

Correlations printed in bold are significant at 5% level

The correlation matrix for all principal measures is shown in Table 4.4. The two nonword repetition measures correlated significantly with one another ($r=.57$) and digit span scores correlated highly with both Greek nonword repetition scores ($r=.39$) and English nonword repetition scores ($r=.50$) (see Table 4.4). All three phonological memory measures (Greek, English nonwords repetition and digit span) were closely linked with the vocabulary scores $r=.45$, $r=.55$ and $r=.65$ for digit span, Greek nonword repetition and English nonword repetition, respectively. Although the correlation between vocabulary scores was higher for English nonwords than Greek nonwords, the difference between the two correlations was not statistically significant $t(37)=1.4$, $p>.05$.

Table 4.4. Correlation matrix for all principal measures

Measure	1	2	3	4	5	6	7	8
1. Greek nonword repetition	-							
2. English nonwords	**.57**	-						
3. Digit Span	**.39**	**.50**	-					
4. Vocabulary knowledge	**.45**	**.55**	**.65**	-				
5. Native items correctly recalled	**.54**	**.56**	.26	**.40**	-			
6. Foreign items correctly recalled	**.34**	**.44**	**.40**	**.38**	**.45**	-		
7. Total items correctly recalled	**.53**	**.60**	**.39**	**.48**	**.87**	**.83**	-	
8. Non-verbal ability	.29	**.53**	**.36**	**.50**	.30	**.60**	**.51**	-
9. Age	.15	**.50**	**.30**	**.59**	.07	.24	.18	**.42**

Correlations printed in bold are significant at the 5% level

A series of partial correlation coefficients were computed in order to investigate further the relationship between phonological memory scores and vocabulary knowledge. In each case differences due to the general factors of age and non-verbal ability were controlled for. The relationship between phonological memory measures and vocabulary remained strong for the two nonword repetition tasks ($r = .40, p < .05$) for the Greek nonwords and ($r = .56, p < .001$) for the English nonwords. In contrast, the correlation was not significant for the digit span test ($r = .26$). This finding could possibly be explained by the "guessing" that children use to recover impaired or incomplete phonological representations when they repeat very familiar material i.e. digits. Although the digit span measure provides a useful indication of children's phonological memory capacity, it may require less accurate storage than unfamiliar spoken forms such as nonwords (Baddeley et al. 1998; Gathercole & Baddeley, 1993), (see table 4.5).

<u>Phonological memory measures and word learning in Greek and English</u>

In order to analyse the associations between general learning ability across both tasks (Greek and English) and the other measures, the mean number of total correct responses on the two learning tasks was computed for each child. All three phonological memory tasks (Greek nonwords, English nonwords and digit span) correlated very strongly with total learning with $r = .53$ $p < .001$, .60 $p < .001$ and .39 $p < .005$ respectively (see table 4.4)

Learning of native words correlated significantly with both repetition of English nonwords and repetition of Greek nonwords but not with digit span.

The English word learning task correlated significantly and with all measures of phonological memory.

In order to investigate further the specific relationships between phonological memory skills and learning in Greek and in English language, a partial correlational analysis was conducted with the general factors, age, non-verbal ability and vocabulary knowledge partialled out. Greek word learning scores were found to share a very close link with both Greek nonword repetition and English nonword repetitions scores ($r = .53$ $p < .001$ and $r = .56$ $p < .001$ respectively) but not with digit span scores (see Table 4.5). Surprisingly, the English word learning task did not correlate with any of the phonological short-term memory measures.

Vocabulary and learning in Greek and English

Vocabulary scores correlated significantly with learning in all cases (see Table 4.4), indicating a contribution of long-term knowledge to new learning of verbal items. More specifically, learning of new words in Greek ($r = 40$ $p < .05$) and learning of new words in English ($r = .38$ $p < .05$) correlated significantly with vocabulary scores and $r = .48$ $p < .005$ respectively. Thus, children with more superior vocabulary knowledge appear to learn more items in both languages. To examine this relationship directly, factors of chronological age and non-verbal ability were partialled out. (see Table 4.5). The correlation between native learning and vocabulary remained significant ($r = .41$ $p < .05$), but the correlation between foreign learning and vocabulary declined to a nonsignificant level ($r = .13$, $p > .05$). In a further partial correlational analysis the phonological memory measures, of repetition of Greek nonwords and English nonwords were partialled out together with the general factors of chronological age and non-verbal ability. The correlation coefficient yielded between vocabulary knowledge and learning did not reach a significant level ($r = .26$ $p > .05$ for Greek word learning and $r = .04$ $p > .05$ for English word learning). These results are in line with the finding that there is stronger link

between phonological memory abilities and new word learning rather than between vocabulary knowledge and new word learning (Gathercole et al 1995).

Table 4.5. Partial correlation coefficients between learning tasks, vocabulary knowledge and short-term memory measures

Measures				
		Vocabulary	Learning tasks	
			Greek items	English items
	Variables partialled out			
Greek nonword repetition	age	**.46**	**.54**	.31
	age, non-verbal ability	**.40**	**.53**	.21
	age, non-verbal ability, vocabulary		**.40**	.17
English nonword repetition	age	**.59**	**.60**	**.38**
	age, non-verbal ability	**.53**	**.56**	.20
	age, non-verbal ability, vocabulary		**.51**	.18
Digit Span	age	**.36**	.26	**.35**
	age, non-verbal ability	.26	.20	.26
	age, non-verbal ability, vocabulary		.08	.22
Vocabulary	age		**.47**	.30
	age, non-verbal ability		.41	.12
	age, non-verbal ability, Greek nonword repetition		.26	.04
	age, non-verbal ability, English nonword repetition		.33	.05

Correlations printed in bold are significant at the 5% level

4.4. Discussion

Study 3 investigated phonological short-term memory and current vocabulary contributions to new word learning in native and foreign language among young Greek speaking children. Strong links were found between vocabulary knowledge, phonological short term memory abilities as assessed by native means and leaning of new native items. These links appear to be stronger for phonological memory than for vocabulary knowledge. However, no links were found between phonological memory and learning of new foreign items.

From this data, it appears that the revised Greek nonword repetition test is a reliable and valid test of children's phonological memory abilities and can be safely used as an immediate verbal memory measure among young Greek speaking children. Like its English equivalent the CNRep (Gathercole et al, 1994), it is significantly associated both with digit span and with native vocabulary knowledge. Repetition of foreign nonwords may also make a useful measure of immediate memory. Assuming that verbal short-term memory links to vocabulary knowledge, the suggestion that CNRep can be used as a short-term measure with children other than English is consistent with the finding that repetition accuracy of English nonwords correlated strongly with Greek vocabulary knowledge. It has been argued that long-term knowledge mediation in phonological short-term memory is minimised in native nonwords (Hulme et al, 1991). Following the same line of reasoning, it could be argued that foreign nonwords offer even less possibilities for lexical and non-lexical mediation. Repetition of extremely unfamiliar material, such as foreign nonwords depends on short-term memory capacity as the support from long-term knowledge is not available. The children lacked any

phonological representations with similar structures to the to-be-repeated-nonwords. It is reasonable that the absence of any lexical information about this material constrains performance on this task.

Repetition accuracy for both native and foreign nonwords was found to be sensitive to nonword length, with accuracy levels declining as item length increased. This finding is in line with what would be expected for a phonological memory measure (Gathercole, Willis Emslie & Baddeley, 1991) and could be due to the increasing articulatory complexity of longer items. Also, repetition accuracy of Greek nonwords was linked to the lexical properties of the items. Greek nonwords that were judged to be more highly wordlike were more accurately repeated than less wordlike nonwords, in line with previous findings suggesting that repetition of nonwords is supported from stored sub-lexical knowledge about the distributional properties of the language (Gathercole et al, 1999). It is possible that nonwords that contain more common phonemes and more frequently used phonemes combinations are also highly wordlike. Thus, the support that those nonwords can get from long term memory is greater. The same pattern was not found with repetition accuracy of foreign nonwords. This is possibly due to the very low levels of wordlikeness rating for the English nonwords.

Further evidence that existing knowledge makes a substantial contribution to memory for nonwords is provided by two findings in Study3. Firstly, repetition accuracy was superior for native that for foreign nonwords. Secondly, repetition of native nonwords benefited from high values of wordlikeness. Both findings indicate that although none of the nonword stimuli had been previously encountered by children, they were nonetheless able to make use of their familiarity with the characteristic sound structures of their native language to enhance the temporary storage of their phonological forms.

This may be achieved via redintegration. By this account knowledge about phonotactic probabilities can be used to reconstruct incomplete traces in the phonological loop (Hulme et al. 1991; 1997). This strategy will be more successful for items with high frequency syllables such as native nonwords, by providing a probability-based reconstruction of impaired memory traces. In contrast, lack of knowledge of the phonotactic properties of a foreign language could make impossible reconstruction at a probabilistic level (Gathercole at al, 1999)

In Study 3 strong and highly specific links were shown between children's phonological short-term memory abilities and their vocabulary knowledge, replicating findings from English speaking children at the same age. It is worth noting that although a distinctive association was expected, the link between current vocabulary knowledge and immediate memory capacity is comparable in strength whether memory is assessed by foreign or by native means. Consider the difference between foreign and native nonword repetition tasks. For the foreign task the child would have to rely more heavily on the representation of the nonword in the phonological loop as a means of supporting its repetition, due to the absence of long-term knowledge support for these items. For native nonword repetition the burden on the phonological loop should be lesser, due to the usage of different kinds of long-term knowledge to support repetition. Thus, it was expected that children's vocabulary knowledge would be linked more closely with repetition of foreign than native nonwords, as the former may be more sensitive to phonological loop function. Foreign nonwords provide a more sensitive and pure phonological memory measure. Nevertheless, in Study 3 no difference was found between the links that vocabulary knowledge shares with repetition of Greek or English nonwords. The unexpected comparable sensitivity of the two task to vocabulary

leaning may be a function of the low levels of Greek nonwords wordlikeness. In fact, the revised version of the Greek nonword repetition task that was employed in Study 3 appeared to provide a very accurate measure of the children's phonological memory abilities. The high levels of phonological sensitivity on this task may have masked the difference between the two tasks and lead to comparable levels of sensitivity. The two list of nonwords (Greek and English) share a comparable levels of wordlikeness, with English nonwords showing slightly lower rating.

The main finding of Study 3 was the close association of both phonological short-term memory and vocabulary knowledge to new word learning in the native language. Firstly, considering the link between phonological memory and new word learning: the findings favour the view that new-word learning is linked to phonological memory skills, even when environmental exposure to new word learning is controlled across children (Gathercole & Baddeley, 1990a; Gathercole, Hitch, Service & Martin,1997; Michas & Henry,1994). Furthermore, even when variances attributable to differences in age, non-verbal ability and vocabulary knowledge were taken into account, the relationship between phonological memory and learning of native-like sounds of nonwords, remained strong. These findings provide support for the suggestion that phonological loop capacity, as assessed by nonword repetition, specifically facilitates the learning of new words. Secondly, considering the links between vocabulary knowledge and new word learning in the native language, Study 3 has shown a strong association between current vocabulary knowledge, new-word-learning and phonological memory efficiency. Children appear to draw not only on phonological loop representations but also on their long-term knowledge of words in their language to learn new words. This suggestion is also supported as discussed before, by the finding that children were more

accurate at learning and repeating nonwords in the native language in which their knowledge about sound distributions is extensive. The findings of Study 3 were clear: children with good vocabulary knowledge and phonological memory abilities learned more new native-like words. However, phonological memory capacity rather than vocabulary knowledge was found to relate more specifically to new word learning. It seems possible that although learning the sounds of new words appears to be mediated by both the phonological loop and by current vocabulary knowledge, the word learning process is supported directly and uniquely by phonological loop representations whilst the role of vocabulary knowledge is more subsidiary.

One interesting finding was the independence of measures of repetition accuracy and foreign word learning. As the children were instructed to learn unfamiliar material we expected them to depend on the phonological representation held STM to learn this material. No links were found with the phonological memory tasks and the learning of foreign words. An alternative explanation could be that for this learning task children used semantic associations to link the foreign to-be-learned items with the corresponding Greek words. For example in the present Study the pair *taflest*-ear could bring the Greek word *affte* (ear) to mind. In that case, they might depend on semantic or acoustic similarities to learn the new material and not on phonological loop representations. Evidence for this strategic approach to new foreign word learning was previously found when English subjects learning Russian words, relied on such associations between foreign and native-language words to recall those items (Baddeley, Papagno & Vallar 1988). As argued in Chapter 1 (paragraph 1.3.5) the learning of phonological forms of foreign words appears to be a demanding task and possibly children spontaneously use a

number of techniques to learn new foreign words (Paivio & Desrochers,1981; Crutcher & Ericsson, 1992; Ellis & Beaton, 1993b)

At present, this interpretation has not being directly tested. To do this, systematic evaluation of repetition and learning links for different items needs to be carried out. An alternative explanation for this finding is that children's low performance levels on this task combined with the very small number of items used here, were insufficient to yielded sufficient power for substantial analysis. A pilot study established the necessity of using a small number of stimulus pairs in the English learning task. This is not surprising as the task is difficult for young children who had no prior knowledge of English. Although only four items were used for this task, children's performance was still very low. Using a smaller number of items on the other hand, would not be substantial enough to reveal robust results. It is possible that the laboratory learning task engaged in Study 3 may not have taped the actual learning process that is involved in natural settings where foreign language learning is achieved successively. Indeed, foreign word learning appears to be facilitated by STM in real life environments (Service 1992; Service & Craik, 1993).

In summary, this Study investigated the relationship between phonological memory skills, current vocabulary and children's abilities to learn new words in native and in foreign language. Strong relationships were found between phonological short-term abilities and vocabulary knowledge. Children's abilities to retain new phonological material in STM and their vocabulary knowledge was linked with their performance on the new word learning tasks. However, these links were stronger for phonological memory abilities than for vocabulary knowledge.

CHAPTER 5

CONTRIBUTIONS OF VOCABULARY AND PHONOLOGICAL SHORT-TERM MEMORY TO SECOND LANGUAGE LEARNING

The studies reported in this thesis so far have investigated contributions of phonological short-term memory and long-term knowledge to children's vocabulary learning in native and foreign languages. Previous research has established close associations between children's abilities to store lexical material in immediate memory, their existing vocabulary knowledge and their performance on new word learning tasks. Research reported in this thesis has also found a link between children's phonological short term memory skills, native vocabulary knowledge, new word learning and second language learning among Greek speaking children. The theoretical explanation of these findings is that the phonological loop supports learning of new lexical forms and experience with a language supports phonological loop representations. However, the issue of whether vocabulary knowledge and phonological short-term memory support new word learning to an equivalent degree, remains open. We need to know what happens in intermediate situations, when an individual is learning a new language over a period of time. The question as to whether both phonological memory representations and long-term knowledge are still important, or whether phonological loop constraints dominate as in the case of learning completely unfamiliar words in an unfamiliar language, is investigated in Study 4.

It is possible that the strong interaction between the two memory systems masks the possible independent contributions to learning of new words. The final study of this

thesis was designed to disentangle the contributions of long term vocabulary knowledge and phonological loop capacity to new vocabulary learning in a group of second language learners. In Study 4 we directly compared contributions of phonological loop capacity and vocabulary knowledge to the learning of new words. In particular, the learning of new words in a foreign language by children who have already acquired significant vocabulary knowledge in this language was examined. This group of children is optimal to allow direct comparisons between possible contributions from memory systems that promote learning since they combine a certain level of vocabulary knowledge in the foreign language with relatively little knowledge of the distributional properties of the language's phonology. Children who are learning new words in a second language presumably have restricted but still some knowledge about the phonological structure of this language. Study 4 investigates how these children learn new words in a second language, and in particular whether they depend on their phonological short-term memory skills to learn new words, or instead on their acquired vocabulary to support new word learning.

5.1 STUDY 4

The notion that phonological short-term memory capacity plays a central role in the ability to learn a second language has been well established in recent research (Service, 1992; Ellis & Sinclair, 1996). In particular, vocabulary acquisition appears to benefit from good phonological memory skills to a greater extent than other aspects of second language learning (Service & Kohonen, 1995). Interestingly, vocabulary acquisition appears also to be a crucial factor in second language competence (Laufer, 1990). Thus, examination of the specific links between phonological memory and second language

vocabulary learning is of great importance. Possible contributions of phonological memory skills and English vocabulary knowledge to new English word learning were investigated in Study 4 in a group of children learning English as a foreign language.

Many of the studies investigating phonological memory contributions to foreign vocabulary learning based their conclusions on correlational data that established close associations between foreign vocabulary knowledge and phonological short-term memory capacity (Service,1992; Service & Kohonen,1995). One possible explanation for this constant link could be that foreign language learners who had better opportunities to acquire foreign vocabulary had experienced a more elaborated linguistic environment and thus, their abilities to store and retrieve phonological information in immediate memory were greater. This possibility has been ruled out in a number of studies that employed experimentally simulated word learning paradigms which allow control over to-be-learned material and ensure that the material is equally unfamiliar to all participants. Because there are several important determinants for the learning of foreign words including method of acquisition, and learnability of the material (Laufer, 1990), experimental control over to-be-learnt material is very important in order to differentiate among children. Findings from such experimental studies are in line with the view that the phonological loop supports word learning in a second language. Phonological short-term memory skills have been found to link to second language acquired vocabulary knowledge and also to predict new word learning in this language (Papagno, Valentine & Baddeley, 1991; Service & Craik, 1993 Cheung,1996; Papagno & Vallar, 1993). In study 4 a similar procedure was employed. A paired-associate learning paradigm developed by Baddeley and colleagues (Baddeley et al., 1988) and used in a

number of experimental studies was employed here to measure children's abilities to learn a new foreign word.

Studies of adults that had no prior knowledge (Papagno, Valentine and Baddeley, 1991; Ellis & Beaton, 1993a; Brown & Hulme, 1992) or a little knowledge of a foreign language (Service & Craik, 1993) have shown that their phonological memory abilities link to their abilities to learn new words in this language. Similar findings come from neuropsychological studies with patients who suffer from deficits in short-term memory and are unable to learn new words in a second language although their abilities to learn new verbal material in their native language are intact (Baddeley, Papagno & Vallar, 1988, Vallar & Papagno, 1993; Barisnikov et al, 1996). Studies of children learning a second language have shown similar findings. Cheung (1996) found that phonological memory measures can predict children's leaning of new words in a second language. The finding that the association between new word learning and phonological memory is independent of individual differences and material limitations, suggests a close and specific link between the capacity of the phonological loop and the learning of novel phonological forms in a second language.

In foreign as in native languages, representations of the phonological structures of words in the loop appear to determine the long-term learning of words' sound pattern (Baddeley, Gathercole & Papagno, 1998). The quality of representations in the phonological loop itself seems to benefit from acquired long-term knowledge of the structure of the language (Gathercole, Willis, Emslie & Baddeley, 1991). Evidence that long term-knowledge is often integrated in temporary phonological memory comes from several sources. Children's performance on phonological memory tasks appears to

be enhanced by knowledge of the phonological structure of their language (Gathercole,1995; Grant et al., 1997; van Bon & van der Pijl, 1997) and of the probabilities of phonotactic patterns in their language (Gathercole et al., 1999; Vitevitch, Luce, Charles-Luce & Kemmerer,1997). Adult's phonological immediate memory has also been found to be influenced by long-term lexical knowledge (Hulme, Maughan & Brown,1991; Poirier & Saint-Aubin, 1995). The hypothesised contribution from long term knowledge to immediate memory performance is minimised in a foreign language. Knowledge about the phonotactic rules of a foreign language is by definition limited and thus, acquisition of the sounds of words in a foreign language can benefit little from long-term knowledge contributions. Furthermore, the specialisation of the perceptual system for the native language can impede the learning of foreign words (Gathercole & Thorn, 1998; Thorn & Gathercole, 1999). The hypothesised contribution of accumulating knowledge about the probabilistic structure of a language to phonological loop representations, raises the issue of the possible limits such an interaction may have. To what extent would the relationship between phonological memory and new word learning hold when the learner has some but not perfect familiarity with the target language? Study 4 addresse this question.

Gathercole et al. (1992) found a significant shift in the relation between phonological memory and vocabulary acquisition before and after 5 years of age. Their results indicated that as phonological skills in the native language improved, the relationship between phonological memory and natural vocabulary development diminished and became nonsignificant. These findings suggest that phonological memory skills have a significant effect on young children's vocabulary development but once the children acquire adult phonological processes, other factors determine vocabulary acquisition

such as analogies with existing vocabulary items (Sternberng, 1987), individual differences in semantic and conceptual skills and the extent of reading activity (Nagy, Herman & Anderson, 1985). Does the same pattern of shift from dependence on phonological memory to dependence on long term knowledge observed in native vocabulary development, occur in foreign vocabulary acquisition too?

Cheung (1996) found that phonological memory measures predicted second-language vocabulary learning for a low foreign-vocabulary knowledge group but not for the high foreign-vocabulary group. This finding was interpreted as an indication of an increased involvement of long-term knowledge in word learning that might have overshadowed the contribution of phonological memory for the high vocabulary group. A similar pattern of increasing dependence on second language vocabulary as proficiency of language increases has been shown in other aspects of second language development, such as lexical processing (Chen & Leung, 1989; Chen, 1990). Also, adult participants involved in foreign language word learning tasks, when possible use their long-term memory knowledge to support the learning of new words rather than relying solely on short-term memory representations (Papagno et al., 1991; Service & Craik, 1993). These findings suggest an increasing involvement of long-term knowledge to new word learning in a second language as vocabulary develops. Study 4 was designed to address the issue of whether children that have a certain vocabulary knowledge in a second language depend on their immediate phonological memory skills or on their vocabulary knowledge to acquire new words in this language.

In Study 4 two groups of learners of English as a second language were selected who were matched for their English vocabulary knowledge but differed systematically in

their phonological short term memory skills. Two more groups of children were selected who were matched for their phonological short-term memory skills but differed in their existing English vocabulary knowledge. The children in each of these four groups completed an English word learning task. The hypothesis was that if children's phonological short-term memory skills determine learning of new English words, then the group of children with high phonological skills should learn the new words more rapidly and more efficiently than the low phonological skills group. If children follow the other hypothetical causal path such that it is long term knowledge that determines the learning of foreign words, faster learning and learning of more words should be expected in the high vocabulary knowledge group.

5.2 Method

Screening phase

Participants

Eighty one Greek children who were learning English as a foreign language at their schools participated in this screening phase. All children were pupils attending the fourth, fifth or sixth year of full-time education at a Greek public primary school or the first grade of a Greek public grammar school. Their mean age was eleven years (mean = 134.33 months), ranging from eight years and five months to thirteen years and five months (*SD* = 15 months). All children had attended English classes three times per week for at least one and half years as part of their school programme. Most of the children (67 of them) had had some extra English tuition on top of the classes attended at school in private educational institutions for foreign language learning.

Parents of all the children who were screened for Study 4 were interviewed and asked about (see Appendix) their child's exposure to English as a foreign language. The questions were designed to provide information about the period of time that the children had spent learning English and about how the children had become familiar with English. Children who had extra familiarity with English, such as children who were bilinguals either because one of their parents was English or because they had spent time in an English-speaking environment were excluded from the study. All the children screened had learn English in classroom settings.

Assessments

Phonological short-term memory

Children's phonological memory abilities were assessed by using two measures of verbal short-term memory. The revised Greek nonword repetition test described in Chapters 3 and 4 was employed here as a native means of short-term memory assessment. The Children's Test of Nonword Repetition (CNRep) as described in Study 1 and Study 2 (Gathercole, Willis, Emslie and Baddeley, 1994) was again employed here to assess children's phonological memory abilities in English.

English vocabulary knowledge

Two tests of the children's knowledge of English vocabulary were given, both involving translation between the spoken English and Greek forms of words.

A new two-way word-translation task was designed for the needs of the study and based on the initial vocabulary task described in Study 2 (Chapter 3). Two lists of Greek and English words were constructed each containing 80 words. All items were selected from children's English text books (Triandafellou, 1996) and arranged randomly in the test.

The items were presented auditorily and the children were asked to provide the English equivalent of the Greek word or the best Greek equivalent of the English word. The procedure described in Study 2 (Chapter 3) was employed to score the test. The total number of correct translation attempts on this test was scored for each child (maximum=160).

Non-verbal ability

Each child's non-verbal ability was assessed using the book from the Raven's Coloured Matrices (Raven, 1984) described in Study 1, Chapter 2 and Study 2,

Chapter 3.

Design and procedure

Children were tested in a single session lasting for about 45 minutes. The order of administration of the assessments was held constant across all the children and was as follows: repetition of Greek nonwords, repetition of English nonwords and English vocabulary.

Experimental phase

Participants

Forty of the children traced in the screening phase were chosen for testing on the basis of the English knowledge and phonological short-term memory profiles obtained in the screening phase. The children were allocated to four groups: 24 children were allocated to each of the two groups matched for phonological memory skills and differing in vocabulary knowledge and 22 children were allocated to each of the two groups matched for vocabulary knowledge and differing in phonological memory capacity. There was a

very small overlap between the four groups with four children being allocated to more than one group. The children in the four groups were matched either for their scores on the English vocabulary tests or on their performance on the nonword repetition tests.

Table 5.1: English vocabulary and phonological short-term memory information for the four groups in Study 4.

Measures				
Mean scores	Matched for STM groups		Matched for vocabulary groups	
	High vocabulary group	Low vocabulary group	High STM group	Low STM group
Vocabulary				
Greek to English	48.17 (16.22)	16.33 (9.97)	38.0 (14.83)	29.31 (16.34)
English to Greek	47.82 (13.36)	12.78 (5.02)	36.2 (18.67)	29.38 (17.65)
Total	96.00 (28.60)	29.11 (14.02)	75.2 (32.81)	59.68 (33.30)
Nonword repetition				
Greek nonwords	37.47 (4.19)	34.67 (5.83)	36.1 (4.84)	32.06 (4.68)
English nonwords	17.58 (3.35)	16.23 (3.34)	21.1 (3.21)	12.12 (3.07)
Tuition in months	53.00 (18.35)	25.45 (17.34)	48.2 (24.03)	37.68 (19.48)
Non-verbal ability	27.52 (4.37)	24.77 (4.92)	27.5 (4.25)	26.37 (5.30)
Age in months	139.5 (11.3)	131.11 (14.11)	140.1 (12.7)	134.6 (12.2)

The mean score profiles of the four groups of children who were selected to participate in the learning phase of Study 4 are shown in Table 5.1. Ten children were allocated to the low foreign-vocabulary group and 14 to the high foreign-vocabulary knowledge group. Allocation to the groups was based on the children's performance on the two-way English vocabulary test. The groups differed significantly in their foreign

vocabulary knowledge $F(10,14)=3.25$, $p<.05$. The groups also differed considerably in the length of time they that had been learning English as a foreign language, with children in the high vocabulary group having studying English for longer than children in the low vocabulary group $F(10,14)=.43$, $p<.05$. The two groups were matched for phonological short-term memory skills on the bases of the children's mean repetition accuracy scores on the two nonword repetition tasks. With $F(10,14)=.66$, $p>.05$ and $F=.76$, $p>.05$ for repetition on Greek and English nonwords respectively. The two groups were also matched for chronological age and non-verbal ability according to their performance on the Raven's Matrices task.

Ten children were allocated to the high phonological short-term memory group and 12 to the low phonological short-term memory group, selected on the basis of their mean scores on the English nonword repetition task. The difference was $F(10,12)=3.42$, $p<.05$. The two groups also considerably differed in their mean performance on the Greek nonword repetition task but this difference was not significant $F(10,12)=1.88$, $p>.05$. The two groups were matched for English vocabulary knowledge on the basis of the children's scores on the two-way translation task, $F(10,12)=.32$, $p>.05$. The children in these two groups had comparable chronological age and non-verbal ability scores $F(10,12)=0.74$, $p>.05$ and $F(10,12)=0.95$, $p>.05$ respectively. The mean time children in these two groups had spent learning English did not differ significantly $F(10,12)=1.362$, $p>.05$.

English new word-learning material

An experimental English-word learning task was developed for the purposes of Study 4. The task consisted of a paired-associate learning task with English picture-word pairs.

The paired associate learning procedure has been used widely in research as a word learning method (Papagno at al.,1991; Service & Craik, 1993; Gathercole et al., 1997) and was the basis for the learning task. In this type of task the items are presented in pairs of consisting a picture with a corresponding English name. This procedure of learning foreign words has been proved successful among children (Chen, Cheung & Lau, 1997) and corresponds to the teaching method used in Greek schools where children learn English through illustrated text books and pictorial associations. The purpose of Study 4 was to ensure that the learning task would yield a sensitive measure of each child's abilities to learn new verbal information in English. Each task consisted of eight item-pairs and ten learning trials per item.

The number of the English words presented on the learning task and the number of trials per item was determined on the basis of pilot data from a small group of 12 children. In the learning phase pairs of pictures and spoken English names were presented for a maximum of ten times. The test phase immediately followed the learning phase of each trial; the experimenter pointed at the picture of each pair and the child was required to recall the English name associated with it. The English picture-name pairs were presented in a different random order in each learning trial and similarly in each test phase the pictures were presented in a random sequence.

The items were chosen from the Long form of the British Picture Vocabulary Scale (Dunn and Dunn, 1982) and the words were common objects or animals. The words were carefully chosen so that it was not to be possible for the children to have come across the words before the learning task; the words did not appear in any of the children's English text books or story books and were selected from the end of the vocabulary scale such that English children younger that ten years of age are not

expected to know those words. The items were *easel, claw, bolt, fern, swamp, tusk, wedge* and *weasel* matched with the corresponding line drawings from the test.

Design and Procedure

The child was asked if he or she would like to learn some new words in English. For the learning session the child was seated at a table and the experimenter asked the child to look at eight pictures and listen carefully, and to try to learn the corresponding English name for each drawing, as he/she would be asked to remember the English words later. The first trial then began. The experimenter placed each picture from the set on the table and pronounced aloud the corresponding English word. The experimenter was a native Greek adult (E.M.) with a very good knowledge of English and was trained by an English native speaker on the pronunciation of each word. The child was asked to repeat the name in English and when the name had been repeated by the child, the picture was removed from view and the same procedure followed for each of the remaining pictures in the set. After the pictures had been named and correctly repeated by the child, the experimenter placed the pictures on the table, one after the other and asked "How would you say this in English?". The child's response was recorded in writing by the experimenter and on audio cassette. The order in which the experimenter named the pictures in English and the order in which the child was asked to recall the English word varied systematically across trials. After the child's response to the eight picture was recorded the next learning trial began with the experimenter pronouncing all the English words corresponding to the pictures again and the child repeating each English name. The child's recall of the English corresponding word for each picture was then retested. Learning trials were continued until the child reached the criterion of two consecutive trials in which all eight pictures were correctly named or for a total of ten

trials. Some of the children failed to reach the learning criterion by the end of the tenth trial.

Children were tested in a single session, the duration of which depended upon the speed with which the child learnt the new English words.

5.3 Results

Mean performance profiles from the screening phase

Table 5.2 summarises the children's performance on all the measures taken in the screening phase of Study 4. Standardised norms do not exist for this age group for the CNRep, the Greek nonword repetition test or the English vocabulary tests. Raw scores were used throughout the statistical analysis. The mean score on the English Children's nonword repetition test corresponded to 40% repetition accuracy and 50% repetition accuracy for the Greek Nonword Repetition test. Children's performance was considerably better on the Greek than on the English nonword repetition task. This difference between performance on the two repetition tasks was highly significant $t(81) = 13.91, p < .0001$.

Table 5.2: Descriptive statistics for the individual differences measures

Measure	Mean	SD	Minimum	Maximum
Phonological Memory				
Greek nonword repetition	34.55	6.19	11	46
English nonword repetition	16.08	5.33	3	29
English vocabulary knowledge				
Translation Greek-to-English	31.22	20.74	1	74
Translation English-to-Greek	29.77	20.33	1	72
Translation total	60.99	40.56	2	146
General measures				
Time studying English in months	39.87	23.69	9	85
Age at which started learning English	94.46 (7.8)	18.42 (1.5)	59 (5)	142 (11.8)
Chronological age in months (years)	134.33 (11)	14.92 (1.2)	104 (8.6)	162 (13.5)

Correlational analysis for screening phase data

The correlation matrix for all principal measures is shown in Table 5.3. The phonological memory measures (repetition of Greek nonwords and repetition of English nonwords) correlated with the English vocabulary knowledge whether this was assessed by translating words from English to Greek or from Greek to English (r=.41, r=.39, r=.48, and r=.48. respectively with $d.f.$=81 and p=<001 in all cases).

Vocabulary scores correlated more strongly with the repetition of English than Greek nonwords, although the difference between the two correlations is not statistically significant $t(81)=1.02$, $p>.05$.

Table 5.3. Correlation matrix for all principal measures

Measure	1	2	3	4	5	6
1. Greek nonword repetition	-					
2. English nonword repetition	**.63**	-				
3. Translation Greek to English	**.41**	**.48**	-			
4. Translation English to Greek	**.39**	**.48**	**.94**	-		
5. Translation total (vocabulary)	**.40**	**.49**	**.99**	**.98**	-	
6. Period of studying English	**.14**	**.29**	**.64**	**.72**	**.69**	-
7. Age	**.13**	**.15**	**.36**	**.37**	**.37**	**.37**

Correlations printed in bold are significant at the 1% level

A series of partial correlation coefficients were computed and differences due to the general factors of age and exposure to foreign language (as estimated by the length of the time the children had spent learning English as a foreign language) were controlled, in order to investigate further the relationship between phonological memory skills and

foreign vocabulary knowledge. The partial correlation coefficients are summarised in 5.4. The relationship between phonological memory measures and foreign vocabulary remained strong for the two nonword repetition tasks, $r=.42$, $p<.001$ for the Greek nonwords and $r=.51$, $p<.001$ for the English nonwords replicating previous findings that phonological short-term memory performance correlates with foreign vocabulary learning (see Table 5.3).

Table 5.4.Partial correlation coefficients between English vocabulary knowledge and short-term memory measures

Measures		English Vocabulary		
	Variables partialled out	Translation to English	Translation to Greek	Translation total
Greek nonword repetition	age	**.39**	**.37**	**.39**
	age, and period of studying	**.41**	**.41**	**.42**
English nonword repetition	age	**.46**	**.47**	**.47**
	age, and period of studying	**.39**	**.40**	**.41**

Correlations printed in bold are significant at the 1% level

Learning phase

For the English word learning task, the mean number of correct responses made on each single trial was calculated. The average number of trials taken by each group to learn the new word was also calculated. This information is summarised for all groups in table 5.5. Performance levels across the four groups of children varied considerably. The children allocated to the high vocabulary knowledge group achieved higher levels of correct responses on the learning task (94.7% correct) than children in the other three groups. Children in the high and low phonological short-term memory groups achieved comparable levels of correct responses (82.5% and 85.5% correct respectively) and

children in the low English vocabulary knowledge group achieved the lowest levels of correct responses (53.7% correct). The low English vocabulary group took on average a greater number of trials than the high English vocabulary group to learn the new English words (8.08 and 4.93, respectively). No notable differences was found in the average number of learning trials needed by the groups differing in their phonological short-term memory abilities (5.71 for the high group and 5.86 for the low group). These results show that the high vocabulary group learnt the new words more rapidly than the low vocabulary group. The high and the low phonological short-term memory groups did not differ in their speed of the learning.

Table 5.5: Performance on the word learning task as a function of learning trials and correct responses for all groups

Learning performance				
Trials[a]	Matched for STM groups		Matched for vocabulary groups	
	High in vocabulary group	Low in vocabulary group	High in STM group	Low in STM group
Trial 1	1.71 (1.21)	0.44 (0.35)	1.80 (0.92)	1.31 (1.45)
Trial 2	3.82 (1.67)	1.78 (1.39)	3.20 (1.23)	3.06 (2.24)
Trial 3	4.65 (1.58)	2.22 (2.11)	4.00 (2.40)	3.94 (1.91)
Trial 4	5.47 (1.74)	2.67 (2.00)	5.00 (2.36)	4.88 (1.93)
Trial 5	6.18 (1.55)	3.11 (1.76)	5.50 (2.64)	5.06 (2.11)
Trial 6	6.59 (1.37)	3.67 (1.80)	5.60 (2.46)	6.19 (1.87)
Trial 7	6.82 (1.19)	3.78 (1.92)	5.60 (2.59)	6.56 (1.93)
Trial 8	7.00 (1.22)	4.89 (1.90)	6.30 (2.06)	6.69 (2.02)
Trial 9	7.29 (0.92)	4.78 (2.05)	6.20 (2.39)	6.81 (1.68)
Trial 10	7.29 (0.69)	4.89 (2.26)	6.00 (2.45)	6.69 (1.58)
Total correct responses[b]	56.82 (10.19)	32.22 (15.21)	49.20 (20.47)	51.19 (15.66)
Total trials[c]	4.93 (1.34)	8.08 (2.08)	5.71 (2.02)	5.86 (2.76)

[a]Mean number of items correctly recalled on each trial.
[b] Total correct responses on all of the ten trials.
[c]Average number of trials taken to learn the new foreign word.

Separate analyses of variance were performed on the mean number of items correctly recalled on each trial for the two group categorisations (high and low vocabulary, high and low phonological mmeor) as a function of group memebership. Significant main effects were found for English vocabulary groups {$F(1, 23) = 22.18, p < 0.001$} but not for the phonological memory groups {$F(1, 21) = .026, p > 0.5$}. The pattern is clear: learning

performance was enhanced by vocabulary knowledge but not by phonological short-term memory ability.

The results reported so far provide strong support for the hypothesis that English vocabulary knowledge is the crucial factor that determines children's further learning of English words: the children of low English vocabulary knowledge took longer to learn to associate English words to corresponding pictures and learned fewer words than children with good vocabulary skills in English.

However, although the four groups were closely matched on factors that can affect learning such as non-verbal intelligence and chronological age, children in the high and low vocabulary groups differed in the number of years they had spent learning English as a foreign language. This is not surprising, as foreign language vocabulary whould be expected to increase as a function of the length of time spent learning the foreign language. This, however, raises the possibility that differences in word learning performance arise from the overall familiarity the children had with the English language and not from their vocabulary knowledge *per se*. There was also a small overlap among the groups with a few children allocated to more that one group. To rule out possible confounding effects of overlapping or of differences in familiarity with the the language, a correlational analysis was conducted in which all children were considered as one single group. Descriptive statistics for this group of children are summarised in Table 5.6.

Table 5.6. Mean performance on all tasks of experimental phase

Measure	Mean	SD	Minimum	Maximum
Phonological Memory				
Greek nonword repetition	35.77	4.70	23	44
English nonword repetition	16.39	4.52	3	28
English vocabulary knowledge				
Translation Greek-to-English	36.06	19.27	8	69
Translation English-to-Greek	35.97	18.80	3	65
Translation total	72.03	37.31	11	134
Learning of new English words				
Correct recalls of new words	50.89	14.65	12	72
Trials to learn new words	6.78	1.42	2	8
General measures				
Time studying English in months	44.13	22.58	3	76
Chronological age in months (years)	138.62 (11.5)	10.94 (0.9)	113 (9.4)	153 (12.7)

Correlation coefficients between the principle measures and mean correct responses on all of the ten trials are shown in Table 5.7.

This analysis revealed the same pattern: existing vocabulary knowledge and not STM abilities associate with children's performance on new wod learning task.

Table 5.7. Correlation coefficients for all principal measures

Measure	1	2	3	4	5	6	7
1. Correct recalls of new words[a]							
2. Trials to learn new words[b]	-.99						
3. Greek nonword repetition	.12	-.13					
4. English nonword repetition	.19	-.20	**.57**				
5. Translation (vocabulary)	**.58**	**-.57**	**.38**	**.48**			
6. Period of studying English	**.44**	**-.44**	.17	**.34**	**.78**		
7. Non-verbal ability	**.35**	**-.32**	.04	.13	**.36**	.21	
8. Age	**.42**	**-.41**	.03	**.27**	**.45**	**.39**	**.37**

Correlations printed in bold are significant at the 1% level

[a]Mean correct responses on all of the ten trials

[b]Mean number of trials taken to meet the learning criterion

5.3.1 Number of errors analysis

In Study 4, children' performance on the English word-learning task was used as an individual difference measure to assess their ability to learn new English words. The children's task was to learn to match the new English word to the corresponding picture and to reproduce the new phonological form of the English word as accurately as possible. The learning trails started only when each picture had been correctly pronounced by the child. Any error in repetition made by the child was corrected by the experimenter. Errors that corrected with multiple repetitions occurred in all groups and trials. On the final learning trial, the children's responses were scored either as correct or incorrect on the bases of whether they were accurately recalled and matched to the correct picture.

In Study 4 according to this initial scoring of the learning task, a response was considered correct only if the child accurately reported the English word and matched it to the appropriate picture. According to the initial scoring, responses in which the reproduction of the word differed by one or more phonemes from the target word were counted as incorrect. However, previous linguistic and psycholinguistic work suggests that memory for linguistic stimuli is not all-or-none (Treiman & Danis, 1988; Gathercole et al, 1999). This gives rise to the possibility that the differentiation used here among children may not be sensitive towards the exact errors that occur in learning. There is a possibility that this scoring does not reveal a child's full potential and a more sensitive measure of scoring might reveal a different pattern of findings. For example, children who are less familiar with the foreign language may make pronunciations errors simply because their pronunciation is still largely specific to the native language, a phenomenon known as the first language phonological configuration effect (Feldman & Healy, 1998). Also, children's errors in learning words in a second language may be due to other influences such as information overload or overgeneralisation (Feldamn & Healy, 1998) and may not directly reflect the children's abilities to learn new words. Clearly, children's learning of verbal items cannot be fully understood without careful consideration of the errors in their responses (Treiman, 1995; Ellis, 1980).

This issue was addressed directly in a more detailed assessment of the children's protocols on the learning task. In a detailed analysis, we examined the number of errors that occurred in the children's responses. This allowed us to yield a more detailed account of participant's performance on the English word learning task. Children's spoken responses were tape recorded during the experimental session and were also noted by the experimenter. Error analysis was based on the tape recorded transcriptions

of the last learning trial. For those children who completed all ten learning trials, error analysis was made on the tenth learning trial responses. For those children who met the learning criterion without going through all ten trials, error analysis was based on the last learning trial that they completed. Although fewer errors were expected to occur on the last learning trial rather than in any other trial, it was thought that errors occurring at this stage of the learning task would be more persistent. Responses that consisted of an inaccurate reproduction of the target word matched to the correct picture were analysed here.

The stimuli to-be-learnt were eight English words that were subdivided into syllables. Of the eight English words, two items contained two syllables and six contained one syllable. The syllables contained in the words were broken down into smaller units of phonemes as offsets and rimes. For example, in the one syllable word *bolt* the onset is the initial consonant *b*. The rime is the vowel *o* and the following cluster of consonants *lt* . Words with two syllables such as *weasel* was broken down into two onsets (*w* and *s*) and two rimes (*ea* and *el*). Counting of errors at the intrasyllabic level was based on previous findings suggesting that syllables are not simply linear strings of phonemes, but that they have hierarchical internal structure (Ellis, 1980; Treiman & Dannis, 1988). Children's memory for unfamiliar syllables appears to be organised in terms of onset-rime coding, at least for English syllables (Treiman, 1992). Misplacements, substitutions, additions and omissions of phonemes in children's responses were counted as errors. The onset or the rime in which the error appeared was counted as incorrect and the rest of the syllables was counted as correct if no further errors occurred. The total number of correct onsets and rimes was calculated for each child. Also the total number of accurately remembered phonemes was calculated for each child and this information is

summarised in Table 5.8. Correlation Coefficients between mean number of units correctly learnt on the word learning task and all the principal measures were computed. The correlation coefficients for this analysis were $r=.82$, $p<.01$; $r=-.82$, $p<.01$; $r=.11$, $p>.05$; $r=.07$, $p>.05$; $r=.45$, $p<.05$; $r=.28$, $p>.05$; $r=.17$, $p>.05$ and $r=.29$, $p>.05$ for the mean correct recalls of new words, trials taken to learn the new words, Greek nonwords repetition, English nonwords repetition, Translation, length of period studying English s a second language, non-verbal ability and chronological age, respectively.

The results show a close correspondence to the findings that emerged from the analysis of the learning scores obtained from the initial scoring and of the learning score based on the total number of units correctly remembered. Correlation coefficients between the revised learning scores and the vocabulary measures were high ($r=.45$, $p<0.5$). In contrast, correlations between the learning scores and each of the two phonological short-term memory tasks were very low ($r=.07$ and $r=.11$, $p>.05$ in all cases). This pattern of associations is consistent with analysis reported above.

Table 5.8. Mean number of onsets and rimes correctly leant from all four groups of children

	Matched for STM groups		Matched for vocabulary groups		
Mean number of correct units	High vocabulary group	Low vocabulary group	High STM group	Low STM group	All groups
Correct onsets	7.68 (0.47)	6.00 (1.58)	6.9 (1.5)	7.31(1.07)	6.98 (1.21)
Correct rimes	6.50 (1.03)	4.4 (1.87)	5.5 (2.27)	6.00 (1.41)	5.60 (1.65)
Total onsets and rimes	14.18 (1.27)	10.44 (3.2)	12.40 (3.60)	13.31 (2.4)	12.58 (1.43)
Correct phonemes	28.18 (2.56)	10.44 (3.2)	24.9 (7.07)	26.25 (5.10)	26.05 (5.24)

5.3.2 Item analysis

Study 4 addressed the hypothesis that children's phonological short-term memory skills and their English vocabulary knowledge contribute to the learning of new English words. This hypothesis was tested by associating phonological memory abilities and English vocabulary knowledge with learning test scores on a new English word learning task. By this approach, the to-be-learnt English items were necessarily equally unfamiliar to all children. Thus, the stimuli in the learning task consisted of eight English words selected on the bases that they were unfamiliar to children with English vocabulary knowledge of the level of the participants in Study 4. However, this selection of the items raises the possibility that items might differ in learnability (Rogers, 1969; Ellis, 1994; Paivio et al, 1968). Findings from psycholinguistic studies suggest that some non-native words are learnt with more difficulty than others and several factors can affect the learnability of foreign words (Laufer, 1990). Thus, there is a possibility that the words used for the learning task may reflect different levels of learnability (Laufer, 1990) or might have been an unrepresentative sample of English words. The possible variability in the items could affect the overall pattern of selective associations between the children's learning performance and their vocabulary knowledge and phonological short-term memory skills. It is possible that the correlations among the principle measures reflect an undue influence by an unrepresentative subset of the stimuli. This possibility was investigated by computing correlation coefficients between the total learning score for each individual stimulus word and each of the nonword repetition and vocabulary measures (see Table 5.9).

Table 5.9.Correlation Coefficients for individual items in the learning task

	STM memory tasks		Vocabulary tasks		
Stimulus word	Greek nonword repetition	English nonword repetition	Translation to Greek	Translation to English	Translation total
wedge	.10	.18	**.50**	**.48**	**.50**
swamp	.04	.03	**.58**	**.55**	**.58**
bolt	.07	.12	**.39**	**.33**	**.37**
weasel	.19	.11	.23	.09	.16
fern	.02	.08	**.48**	**.31**	**.40**
easel	.01	.11	**.47**	**.34**	**.41**
tusk	.04	.19	**.53**	**.54**	**.55**
claw	**.38**	.25	**.34**	.28	**.32**

Correlations coefficients printed in bold are significant at level 5%.

The item analysis revealed the same pattern that the overall data showed. The correlations between scores on specific items in the English learning task and the other measures showed no significant association between learning scores on this learning task and the two phonological memory measures. A significant link was established with English vocabulary knowledge. Only one of the items correlated significantly with one of the phonological memory measures, whereas seven of the eight English words correlated significantly with English vocabulary knowledge.

This analysis of the associations between performance on the individual stimuli and performance on the phonological memory and English vocabulary knowledge task indicate that the pattern of findings revealed from the principal analysis is not simply a function of influences from a small set of unrepresentative stimuli. The link between children's English vocabulary knowledge and their abilities to learn English words

appears to be consistent across stimuli. Also, the relationship between learning of individual English words and the two phonological memory tasks was extremely consistent across items. The outcome from the item analysis does not support the view that the principal findings reflect the influences of specific experimental stimuli on the learning task.

5.4 Discussion

Study 4 found a close relationship between children's phonological short-term memory skills and their knowledge of vocabulary in a foreign language. This relationship was found to be independent of more general factors such as chronological age and non-verbal ability. This finding confirms the same pattern that other similar studies were shown (Service, 1992; Service & Kohonen, 1995). However, phonological short-term memory skills were not related to speed and ease of learning new foreign words. In particular, children's phonological short-term memory skills (as assessed by nonword repetition accuracy) associated highly with acquired vocabulary knowledge in English but not with their speed and ease of learning new English words. Their vocabulary knowledge itself, linked to their abilities to learn new words in English.

Children with better English vocabulary knowledge in Study 4 showed superior performance to children with lower English vocabulary in a foreign word learning task. Children with high vocabularies also learned new English words faster and made less mistakes than children with lower vocabulary knowledge. No links were found between children's abilities to learn new foreign words and their phonological memory skills. The principal analysis of Study 4 shows that for this group of learners, vocabulary knowledge in English rather than phonological short-term memory skills promotes

learning in English. These results can not be attributed to factors other than differences among individuals in English vocabulary knowledge. Children's chronological age, non-verbal ability and period of tuition was comparable in the high and low English vocabulary knowledge groups.

At first glance, this aspect of the results of Study 4 appears to be in conflict with previous findings establishing contributions of phonological loop capacity to the learning of the sound patterns of new words that is independent from vocabulary knowledge (Gathercole, Hitch, Service & Martin, 1997). Study 4 though, investigated long-term memory vocabulary knowledge and short-term memory capacity in a group of young learners of English as a second language. The Greek children who participated in Study 4 were already quite familiar with English as a result of their tuition period of three and a half years combined with more general environmental exposure to spoken English (several TV and radio programmes, movies in Greece are in English). Thus, although they are still in the process of learning English as a foreign language , they had a substantial English vocabulary knowledge. Assuming that vocabulary size indicates long-term experience with the language, Study 4 findings suggest that once lexical phonological knowledge has been established but is not yet perfect, support from long-term knowledge may be more effective. Contributions of the two memory systems may differ in importance and in certain conditions long-term knowledge can mask the importance of short-term phonological storage capacity.

This suggestion is consistent with the notion that lexical knowledge supports performance on short-term memory tasks (Gathercole, 1995; Gathercole, Willis, Emslie & Baddeley, 1991 Grant et al,1997). On those grounds , lexical knowledge supports

phonological aspects of learning. Learning the sounds of new words can be facilitated by acquired representations of words with similar sound patterns. Children who know many words are more likely to rely on long-term representations to find a close match than are children with poor vocabulary knowledge (Gathercole & Baddeley, 1990a; Gathercole, Hitch, Service & Martin, 1997). Consistent with this view is evidence that adults that are able to speak many languages are better at learning new words in a new language. Papagno and Vallar (1995) found that students that were able to speak more than three languages (polyglots) fluently showed superior performance on learning new words in a new language than matched nonpolyglots. One possible interpretation of this finding is that the already acquired vocabulary *in toto* (in all their languages) may have helped them to learn more new foreign words.

The implication that contributions of long-term lexical knowledge increases by age and by accumulating familiarity with the language, has been suggested by several studies (Gathercole et al,1992; Cheung, 1996; Papagno, Valentine & Baddeley, 1991). This hypothetical increased involvement of long-term knowledge in word learning might have overshadowed the contributions of phonological memory to the learning of new English words in Study 4. The same pattern seems to occur in both native and foreign languages. Investigating native vocabulary acquisition, Gathercole et al. (1992) found that phonological memory measures at age 4 can predict vocabulary size at age 5, but vocabulary size can predict performance on phonological memory tasks beyond age 5. Children's long term knowledge (as reflected by their vocabulary knowledge) did not emerge as an important factor for learning native-like lexical material until a certain age. Similarly, Cheung (1996) found that phonological memory skills linked with new foreign word learning abilities only in children with low vocabulary knowledge in the

foreign language. For children with high vocabulary knowledge in a foreign language (English) phonological short-term memory skills were not linked to new word learning. As proficiency in a foreign language increases, a shift from dependency on phonological memory to dependency on long-term knowledge for further vocabulary acquisitions seems to occur (see also Service & Craik, 1993; Papagno, Valentine & Baddeley, 1991). Those findings are consistent with results from Study 4 that suggest a close link between vocabulary size and the ease of learning new English words in a group of children with extensive familiarity with spoken English.

The theoretical dependence on phonological short-term memory skills to support vocabulary acquisition appears more important at early stages of second language learning. As children accumulate knowledge about the second language they depend less on immediate memory representations to aid learning of new words. As children became older and more proficient speakers of languages, support from long term memory is more effective for new word learning. The exact level of proficiency that elicits this shift of dependence still needs to be identified. Also, the exact mechanism that underpins the contributions of long-term knowledge still remains uncertain. One possible mechanism that has been suggested to integrate long term lexical knowledge in new foreign word learning is association to semantic units similar to the new material. When a new foreign word is presented presumably an automatic search for a memory address for the new concept-form unit in a network is initiated. Assuming that the network or the structure is semantically organised, a successful search relates the unit to existing lexical units with semantic associations (Papagno Valentine & Baddeley, 1991; Service & Craik, 1993). Children with advanced vocabularies in a second language are

better able to find a suitable slot in the network to accommodate the new form than beginner learners.

Regardless of which the exact mechanism that delivers long-term lexical knowledge to new word learning in a foreign language is, there is evidence that such a mechanism does not emerge as the crucial influence on word learning until a later age (Gathercole et al., 1992). This increased long-term knowledge involvement in new foreign word learning can possibly account for the observed differences between children and adults in ease of learning foreign languages. Several studies have shown that children are better second language learners than adults and that they reach higher levels of final second language proficiency (Long, 1990; Johnson & Newport, 1989). This children's advantage over adults may be attributed to greater dependence on phonological memory skills to acquire new lexical material in a second language. As children develop their language skills, they shift from dependence on phonological memory to dependence on long-term language experience to internalise new material. Young children rely heavily on phonological loop representations to create a permanent record of new words in their long-term memory. Older children and adults use long-term knowledge to associate the new form to a matched existing phonological form. This difference in the means used to support new foreign word learning may give an advantage to children over adults.

An alternative explanation for findings from Study 4 relates to the teaching method used in Greek schools. Greek children typically learn English vocabulary by associating new English words with equivalent native ones at the earlier stages of education. At later stages as the second language gradually develops the children learn to associate new words with words acquired already in the second language (Traidafeledes, 1990).

Repetition of the new phonological forms is not particularly used as a word learning strategy. Children are less encouraged to repeat the unfamiliar foreign form than to listen to it. Possibly this group of children were not experienced in repeating new phonological forms in order to acquire vocabulary. A teaching method that would encourage repetitions would be more beneficial for children (Ellis & Beaton,1993b) and more optimal to detect phonological memory contributions to new foreign vocabulary learning.

To summarise, highly significant links were found between children's phonological memory skills and their knowledge of vocabulary in a foreign language in Study 4. However, phonological short-term memory skills were not related to speed and ease of learning new foreign words. Findings from Study 4 suggests that contribution of immediate memory to foreign language learning is more effective when children are in the earlier stages of second language learning, where support from long-term lexical knowledge is not readily available. At later stages of learning though, when opportunity for support from long-term knowledge is more extensive, children may chose to depend on their existing vocabulary knowledge to support the learning of new items.

CHAPTER 6

GENERAL DISCUSSION

Outline

There is now compelling evidence that a particular component of the working memory model (Baddeley & Hitch, 1974; Baddeley, 1986), the phonological loop, plays an important role in children's acquisition of language. Especially, learning of phonological forms of new words has been found to link significantly to phonological memory capacity (Gathercole et al., 1997;). As yet, however, several aspects of this association between phonological memory and vocabulary knowledge need to be investigated.

Although the evidence for such an association comes for several populations (Baddeley et al., 1998), the exact limits and the generalizability of this relationship has not being explored yet. The distinctive importance of phonological memory for word learning under different degrees of familiarity with a language is vague.

The series of studies presented in this thesis were designed to investigate the links between phonological memory and new word learning in varying stages of language learning, familiarity and knowledge. Most of the research mapping the links between phonological short-term memory and vocabulary acquisition, has been based on English-speaking populations; the research reported in this thesis explored whether the same phenomena arise in Greek children learning English as a second language. A further important issue tested in this research concerned the specific contribution of phonological memory to vocabulary learning at different levels of foreign language

proficiency. A final issue concerned the contributions of existing vocabulary knowledge to novel words learning and to phonological memory tasks.

6.1 THE PRINCIPAL FINDINGS

Study 1 was designed to investigate phonological short-term memory involvement in the acquisition of native vocabulary among young children. The phonological memory skills and vocabulary knowledge of a group of five-year-old Greek children were assessed. Strong links were found between children's ability to hold unfamiliar phonological information in short-term memory, as assessed by repetition accuracy of native and foreign nonwords, and vocabulary knowledge. Unsurprisingly, children's nonword repetition accuracy was greater for native nonwords than for foreign. Interestingly, children's abilities to repeat English nonwords are linked closely to their vocabulary knowledge in their native language, Greek. These features of Greek children's performance on the English nonword repetition task suggest that Children's Nonword Repetition Test (Gathercole & Baddeley, 1996) may provide a good test of phonological memory for Greek as well as English children.

Furthermore, foreign nonword repetition scores correlated with performance both on the conventional short-term memory task digit span and on repetition accuracy of native nonwords. Children's performance on the task decreases as length of the nonwords increases in number of syllables. More detailed analysis of the association between children's phonological memory abilities and vocabulary knowledge revealed that this link is independent of chronological age and non-verbal abilities. Irrespective of the exact nature of the mechanisms which underpin this facilitation, the relationship between phonological memory and vocabulary, appears to be equivalent for Greek

speaking children as it does for their English peers. Findings from Study 1 are in line with previous research and expand established links between vocabulary knowledge and phonological memory abilities to another population.

Study 2 investigated whether the established contributions of phonological memory to new word learning extend also to foreign vocabulary knowledge among Greek children who learn English as a foreign language. The main aim of Study 2 was to investigate the association between children's phonological memory abilities and their knowledge of both foreign and native vocabulary. The children participating in the study were Greek ten-year-olds learning English as a foreign language over three years. Although they had some English vocabulary knowledge and had experience in spoken English, they were not proficient English speakers and were still in the process of learning English as a foreign language. Their English vocabulary knowledge was assessed in a task involving word translation both ways (i.e. from native to foreign and from foreign to native). Strong associations were found between all three test of phonological memory and vocabulary knowledge in Greek and English, which were independent of children's chronological age, non-verbal abilities and period of experience with English as second language. Foreign vocabulary was found to be more closely related to phonological memory capacity than native vocabulary. Study 2 showed that children repeat Greek more accurately than English, consistent with findings from Study 1. Note that the pattern remained the same for both participants of Study 2 who were English learners with some degree of exposure to English language and some English vocabulary knowledge, and children in Study 1 who had no knowledge of English. Even children who had experience with English showed difference in their abilities to repeat Greek over English nonwords. A similar pattern was found for repetition of native nonwords.

Greek nonwords that were high on wordlikness were more accurately repeated than nonwords low in wordlikeness. It seems that the phonotactic frequency of nonwords influence short-term memory capacity.

So far, it appears that children with good short-term memory skills have superior vocabulary knowledge in both native and foreign languages. The interpretation of this finding is that children who are less able to create an accurate representation of a potential new vocabulary item could be similarly less able to create a durable representation of this item in long-term memory. However, there is an alternative explanation for this findings. Children who listen to more elaborate speech, can develop both their vocabulary knowledge and their phonological memory abilities concurrently.

Study 3 was designed to test this possibility and investigate the relationship between children's short-term memory abilities and vocabulary acquisition under circumstances where all children exposed equally to the new items and had the same opportunities to learn the new words. Study 3 aimed mainly to rule out differential environmental experiences as basis of the link between phonological memory and vocabulary knowledge. Children attempted to learn the names of some pictures over a certain number of trials. One set of pictures was given native-sound names (Greek nonwords) and the other picture set was assigned phonologically extremely unfamiliar names (English nonwords). The items were equally unfamiliar to all children, thus differences in ease at which children learnt novel items did not suggest simply that some children had heard a new word more often than others. The results showed strong associations between vocabulary knowledge, short-term memory abilities and ease of learning novel items. The new word learning task though, associated more closely to phonological

memory measures than to the existing vocabulary knowledge. Children who found to have both good phonological memory skills and good vocabulary knowledge learned more novel native items, but children with just good phonological memory skills learned more new native names independently of their current vocabulary knowledge. Surprisingly though, children's abilities to learn new foreign items dwas not related strongly either to their vocabulary knowledge or memory skills.

The items which were used for the nonword repetition tasks were assessed for wordlikness by Greek and English adults. Throughout the studies the children were able to repeat high in wordlikeness nonwords more accurately than they were able to repeat low in wordlikeness nonwords. In Study 3 some properties of the Greek nonwords were investigated and it was found that phonological complexity of nonwords does not influences adults' judgements of wordlikeness. The articulation complexity of a nonword did not appear to affect wordlikness.

As argued earlier, Study 3 ruled out the hypothesis that children with better phonological memory abilities acquire more vocabulary simply because they have been exposed to richer linguistic environments and had more opportunities to develop both their vocabulary knowledge and verbal memory skills. Taken as a whole, findings suggest that phonological memory appears to contribute directly to long-term learning of new words even when exposure to new items is strictly controlled across all children. Findings from all 3 studies have shown that phonological short-term memory is associated with vocabulary knowledge in native and foreign languages. Also, it plays an important role when young children encounter novel lexical material such as potential new words.

Study 4 was designed to determine whether immediate memory or existing vocabulary knowledge is the crucial factor that promotes children's learning of foreign words. Children from a large group of English-as-a-second language learners who had been assessed for phonological memory skills and vocabulary knowledge in English, were selected to participate in a new word learning task. These children had been learning English as a second language over a period of three years during which they had acquired an extensive vocabulary. Children were arranged into two groups of high and low phonological memory skills matched for vocabulary knowledge. Two more groups were formed of high and low vocabulary knowledge children matched for phonological short-term memory skills. Groups were also matched for non-verbal ability to ensure that children with high vocabulary or high STM are not simply brighter. Children were compared on a task which simulated natural vocabulary acquisition so that they all had equal opportunities to learn the new words, as in Study 3. The total number of English words learnt and the mean number of trials taken by each child to learn a new English word were obtained.

Study 4 showed that this stage of advanced proficiency with the foreign language, children depend more on long-term vocabulary to learn new foreign words and less on their phonological memory abilities. On every trial the high vocabulary children learned more English words than the low vocabulary group. In addition, the high vocabulary group took less number of trials to learn the new words. No differences were found on number of words learnt between the high and low short-term memory groups. So, the children with better vocabulary knowledge learnt more rapidly and acquired more English words that the children with less vocabulary knowledge. These findings support

the hypothesis that when children achieve a certain level of proficiency in a second language, existing vocabulary facilitates learning of new words and short-term memory abilities are less important.

In summary, it was found that phonological memory abilities link strongly to native vocabulary knowledge in Greek young children. A strong association between phonological loop capacity and foreign vocabulary knowledge holds also for older children who learn English as second language. This association appears to be independent of individual differences on linguistic environments. The involvement of phonological memory is less crucial in later stages of second language learning and proficient learners depend more on their long-term knowledge to acquire novel words. The association between phonological memory and vocabulary knowledge appears stronger when it links to foreign rather that native vocabulary knowledge. Some detailed aspects of the results suggest that Greek nonwords that are likely to pass for real native words can be repeated more accurately than less wordlike nonwords. Also, children's performance on repeating nonwords declined as a function of length in both native and foreign items.

6.2 THEORETICAL ACCOUNTS

6.2.1 Evaluation of the findings in relation to previous research

It was argued in Chapter 1 that vocabulary knowledge is a crucial developmental ability which facilitates communication and academic achievement. What cognitive abilities that are involved in such an important acquisition? The present findings suggest that at least one such an ability is children's phonological memory. The studies reported in this

thesis have shown that phonological memory capacity links to vocabulary knowledge in native and foreign languages and plays a role in learning phonological forms of new words in native language. This link appears to exist over and above non-verbal ability and individual differences in linguistic environments.

One view which can accommodate these findings is the suggestion that a verbal component of short-term memory system contributes to the learning of sound patterns of words (Baddeley et al., 1998). By this account the novel verbal material is represented temporarily in the phonological loop and then transferred into long-term memory to become part of child's vocabulary. The efficiency of registration in long-term memory depends on the quality of the temporal representation in the loop. Previous studies suggest that indeed long-term learning of words is directly constrained by children's phonological memory skills (Gathercole & Adams, 1994; Gathercole, Willis, Baddeley, 1991; Michas & Henry, 1994). It appears possible that children who were able to store new phonological forms of words more accurately in the phonological loop constructed better long-term memory representations of these words.

An alternative explanation for these findings could be that children who live in rich linguistic environments have better opportunities to acquire vocabulary and they also develop their phonological memory skills, because they frequently encounter a wide range of new sounds. On this account, children with good vocabulary knowledge have good phonological memory skills and this association reflects their extensive experience with the language and not their better phonological memory skills. Results from Study 3, in line with findings from similar studies (Gathercole & Baddeley, 1990a; Gathercole, Hitch, Service & Martin, 1997) ruled out this possibility and confirmed that the same

crucial role of short-term memory arises in situations in which children had the same opportunities to acquire new native-like words.

This theory can also account for the finding that children with good phonological memory skills had better vocabulary knowledge in a foreign language which they were learning as a second language over a short period of time. Again this association appeared to be independent of their age and non-verbal ability (Study 2). A similar involvement of phonological loop may arise for vocabulary acquisition in both native and foreign languages (Papagno, Valentine & Baddeely,1991; Papagno & Vallar, 1995; Service, 1992; Service & Kohonen, 1995). Nevertheless, the vocabulary knowledge in children's second language appeared to link more closely to phonological memory skills than native vocabulary knowledge does (Study 2). Why is learning words in a foreign language so heavily dependent on phonological memory efficiency? The view that phonological loop facilitates learning of words, especially when this learning involves acquisition of unfamiliar phonological forms, can provide an explanation for this finding. Consider the differences in phonological involvement between acquiring vocabulary in native language and in foreign language, learning new native words involves learning both the phonological and the contextual properties of words. The sound patterns of new native words involve highly familiar combinations present in other words in the language. In the first year of life, children became sensitive to these sound combinations of their own native language (Jusczyk, Luce, & Charles-Luce, 1994). Sound combinations are limited in every language and accumulative knowledge of these forms makes learning of phonological forms in native language an easy task. Even unknown words in a child's native language are composed of familiar phonemes and can

be learnt easily by most young children (see also Werker and Tees, 1984; De Boysson-Bardies & Vihman, 1991).

Nevertheless, learning a foreign word puts a heavier burden on children's phonological memory abilities. Foreign words consist of unfamiliar sound patterns combined in an unknown manner. Beneficial support from previous experience with language to reproduce the new word is less possible to arise (Thorn & Gathercole, 1999). Furthermore, the specialisation of the conceptual system to the sounds of the native language is more likely to impede rather to facilitate learning of foreign words (Gathercole & Thorn, 1998; Thorn & Gathercole, 1999). Children have to depend more heavily on their phonological loop representation as a means to form long-term record of foreign words. The support from previous experience is less likely to arise and so children may rely more heavily on their phonological loop representations. Thus, facilitation from the phonological loop store is less crucial when learning involves acquisition of native words.

However, the idea that phonological loop serves primary the learning of novel items is inconsistent with findings from Study 3, where no association found between phonological memory and learning of new foreign items. It appears that other factors, beyond phonological memory contributions are involved in learning of foreign words. The function of phonological loop can not account sufficiently for differences in phonological learning of foreign words. Where possible, learners of second languages, are engaged in semantic associations, to learn the new foreign words (Papagno et al., 1991; Service & Craik, 1993). It is plausible that children associated the new unfamiliar item with an already known word that resembles the new phonological form. This

involvement of long-term semantic memory can overshadowed contributions of short-term memory. Consistent with this view are findings suggesting that encouragement to associate foreign words with native words semantically or acoustically promotes foreign vocabulary learning (Paivio & Desrochers, 1981; Healy et al., 1998). Clearly, learning a new foreign word is a demanding task and children can spontaneously employ several strategies in order to acquire the new form. Also, a number of factors such as other developmental abilities (i.e. imitation, episodic memory skills) can mediate learning of foreign words.

Throughout the studies the children were able to repeat native-like nonwords more accurately than foreign nonwords. The same pattern arose for high and low in wordlikness native nonwords. Previous studies of phonological memory have also shown similar effects (Hulme, Maughan & Brown, 1991; Gathercole, 1995; Gathercole et al., 1991). The most prevalent interpretation of this important feature of the operation of the phonological loop seems to be the integration of long-term knowledge with temporary memory representations. Children possibly used previous knowledge to support phonological loop representations.

Although there is a general agreement on the contributions of long-term knowledge to short-term memory performance, the precise mechanisms that highlights this contribution remain uncertain. One suggestion is that lexicality and wordlikness effects reflect activation across a network of phonological units. This is consistent with some computational models which conceptualise working memory in terms of the activation of some aspects of long-term memory (Gathercole & Martin, 1996; Guplta & MacWhinney, 1997). By this account, repetition of foreign nonwords is inferior because

there are less shared segments available to activate in the recognition of the phonological form of extremely unfamiliar spoken material.

The greater repetition accuracy of the familiar items can be attributed to the application of stored knowledge about the structure of a language to the phonological loop (Hulme et al., 1991; Poirier & Saint-Aubin, 1995; Gathercole at al., 1999). One possible process that serves the connection between long-term memory and phonological loop is redintegration. By this account, long-term knowledge of both lexical and phonological properties of the language are used to guess incomplete parts of the loop representations (Hulme et al., 1991, 1997). The more stored information one has about a language, the possibility of guessing correctly and filling in the gaps of the decaying trace of the memory. By using a process of reconstruction, partial traces of native-like or highly wordlike nonwords have better chance of being correctly recovered than nonwords with uncommon sound patters or foreign nonwords. Knowledge of the phonotactic properties of the native language (i.e. frequencies of sound combinations) can provide a successful reconstruction of incomplete memory traces (Gathercole, Frankish, Pickering & Peaker, 1999). Long-term knowledge of the sound combinations that are characteristic in a language is likely to be more extensive for native than for foreign language, and therefore more likely to support reconstruction of native-sound stimuli. Although the process of redintegration can account for the wordlikeness effect, it is still unclear if it takes place during storage or at retrieval, or both.

An alternative suggestion is that these findings reflect a better perceptual analysis of native-like nonwords. Children could be better at perceptually analysing and

representing phonological forms in their native language than in foreign language prior to any phonological storage (Martin and Saffran; 1992 Vitevitch et al., 1997).

Irrespective of the exact mechanisms that facilitate representations of familiar lexical material in immediate memory, the possible properties of nonwords that make them sound less or more familiar are crucial. It is possible that the wordlikness effect is an output effect and high in wordlikness words are repeated more accurately simply because they can articulate more rapidly. Present findings suggest that this is unlikely. It was found that the wordlikness effect in nonword repetition does not arise from phonological simplicity or complexity *per se*. Possibly the words are repeated more accurately because the phoneme combinations that consist these nonwords appear frequently in the language. On this account, even nonwords that are phonologically complex can be highly wordlike and easy to repeat. For example, the combination CCC which is typically difficult to articulate but is common in Greek language (Petunias, 1997) is more likely to be repeated accurately than a simple, but less common, sequence.

So far, it appears that the function of the phonological loop as a system that promotes language learning can account for the findings presented in this thesis. It remains unclear though, why children who participated in Study 4 showed little sensitivity to phonological memory as means to learn new words in their second language. The relationship between temporary memory and foreign language learning fluctuates from more to less significant. It seems possible that contributions of phonological memory become less important at some stage of the learning procedure. A similar pattern of decreasing phonological memory involvement after the age of five or so has been found for acquisition of native vocabulary (Gathercole et al., 1992).

One feasible explanation for these findings could be that the involvement of short-term memory in phonological learning diminishes after a critical age. There are two reasons why this possibility is doubtful. Firstly, there is evidence that disrupting articulatory rehearsal by articulatory suppression in adults who learn pairs of native word-foreign word associations impairs learning (Papagno, Valentine & Baddeley, 1991). This result suggests that the phonological loop still plays a role in foreign vocabulary acquisition in adults. Secondly, neuropsychological patients with selective impairments in working memory system are severely impaired in learning word-nonword pairs (Baddeley, Papagno & Vallar, 1988; Vallar & Baddeley, 1984). It seems that phonological memory plays a crucial role in acquiring new words in adulthood and this role does not eliminates after a certain age. The transformation from dependence on phonological memory to greater involvement of existing vocabulary as means to acquire new words, does not seem to reflect a biological-maturational factor (such as achievement of some critical level of learning skills) but rather an increasing familiarity with a language.

An alternative explanation for this lack of association between foreign word learning and short-term memory in advanced learners could be that extensive experience with a language increases knowledge about the phonotactic properties of words (Gathercole, 1995; Gathercole, Willis, Emslie & Baddeley, 1991; Garnt et al.,1997; van Bon and van der Pijl, 1997; Vitevitch et al., 1997), in a way that existing knowledge becomes more important as a means to boost the temporary representations in the phonological loop. This accumulative knowledge about the phonotactic rules of the language can be used to boost the incomplete phonological loop representations (Hulme et al., 1991, 1997). On this account the representation in the phonological loop is similarly precious for long-

term learning in advanced and beginner learners. In the initial stages of foreign language learning the quality of phonological loop representation depends heavily on individuals short-term memory capacity, while in later stages of learning it can be aided by long term knowledge. Irrespectively of the exact mechanism which underlines this aid, the quality of representation is crucial for long-term learning in all cases. In the initial stages of learning the contributions of short-term memory capacity is clear while in later stages long-term memory overshadows these contributions. A decreasing involvement of phonological memory as language knowledge increases had been found for other groups of foreign language learners (Cheung, 1996). A similar shift in foreign vocabulary learning process has been seen for other aspects of foreign vocabulary leaning, such as visual lexical processing of foreign words (Chen & Leung, 1989) and also in the area of mediation strategy use (Chen, 1990; Opoku, 1992).

Thus, when a child learns a second language over a period of time and has already acquired an extensive vocabulary in this language, it is possible that phonological memory involvement is less crucial. Long-term knowledge may take over facilitation of learning and children with certain knowledge of a foreign language depend less on temporary representations to learn a new word.

A broad overview of the relationship between vocabulary acquisition and phonological loop function is suggested in Figure 1. The link between short-term and long-term memory appears to run in both ways (Hulme, Maughan & Brown, 1991; Roodenrys, Hulme & Brown, 1993; for discussion see Gathercole & Martin, 1996), nevertheless, present findings indicate that in certain circumstances each one of the two directions may become more dominant. An account which can accommodate these findings is that

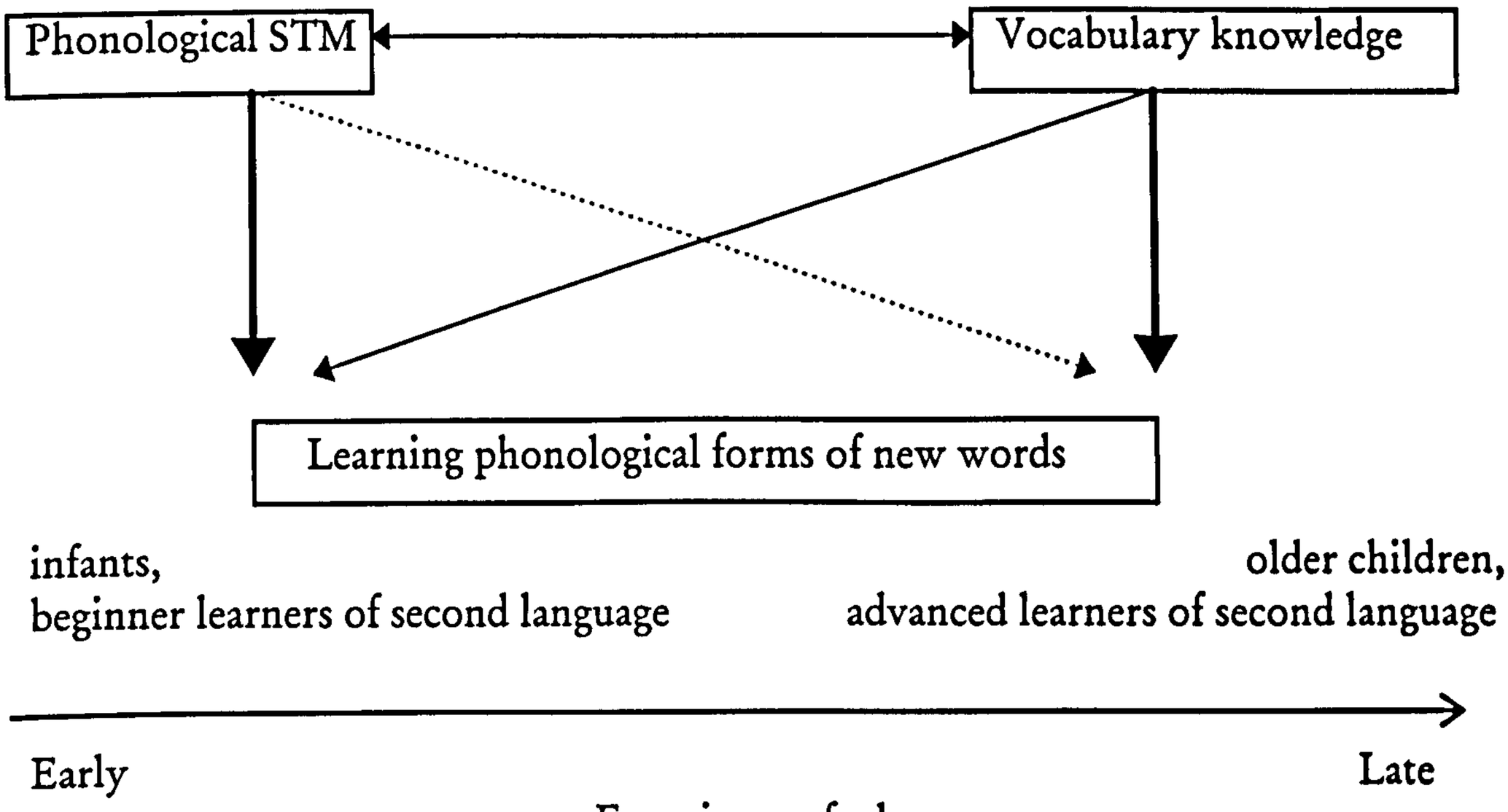
a shift occurs from dependence on phonological representations to dependence on existing vocabulary existing as means to learn new words. During the early stages of vocabulary acquisition when young children have little lexical knowledge and limited experience of the phonological constraints of language, the first causal pathway (i.e. phonological memory capacity promotes long-term learning), is most important. Their abilities to briefly hold verbal material in phonological loop determines potential registration of new words in long-term memory.

When children have accumulated experience with the language and their vocabularies have became more extensive, the second pathway (i.e. prior knowledge affects phonological short-term memory operation) becomes more active. Long-term knowledge can be use to improve temporal representations in the loop and support vocabulary acquisition. Similarly, older children or adults who learn a second language after they have achieved some proficiency in their own language have limited experience with the phonology of this second language at the initial stages of a learning programme. On this aspect they are more like young children who depend on phonological loop representation as means to learn new phonological forms rather than adults who have extensive experience with the language. Again they depend on phonological memory representations to acquire an unfamiliar form. In later stages of second language learning, when the vocabulary knowledge expands and learners are becoming more familiar with the foreign phonological system, contribution of prior knowledge can be beneficial for new learning.

The shift from dependence on phonological memory storage to long-term knowledge appears to be dictated by degree of familiarity with the language being learned rather

than with age *per se*. The more extensive the experience with the language is the more possible learning of new lexical material is to be support from prior knowledge independently from learner's chronological age.

Figure 1.Changing contributions to vocabulary acquisition as a function of degree of experience with language



Even if we hypothesise that the phonological loop played a role in children's long-term learning of native and foreign words, it is still unclear as to what aspect of the loop was crucial for this learning. In the current model of working memory the phonological loop consists of two components: the phonological storage and a subvocal rehearsal process that refreshes decaying representations in the phonological loop (Baddeley, 1986; Baddeley et al., 1975). Given that the children who participated in Studies 1 and 3 were about seven years old or younger, it is tempting to assume that phonological store was crucial for their vocabulary acquisition rather than the rehearsal process. There are two reasons why this seems most likely. Firstly, there is evidence suggesting that although children can store phonological information in the phonological loop as soon as

language abilities began to develop, they do not use subvocal rehearsal before the age of 7 years so (Cowan & Kail,1996; Gathercole & Hitch,1993; Henry, 1991; Gathercole & Adams, 1994). Considering that rehearsal does not take place at ages younger than 7 and links between vocabulary and phonological memory were found, it is more likely that it is the phonological store that underlines this link. Secondly, the nonword repetition task which was used in all of the studies here as a measure to assess phonological loop efficiency, appears to provide a measure of phonological storage, not subvocal rehearsal (Gathercole, Willis, Emslie & Baddeley, 1992). Given that the nonwords used here have a spoken duration of less than 1 sec (Gathercole, Willis, Baddeley & Emslie, 1994) and the estimated capacity of the phonological store is about 2 sec (Baddeley et al., 1975) it is unlikely that even older children rehearsed the items subvocally. It appears that the ability which is estimated in the present studies and found to link with vocabulary knowledge is the phonological store.

A final issue that concerns present findings is the greater repetition accuracy found for short over lengthy (i.e. in number of syllables) native and foreign nonwords. These length effects may arise either from the spoken duration of the items (Baddeley, Thomson & Buchanan, 1975) or the phonological complexity (Caplan, Rochon & Waters, 1992; Service, 1998). In this account repetition accuracy of long nonwords decreases because these items take longer to say and thus, longer to rehearse in the phonological loop (Baddeley, 1986). In studies reported in this thesis, a length effect was found for repetition of nonwords by young children. Presuming that they do not rehearse at all before the age of seven or so (Cowan & Kail, 1996; Gathercole & Hitch, 1993), it is unlikely that the length effect arose from better rehearsal process of the short items. Alternatively, the length effect may reflect the decay during the articulatory

output process which is typically required in spoken recall (Cowan, et al., 1992; Henry, 1991). This view can account for the findings reported here.

The precise operation of verbal short-term memory that causes length effect is uncertain. The short items may be easier to encode, store or rehearse. Several suggestions have been made with little agreement to one another (Brown & Hulme 1995; Cowan, Wood, Nugent & Treisman, 1997; Service, 1998).

6.2.2 Phonological loop and language.

It is argued above that short-term memory and language acquisition share a highly interactive relationship. The present findings of link between phonological memory and vocabulary knowledge support the interactive nature of the relationship between memory and language. Irrespectively this association, short-term memory and language as areas of human cognition have been thoroughly investigated for years in isolation from each other. Recently, several models of short-term memory have been suggested (see Gathercole, 1996) and much is already known about the cognitive process involved in language acquisition (Clark, 1983; Markman, 1994; Gleitman, 1993;Fowler, 1991).

In a comprehensive model of short-term memory, Baddeley and Hitch (1974) introduced the concept of phonological loop component of working memory (fully reviewed in Chapter 1) which plays a crucial role in language learning. Since then, the phonological loop has been extensively explored and can account successfully for several empirical phenomena in short-term memory. Nevertheless, the exact links between the phonological loop and language remain unspecified. Is an attempt to define these links the recent development of explicit computational models. Computational frameworks

have been found useful for exploring the precise relationship between vocabulary acquisition and verbal short-term memory. A computational model can integrate aspects of several systems, and thus, it can explain in mechanistic terms how language and memory are related. As yet, most of the suggested models though, fail to explain certain details of the learning process, such as how short-term memory representations lead to durable learning or how the phonological learning of more that one languages is achieved.

Some of the available computational models (Hartley & Houghton, 1994; Burgess & Hitch, 1992) concentrate on the phenomena of verbal short-term memory and they do not directly address the process of vocabulary acquisition while others concentrate on word learning and they do not explain phenomena of verbal memory (Grossberg, 1987; Miikkulainen, 1990). Some connectionist models see the phonological loop as the representation of those systems responsible for the perception of the language (Allport, 1984; Brown & Hulme, 1996; McClelland & Elman, 1986). It is not clear though why some phenomena that affect the phonological loop do not affect perception of language. One would assume that if the phonological loop simply represents activation of a language perception system (or systems) the same factors that have effects on the phonological loop should influence perception as well. This does not seem to be the case however. Articulatory suppression that impairs short-term memory performance leaves perception of phonological items intact (Baddeley & Lewis, 1981; Besner, Davies & Daniels, 1981). Also, patients with impaired short term memory ability have no problems with language perception (Shallice, 1988; Vallar & Baddeley, 1984). Thus, it appears that although there might be a direct association between an individual's perceptual skills and their phonological-short term memory performance (Allport, 1984;

Gathercole & Martin, 1996), a conception of a separate short-term memory system is necessary to account for empirical evidence.

A comprehensive connectionist model should account not only for the phenomena of verbal memory but also for language acquisition. Furthermore, some aspects of language such as vocabulary acquisition, which is an intricate ability and associates both phonological and lexical development should be considered carefully in a computational model and certain questions, directly addressed. For example, how this knowledge is internalised and why some children learn words more rapidly than other? Also, with the increasing numbers of children who learn foreign languages, vocabulary acquisition in a second language should also considered.

Some findings reviewed here indicate that foreign language vocabulary learning differs from native vocabulary leaning in some crucial respects. It is less strongly linked to intelligence than native vocabulary (Long, 1990), it is constrained by the conceptual system's specialisation while native vocabulary is favoured by such a specialisation (see Gathercole & Thorn, 1998), it depends on the similarities between the phonological features of the native language and the particular foreign language (Feldman & Healy, 1998) and acquisition of the exact phonology of foreign words becomes difficult with age (Oyama, 1976; Scovel, 1981; Ioup, 1984) but easier with increasing familiarity with a language. Thus, vocabulary acquisition in a foreign language appears to be phonologically more difficult task and so depends heavily on phonological memory skills. Most of the proposed models of phonological store have not yet directly addressed the question of how long-term learning of extremely unfamiliar material, such as foreign words, occurs.

A broad overview of phonological loop as a device for language learning is proposed by Baddeley et. al. (1998). They suggest that auditory information is analysed and represented by means of STM trace in a phonological store system. By using connectionist terms to describe this system Baddeley and colleagues referred to it as dependent on *fast weights* and represents a temporarily activation of a network that reflects the influence of a phonological long-term memory system. They suggest that the STM trace gives a brief but accurate record of specific input while this input is related to the prior knowledge of the structure of language. In connectionist terms again, the durable, long-term representations are referred as *slow weights* (Hinton & Plaut, 1987). As it mentioned above the activation that the trace involves is short in duration but influences the long-term representation. This connection between a potentially novel output to the long-term knowledge although influences does not prevails over the STM trace. Learning of novel input is always possible as the system makes use of prior knowledge but does not allow this knowledge to override the short-term memory representation. Clearly, a mature phonological system with abundant knowledge of the structure of a language is more likely to apply to novel input those phonological patterns which are common in the familiar language. Acquisition of very novel spoken material is more difficult and in this case further modification of the long-term system is constrained by the already acquired knowledge (Baddeley et. al., 1998; see also Gathercole & Thorn, 1998).

The notion of the phonological loop as a device that supports phonological learning of vocabulary fits well with the findings from studies presented here. Indeed, close links between children's phonological loop capacity and vocabulary learning in acquiring

vocabulary in both native and foreign languages can be explained in terms of an association between a temporarily phonological store system and a more permanent storage that runs both ways. It appears that phonological loop represents a system with the capacity to store (and refresh when necessary) novel verbal sequences (i.e. words) before they became permanent records of a long-term system. That is why children with good phonological loop skills have also good vocabulary knowledge. Of course not every spoken sequence that is represented temporarily in the phonological loop registers in long-term memory. This would be an excess and lead to an overload of the system. Crucially, the phonological loop can make use of prior knowledge and the frequently repeated phonological features of words can guidance the temporal representations. This link with prior knowledge can be the a basis of more accurate repetition of familiar over less familiar material. Over time accumulative knowledge about the phonological probabilistic features of a language leads to a specialisation of the perceptual system which favours acquisition of familiar sound stimuli. Children participating in Study 3 learnt more native that foreign novel items. Nevertheless, as mentioned earlier in this chapter, wordlikeness and nonword familiarity effects can also accommodated well in terms of perceptual analysis of the stimuli prior to its storage in phonological memory (see Gathercole et al., 1999 for detailed discussion).

Vocabulary growth involves also acquisition of semantic, thematical and syntactical aspects of words. Development of these variables is beyond the scope of present work which focuses on acquisition of phonological forms of words. The capacity of phonological memory can not account for acquisition of these aspects and its contributions are confined to acquisition of the sound patterns of words.

In summary, the phonological loop, component of working memory is responsible for supporting language learning. Although a system of limited capacity, the phonological loop provides an effective language learning devise with high flexibility in storing novel phonological information but also with adequacy to use prior knowledge of the structure of the spoken language to aid impaired temporary storage. The main function of the phonological loop is to store temporarily novel sound sequences in order to support the more permanent representations of these sequences in the long-term memory system.

6.3 IMPLICATIONS OF THE MAIN FINDINGS

6.3.1 Theoretical implications.

The results of the studies presented here confirm and extend previous findings (reviewed in Chapter 1) of significant association between phonological memory and vocabulary acquisition. Considering the importance of vocabulary growth to cognitive development and to everyday life activities, the phonological loop emerges as a significant component of human cognition. It seems likely that phonological loop capacity will have considerable control over an individual's ability to learn new words not only in the native language but also in unfamiliar foreign languages.

The clear links between performance on phonological memory tasks and vocabulary knowledge in children who participated here, suggests that there is crucial involvement of verbal STM in vocabulary learning. The close association between phonological memory and vocabulary knowledge in second language in particular suggest that contributions of phonological memory abilities are crucially important for second

language vocabulary learning. Learning vocabulary in a second language is different from learning vocabulary in native language, especially after a certain age when many of the concepts of words have already been established. One obvious difference is that learning of a foreign word implies only learning of the phonological form of the word since the context of the word has been already acquired in native language. While learning a new word in native language implies learning both the conceptual and phonological properties of the word. Furthermore, words in native language consist of sounds familiar to the speaker and phonemes are combined in an established manner typical of each language. Thus, although conceptual learning demands are considerably reduced in second language acquisition, the phonological learning demands are particularly increased.

In its current form the phonological loop seems to be evolved primary to store novel sound patterns (Baddeley et al., 1998). If the phonological loop is important for storing unfamiliar phonological forms, it should be involved notably in second language vocabulary learning. Indeed, the suggestion that the phonological loop capacity is crucial for learning new words in foreign language explains many of foreign vocabulary learning phenomena. The competence some people show in learning a second language rapidly independently of their intelligence (Long, 1990, Service,1993, Ellis, 1994) may reflect their good phonological memory skills without necessarily having particularly high intelligence. Similarly, individuals with learning disabilities but intact phonological memory skills are able to learn foreign languages (Barisnikov et al., 1996; Rondal, 1995; Vallar & Papagno,1993).

At the first stages of second language vocabulary learning phonological loop representation of novel speech input supports the construction of more durable records

of the phonological structure of new words. In later stages of foreign language learning, when a mass of vocabulary has been acquired and a considerable knowledge of the phonology of the new language has been accumulated, established knowledge of the second language is used to support fragile phonological loop representations. The process of familiarisation to the phonotactic probabilities of a second language emerges as soon as the exposure the language begins. Obviously, for the typical learner of second language it starts later in life while familiarisation with the native phonology emerges at the very first stages of development (De Boysson-Bardies & Vihman, 1991; Juscyk et al., 1994; Werker & Tees, 1984).

Evidence of such a familiarisation of perceptual system to the native language was found in children participating in all of the studies reported here. Even among advanced learners of second language the better performance on native-sound items was significant.

The critical involvement of the phonological loop to second language vocabulary acquisition and its interaction with long-term knowledge of the structure of the language can form the base for some findings in the area of applied psycholinguistics. Learning a second language appears to get more difficult with age (Johson & Newport, 1989; Lenneberg, 1967;). Also, acquisition of the exact accent of a foreign language seems to be difficult and often remains impaired after proficiency in other levels of vocabulary has been achieved (Ioup, 1984; Oyama, 1976). These findings fit well with the suggestion that phonological loop interacts actively with permanent knowledge about the structure of the language and forms a learning device adapted specially to promote acquisition of native language. As it has been already acknowledged, learning in native language

benefits from the specialisation of the perceptual system towards the properties of the sound system of the language. This native-language specialisation of the perceptual system obstructs the learning of foreign sounds which have clearly different structure of the native words. With time as the familiarity with one's native language grows the specialisation increases and learning of a second language becomes more difficult.

6.3.2 Educational implications

Despite the existence of several programmes which aim to boost foreign language learning, a literature search failed to find evaluations of any published programmes which aim to enhance phonological memory skills. The main technique in the literature that implies contributions of memory to foreign vocabulary learning is the keyword method. In this technique an unfamiliar foreign word is first related to a similar sounding native-language keyword which in turn is related to the native language equivalent using an interactive image (Healy et. al., 1998; Paivio & Desroches, 1981; see also introductory chapter for this issue). This technique though, appears to be use as a method for enhancing foreign vocabulary learning in experimental environments and not as a typical teaching strategy in classroom settings .

Findings from studies presented here and studies reviewed in the introduction section (Chapter 1) indicate that learning the sounds of words of a foreign vocabulary is strongly mediated by phonological short-term memory. Thus, any technique that improves performance on phonological memory tasks should also enhance foreign vocabulary learning. Although there is evidence that indeed repetitions can aid significantly foreign vocabulary learning (Ellis & Beaton, 1993a) they do not appear to be used as a teaching strategy for enhance foreign vocabulary learning. However, it could be argued that

teaching strategies for improving phonological memory involve learning nursery rhymes, singing songs and cueing texts from regularly-read storybooks. These strategies can presumably improve both phonological memory skills and learners' ease at learning new vocabulary. Findings from research presented here favours the usage of such paradigms as means to aid vocabulary learning.

6.3.3 Research implications.

The present findings of phonological memory involvement in vocabulary acquisition suggests some answers to questions such as why some children learn vocabulary more rapidly than others and why some individuals pick up words in foreign languages more easily that others. Individual differences in phonological loop capacity can account significantly for these variations at least in learning phonological forms of words. Nevertheless, they can not account for differences in children's abilities to acquire the conceptual components of words.

In addition to the questions that were answered, the studies presented here raise some more questions and a number of areas were identified as possible topics for future research.

Firstly, contributions of phonological memory and existing vocabulary knowledge to learning of novel words in foreign language examined in this thesis suggest a shift in the importance of these contributions. Initially, it appears that the phonological loop facilitates the more permanent learning of unfamiliar phonological forms. With increasing familiarity of the foreign language, however, the extent of vocabulary knowledge appears to become important. When does this transition takes place? For example, is it the case that when vocabulary growth has reached a critical level this

knowledge becomes important for novel word learning? Further studies may be able to identify more specifically the point when this shift takes place.

Another issue concerns the association between vocabulary knowledge in native and foreign languages. Current findings suggest that native and foreign vocabulary shared close links. What is not clear is the exact nature of these links. Is it the case that vocabulary knowledge in one's native language directly facilitates vocabulary learning in a foreign language by enabling direct associations between novel words and similar ones existing in native vocabulary? By this account, individuals with better native vocabulary knowledge should be more likely to create phonological or semantically associations between to-be-learnt material and already learnt words. Further investigations can aim at clarifying any possible causal nature of vocabulary knowledge between two languages.

Aside from the precise point when the transition of importance takes place, future research needs to address possible qualitative differences in phonological memory contributions to vocabulary learning. Current findings suggest that the fundamental mechanism linking phonological memory and vocabulary acquisition is the phonological store rather that the subvocal rehearsal. Nevertheless, the role of subvocal rehearsal in older children or adults who learn a second language is still unclear. It is possible that a mature phonological memory system that uses subvocal rehearsal, can benefit in like manner from the efficient operation of the rehearsal process as from the phonological store?. Considering that some aspects of the vocabulary learning modify as familiarity with language increases it is possible that role of subvocal rehearsal changes as well. Clearly, this issue needs to be addressed in order to establish the precise aspect of the phonological loop which is critical for the learning function.

Conclusions

The studies presented in this thesis have established some of the critical links between phonological short-term memory and the language learning system. The evidence presented demonstrates a close link between a child's phonological memory skills and his or her vocabulary knowledge in both native and foreign languages. Contributions of short-term memory capacity and of long-term vocabulary knowledge to new foreign word learning identified. The differential importance of these sources depends on the level of familiarity with the second language. The current findings therefore demonstrate that the phonological loop is a system whose capacity is crucial for initially learning unfamiliar words while its interaction with the long-term memory system eventually results in an increasing importance of existing vocabulary knowledge to new word learning.

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APPENDIX A

APPENDIX B

PAGE NUMBERING AS ORIGINAL

APPENDIX C

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APPENDIX A

Nonword stimuli in the English CNRep used in Studies 1, 2, 3 and 4.

Two syllables		Four syllables	
Ballop	ˈbaləp	Blontersatping	ˊblɒntə́steɪpɪŋ
Bannow	ˊbanəʊ	Commecitate	ˊkəmˊisəteɪt
Diller	ˊdɪlə	Contramponist	ˊkənˊtrampənɪst
Glistow	ˊglɪstəʊ	Empliforvent	ɛmplɪˊfɔvənt
Hampet	ˊhampənt	Fenneriser	fɛnəˊraɪzə
Pennel	ˊpɛn!	Loddenapish	lɒdəˊneɪpɪʃ
Prindle	ˊprɪnd!	Penneriful	pənˊɛrɪf!
Rubid	ˊrubɪd	Perplisteronk	pɜˊplɪstərɒŋk
Sladding	ˊsladɪŋ	Stopograttic	stɒpəˊratɪk
Tafflest	ˊtafləst	Woogalamic	wugəˈlamɪk

Three syllables		Five syllables	
Bannifer	ˈbanɪfə	Altupatory	altˆʃúpeɪtərɪ
Barrazon	ˊbərəzən	Confrantually	kənfrantˆʃulɪ
Brasterer	ˈbrastərə	Defermication	difəmɪˈkeɪʃn
Commerine	ˊkɒmərɪn	Detratapillic	ditrətəˊpɪlɪk
Doppelate	ˊdɒpəleɪt	Pristoractional	prɪstərˊakʃən!
Frescovent	ˊfrɛskəvɛnt	Reutterpation	riʌtəˊpeɪʃn
Glistering	ˊglɪstərɪŋ	Sepretennial	sɛprəˊtɛnɪʊl
Skitikult	ˊskɪtɪkʊlt	Underbrantuand	ʊndəˈbrəntˆʃuand
Thickery	ˊθɪkərɪ	Versatrationist	vɜsəˊtreɪʃənɪst
Trumpetine	ˊtrʊmpətin	Voltularity	voltˆʃuˊ larɪtɪ

APPENDIX B

Nonword stimuli in the Greek nonword repetition task employed in Study 1.

	Two syllables	Three syllables	Four syllables	Five syllables
Form A				
	lalma	planero	aligea	paremofora
	nidos	kavotos	nistomia	lavirigikos
	kamos	atrovo	harostikos	thimopilia
	tida	miniktos	kolimia	kanilaniso
	thati	edonas	kastalono	stonipilia
	aros	magratos	fonorizo	imnosalono
Form B				
	prosta	dolatos	sinafikos	akainatizo
	fire	mopado	alkotita	kalthamotita
	kourma	epnasi	krotinaki	nakonidisto
	midra	almahis	nilagia	athoiditos
	volsi	natalo	tomaleti	lolminadiko
	rivo	xiama	pravagos	nireftolaso

APPENDIX C

Nonword stimuli in the Revised-Greek nonword repetition task used in Studies 2, 3 and 4.

Two syllables		**Four syllables**	
volsi	v´olssɪ	alkotita	alk´otɪta
kourma	k´urma	epnoasi	ɛpn´oassɪ
midra	m´iðra	krotinaki	krotɪn´akɪ
prosta	pr´osta	nilagia	nɪlaj´ɪa
rivo	rɪv´o	tomaleti	tomal´ɛtɪ
fire	f´ɪrɛ	sinafikos	sɪnafɪk´oʃ
aros	ar´oʃ	aligeaα	alɪg´ɛa
thati	θ´atɪ	kastalono	kastal´ono
kamos	k´amoʃ	kolimia	kolɪm´ɪa
lalma	l´alma	vistomia	nɪstom´ɪa
nido	n´ɪðoʃ	fonorizo	fonor´ɪzo
tida	t´ɪða	harostikos	harostɪk´oʃ

Three syllables		**Five syllables**	
almahis	almaχ´ɪʃ	athoniditos	aθon´ɪðɪtoʃ
dolatos	ð´olatoʃ	akenatizo	akɛnat´ɪzo
mopado	mopað´o	kalthamotita	kalθam´otɪta
natalo	natal´o	lolmonadiko	lolmɪn´aðɪko
xiama	ks´ɪama	nakonodisto	nakon´ɪðɪsto
pravagos	pr´avajoʃ	nireftolasso	nɪrɛftol´asso
atrovo	atrov´o	thimopilia	θɪmopɪl´ɪa
edonas	´ɛðonaʃ	kanilaniso	kanɪl´anɪsso
kavatos	k´avatoʃ	lavirigikos	lavɪrɪjɪk´oʃ
magratos	m´agratoʃ	paremofora	paɾɛmofor´a
minikktos	m´ɪnɪktoʃ	*stonipilia*	stonɪpɪl´ɪa
planero	pl´anɛro	imnosalano	imnossal´ono

APPENDIX C

Example of the word-translation task for the English vocabulary knowledge explored in Studies 2 and 4.

How would you say that in Greek?

English word	Greek equivalent	Response	Score	English word	Greek equivalent	Response	Score
room	δωματιο			ashtray	τασακι		
hello	γεια			behind	πισω		
this	αυτο			realistic	πεαλιστικος		
idea	ιδεα			dentist	οδοντιατροσ		
girl	κοριτσι			swimming	κολυμπι		
bed	κρεβαττι			guest	καλεσεμνος		
pilot	πιλοτος			director	σκινουετης		
chair	καρεκλα			towel	πετσετα		
big	μεγαλο			suggestion	προταση		
kitchen	κουζινα			urgent	επειγον		
woman	γυναικα			chest	στηθος		
garden	κηπος			leg	ποδι		
river	ποταμι			Parliament	Κοινοβουλιο		
mountain	βουνο			industry	βιομηχανια		
fork	πιρουνι			panther	πανθηρας		
mirror	καθρευτης			water	νερο		
there	εκει			story	ιστορια		

Total:

How would you say this in English?

Greek word	English equivalent	Response	Score	Greek word	English equivalent	Response	Score
μητερα	mother			γραμμα	letter		
οικογενεια	family			αιυοθσα	classroom		
ευχαριστω	thank you			παιδια	children		
Αγγλικα	English			δεξια	right		
και	and			σχολειο	school		
ονομα	name			θυμωμενος	angry		
τηλεφονο	telephone			κιθαρα	guitar		
χρωμα	colour			ακριβο	expensive		
αδελφη	sister			δασος	forest		
φιλος	friend			ποτε	never		
εδω	here			εφιμεριδα	newspaper		
καναπες	sofa			χιονι	snow		
σπιτι	house			συντομα	soon		
τραπεζι	table			δωρο	present		
εισιτηρια	tickets			αγαπημενο	favourite		
μαυρο	black			γεννεθλια	birthday		
παιζω	play			εκκλησια	church		

Total:

APPENDIX E

Exposure to English questionnaire used in Stdy4.

Language background		
1. Is any the child's parents English?	YES ☐	NO ☐
2. Have your child ever lived abroad? If yes for how long?	YES ☐ Years:	NO ☐ Months:
3. Have your child ever gone to a foreign school? If yes for how long?	YES ☐ Years:	NO ☐ Months:
4. Does your child speak any other language?	YES ☐	NO ☐
5. For how have your child been learning English at school?	Years:	Months:
6. For how long have your child been learning English in a private institution?	Years:	Months:
		Total: