THE REPRESENTATION OF NEWLY LEARNED WORDS

IN THE MENTAL LEXICON

by

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DEDICATION

I wish to dedicate this dissertation to Dr. Kenneth Forster, my family and my parents, who have all been very important in my life.

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ABSTRACT

Most research in word recognition uses words that already exist in the reader's lexicon, and it is therefore of interest to see whether newly learned words are represented and processed in the same way as already known words. For example, are newly learned words immediately represented in a special form of lexical memory, or is there a gradual process of assimilation? As for L2 language learners, are newly learned words incorporated into the same processing system that serves L1, or are they represented quite independently?

The current study examines this issue by testing for the existence of the Prime Lexicality Effect (PLE) observed in masked priming experiments (Forster & Veres, 1998). Strong form priming was found with nonword primes (e.g., contrapt-CONTRACT), but not with word primes (e.g., contrast-CONTRACT). This effect is generally assumed to result from competition between the prime and the target. So if the readers had been trained to treat "contrapt" as a new word, would it now function like a word and produce much weaker priming? Elgort (2007) demonstrated such an effect with unmasked primes with L2 bilinguals. The current study investigates the PLE in both L1 and L2 bilinguals under different training conditions. When the training program involves mere familiarization (learning to type the words), a PLE was found with visible primes, but not with masked primes, which suggests that unmasked PLE is not the best indicator of lexicalization. In the case of "real" acquisition where the new word is given a definition and a picture of the object it refers to, and learning is spread over two weeks, a clear PLE was obtained. However, when the same experiment was carried out on

Chinese-English bilinguals using the same English materials, completely opposite results were obtained. The learning enhanced priming, rather than reducing it, suggesting that the L2 lexicon might differ qualitatively from the L1 lexicon. The implications of these results for competitive theories of lexical access are discussed, and alternative explanations are considered.

CHAPTER 1: INTRODUCTION

1.1. Introduction

Word recognition studies normally have the two following presuppositions: firstly, words that a reader knows are stored in the memory system along with various types of representations. Secondly, the process of word recognition must determine which lexical representation in memory is the closest to the input stimulus. These presuppositions imply that the lexical effects that have been found in the process of word recognition would not occur on nonwords, or novel words, since no permanent codes have yet been established in the memory system --- is this true? Most research in this area uses words that are already well-established in the memory system, and therefore it would be of interest to examine what happens when novel words are learned: for example, how are the representations of the newly learned words formed in the memory system? Are the representations different from the way early-learned words are represented? When do newly learned words get into the mental lexicon? Are we able to tell when they are integrated into the system?

Before we get too far into this issue, I would like to make a couple of disclaimers. First, the learning processes this paper will discuss are later lexical developments that occur in adults, not children. Some readers may think it is not that frequent for grown-ups to learn new words. In fact this is not true. It was estimated that adults learn about a thousand new word forms (a word and its close morphological relatives) per year, which makes an average of three word forms per day (Leach & Samuel, 2007; Nation & Waring, 1997). The difference between early and later lexical acquisition resembles the distinction between establishing a new lexicon and adding words to the already-existing mental lexicon. For the latter case, since there are pre-existing mental representations, we suspect that more complicated processes are involved. However, it is important to admit that one might not be able to make a clear-cut distinction between early learning and later acquisition. Prior knowledge is likely to have an effect (as facilitation, or interference) on learning at any age and any stage of learning.

Leach & Samuel (2007) suggested there are two aspects of lexical acquisition: "lexical configuration" and "lexical engagement". They claimed that in order to understand the lexicon and its development, it is important to keep this distinction clear, because they represent different aspects of lexical development. According to them, lexical configuration is the set of "factual" information associated with a word, such as the word's sound, spelling, meaning, or syntactic role. They can be directly measured and indicated by the ability to report a word given a brief orthographic input or a picture, or the ability to retrieve information associated with a newly learned word. They point out that almost all previous research on word learning focused on this aspect (p. 306). On the other hand, lexical engagement is the way in which a lexical entry dynamically interacts with other lexical entries, or with sublexical representations. For example, lexical entries compete with each other during word recognition (inhibition within the lexical level), and they also support the activation of their constituents (top-down lexical-phonemic facilitation, and lexically-based perceptual learning) (p. 306). Leach and Samuel used separate measures of lexical configuration and engagement in their study, and observed dissociations between the two aspects. The current study is not intended to examine the relationship between these two concepts, but the distinction between them emphasizes the complexity of adult learning. Measures of lexical competition will be included as the main criterion of lexicalization in the present study. The nature of inhibition within the lexical level will also be discussed

The second disclaimer is that the current study focuses on new word acquisition in the written modality, instead of spoken. In order to parallel the first language acquisition, most research in this area involves spoken word acquisition studies (Gaskell & Dumay, 2003; Leach & Samuel, 2007). However, recent developments in visual word recognition theory make studies of new written words more interesting, and the implications more enlightening. For example, many factors can be studied about new form representations, such as the change of the neighborhood (Bowers, Davis, & Hanley, 2005), the chances of showing word superiority effect by the novel words (Salasoo, Shiffrin, & Feustel, 1985), and whether the access is automatic or not etc. (Forster, 1985; Elgort, 2007).

In the following section these questions will be examined one by one to form a framework of questions that the dissertation attempts to answer. The first question is about the representation in the memory system, specifically, whether there are two separate memories for novel words and already-existing words, and whether there is a transition from one system to the other.

1.2. The memory issue

The question of how novel words are represented, in the first place, is a memory issue. One way to look at this problem is in terms of the distinction between semantic memory and episodic memory proposed by Tulving (1972). In this theory, declarative memory (the memory that stores facts, rather than skills) is divided into semantic memory (which includes lexical memory) and episodic memory. Whereas episodic memory is about personal experiences, and temporally dated episodes or events (Tulving, 1972, pp.385-386; 1983), semantic memory (which includes lexical memory) is a generalized representation of multiple exposures and the organized knowledge a person possesses about language, concepts, facts and principles. Thus, for instance, one's general knowledge about dogs, about terriers, and about his or her own pet terrier would be stored in the semantic memory system, whereas the memory of the first encounter with the pet dog would be stored in episodic memory. Similarly, word knowledge is stored in the permanent and general lexical memory, but information about a new word, or the episodes in which a new word is encountered must be initially registered in episodic memory. Subsequently when we begin to encounter the same word repeatedly in different contexts, an abstract or generalized representation of that new word eventually is formed within lexical memory, and the retrieval of the information about the new word would then go through the lexical memory system, rather than the episodic memory system (Jacoby, 1983; Craik & Lockhart, 1972; Craik & Tulving, 1975).

What is the evidence for the existence of two distinct memory systems for words and new words, and for the transition from one to the other after repeated exposure? Salasoo, et al. (1985) provided evidence using a tachistoscopic identification task. Normally, the letters within words can be identified better than letters within nonwords when they are exposed very briefly and masked. Their study asked whether this advantage of words over nonwords would disappear if the nonwords were repeated a number of times. The assumption is that if word identification tasks are memory tasks in which activation of the "permanent codes" (i.e., lexical representations) are used to identify presented strings of letters, it is the existence of these permanent codes that produces the superior performance on strings of letters that form words compared to strings that do not. Therefore since nonwords don't have such "permanent codes", poorer performance is expected. But if repetition helps to establish a permanent code, there may be no difference between words and nonwords that have been presented multiple times. Their experiments found that after only five repetitions, words and nonwords were identified equally accurately, and the word superiority had not reappeared even a year later. They concluded that new permanent codes were established after the repeated presentations, and this change permanently improved identification accuracy. The fact that this improvement was long lasting suggests something that resembles the development of lexical memory.

More interestingly, compared to the long-lasting improvement, they also found that there was a temporary improvement of accuracy for repeated *words* as well, suggesting that episodic memory might be in play as well. Therefore they suggested maybe both permanent codes and episodic images (a term they used to refer to the presentations in the episodic memory system) facilitate identification interactively, and the two systems might affect word recognition in a simultaneous fashion (p. 75).

However, as a demonstration of lexical acquisition, this study is limited. Participants were simply exposed to the novel items several times, no meanings were provided, nor context of using the novel words (all participants did was to identify the novel sequence repeatedly). It seems doubtful that this would be enough to establish a new lexical representation. What might be happening instead is that the representations that produced the "word" superiority were not permanent codes stored in the semantic memory system, instead they were temporary codes that were stored in the episodic memory system. An identification task would not be able to distinguish between these possibilities since both memory traces will improve the performance in an identification task. In other words, the performance in identification tasks may not rely solely on one type of representation. A task that rules out one type of representation is necessary to solve the problem.

Forster (1985) examined this issue using the masked priming technique (Forster & Davis, 1984). In a *priming* experiment, we observe that responses to a target item can be influenced by prior presentation of another item that is related in one way or another to the target. For example, if access to the word *doctor* is faster when it is preceded by the word *nurse* compared to the word *bread (*Meyer & Schvaneveldt, 1971), this is called *semantic priming*, and *doctor* is referred to as the target, *nurse* is the related prime, and *bread* is the unrelated prime. Similarly, a form priming study may explore the effects of the presentation of a related nonword prime *fountein* or related word prime *mountain* on the recognition of the target word *fountain* (Forster & Veres, 1998). These effects can be obtained even when participants are unaware of the prime (and sometimes only when the participant is unaware of the prime). In a typical three-field masked priming paradigm (Forster & Davis, 1984) (see Figure 1.1.), three stimuli are presented successively, with each stimulus superimposed on the previous one. Normally, the first stimulus is a pattern mask (e.g., #######), the second is the prime, and the third is the target. The target is presented in upper-case letters, while the prime is in lower-case letters. The participant's task is to classify the target as a word or a nonword. The first and last stimuli are each presented for 500ms, while the prime is presented for only 50ms. The combination of the short duration of prime (50ms), the forward mask, and the backward masking effect of the target make the prime completely invisible to almost all the subjects. In a typical study, participants performed at chance when asked whether the prime is a word or not, and a 43% error rate when asked whether it was the same as the target or not (Forster & Davis, 1984).

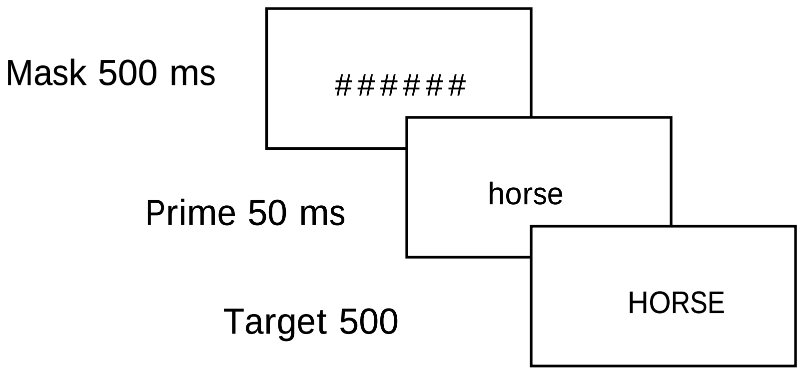

Figure 1.1. A typical three-field masked priming paradigm.

Although the prime is very difficult to detect, it produces a reliable effect on the lexical decision time for the target. The earliest and most reliable effect is the masked repetition priming effect (Evett & Humphreys, 1981; Forster & Davis, 1984), namely the recognition of the target is faster when the prime and the target are the same word. For example, the recognition of word *ATTITUDE* could be 50ms or 60ms faster (depending on the prime duration) when it is preceded by *attitude* as the prime compared to a different word or nonword as the prime. Forster and Davis (1984) argued that the masked repetition priming is a genuine lexical effect, and the reasons are as follows: first, such an effect was only found for word targets, not for nonwords (e.g., Forster, 1987; Forster, Davis, Schoknecht, & Carter, 1987; Rajaram & Neely, 1992). If masked priming is based on access to a lexical entry, only words have the possibility of being primed, because only those items have lexical entries. However, if masked priming were episodically based, one might expect that nonwords would also show a priming effect. Second, Forster and Davis (1984) showed that, with masked primes, high- and low- frequency word targets produced similar amounts of priming (e.g., Ferrand, Grainger, & Segui, 1994; Segui & Grainger, 1990; Sereno, 1991), whereas low-frequency words yielded substantially more priming than high-frequency words in a long-term priming paradigm, where subjects are aware of the prime (e.g., Duchek & Neely, 1989, Norris, 1984; Scarborough, Cortese, & Scarborough, 1977). This dissociation indicated that the masked priming paradigm eliminated the episodic influence that is present in a long-term priming paradigm, so the different priming effect from high- and low- frequency items is present in long-term priming, but absent in masked priming studies. Third, the influence of a masked prime is short-lived (seconds), whereas long-term priming effects are often long-lasting (minutes, hours, even days) (e.g., Forster, Mohan, & Hector, 2003; Forster & Davis, 1984). These dissociations serve as an important foundation for the assumption that masked priming is free of episodic influences (Forster, 1998; Bowers, 2000; Tenpenny, 1995).

Now let us return to what the masked priming studies would suggest about how newly-learned words are represented. Forster (1985) examined this issue on the assumption that if the masked repetition priming is restricted to words, then a no-longer used word such as *holimonth* should show priming only after a new entry has been created for it. So if such items were used in a normal repetition priming experiment, they will be treated as nonwords, hence there will be no priming effect. But if the meaning of *holimonth* was explained, and the subject is asked to make a "YES" decision to this new word in a lexical decision experiment, then if the training has the effect of creating a new lexical entry, it is conceivable that a repetition priming effect should be observed. However if the subject's decision is based on a nonlexical (i.e., episodic) representation, such an effect would not be expected. Compared to the Salasoo et al's (1985) study, the use of the masked priming technique ensured that any subsequent effect of this prime on the processing of the target would be purely lexical and free of episodic contamination. The first experiment in this study showed that if subjects were given the meaning of the new words, and were told to treat them as words in a lexical decision task, a very strong masked repetition effect was established immediately. There were two possible explanations: first, new lexical entries can be created very rapidly; second, the masked repetition effect is not restricted to lexical representations. To tell them apart, the second experiment used an episodic recognition memory task. Participants were given a list of nonwords to learn, and then were tested in a speeded recognition task, in which participants had to decide as rapidly as possible whether or not a target item was one of the nonwords that was on the learned list. Since there was no attempt to treat the items as words, and they were not designed to resemble existing words (e.g., *odduban*), any priming effect should be purely episodic. The result showed that priming effects can still be produced for both words and nonwords in an episodic recognition memory task, suggesting that nonlexical representations can also be primed by masked repetition.

By now it seems the memory issue has become increasingly complicated because it cannot account for different observations in word recognition. Salasoo et. al. 's study might not have made clear distinctions between memory traces stored in the episodic memory or the lexical memory, but Forster's study showed that although words showed masked repetition priming in a lexical decision task (and non-words did not), non-lexical representations can be primed in an episodic recognition task. So if we stick to the distinction of two memory systems (episodic vs. semantic), we have to say that both words and nonwords are possibly represented in both memory systems at different stages of development. Specifically, words are normally stored in the lexical memory, but they leave episodic memory traces after they were newly encountered (Forster, 1985; Experiment 1); as for the nonwords, they can be identified as well as words after repetition (Salasoo et. al., 1985), but it is not right to say they are stored in the lexical memory. It seems for the purpose of the current discussion that is mainly related with word recognition, using "episodic" memory as the counterpart of lexical memory might not be appropriate: the important thing is to distinguish the lexical memory and non-lexical memory, where lexical memory consists of abstract representations of words that can be retrieved automatically without consciousness, all the other representations are regarded as non-lexical representations. For this reason "non-lexical memory" (as well as episodic memory) will be used in the later discussions. It is hoped the current study will give us insights into the nature of this memory system so that we are in a position to give it a more accurate name.

1.3. The competition issue

Another issue in the investigation of whether newly learned words have established fully specified representations is about the effect they have on other lexical entries. As discussed earlier, this was referred to by Leach & Samuel (2007) as "lexical engagement". We used "competition" (reluctantly) simply because it might be easier to remember. We do not agree that the effect that newly learned words have on already-existing words are, in nature, competitive. In fact, competition is a key process in the Interactive Activation Model, but not in other models. Not all models acknowledge the existence of competition.

In word recognition research, competition is indicated by inhibition which has been observed repeatedly in a lot of studies. For example, Forster et al. (1987) found that form priming was obtained only for target words that had few neighbors (a neighbor is a word that differs from the target word by one letter). For example, when the target word has three or fewer neighbors (e.g., *axle*), then a related form-prime (e.g., *exle*) produces a facilitatory effect compared to an unrelated prime. But if the target word has more than seven neighbors (e.g., *face*), a related form prime has either no effect or an inhibitory effect. Besides, researchers have stressed that if the prime is a word, then the relative frequencies of prime and target determines whether the effect is facilitatory or inhibitory (Colombo, 1986; Lupker & Colombo, 1994; Segui & Grainger, 1990; Coltheart, Davelaar, Jonasson, & Besner, 1977). A low-frequency prime might have an inhibitory effect on a high-frequency neighbor target, but a high-frequency prime has no effect or less inhibition for a low-frequency neighbor target (Segui & Grainger, 1990).

What is the mechanism of the inhibition observed in the above cases? The Interactive Activation model (McClelland and Rumelhart, 1981; 1985; McClelland, Rumelhart, & Hinton, 1986) used the notion of competition to account for it. In the IA model, because of the assumption of parallel activation --- letter units simultaneously activate all word units containing those letters to varying degrees --- a given letter sequence will generate activation in many different word units, depending on the orthographic overlap between the input and the word units (see Figure 1.2.). This raises the problem of deciding which word unit is the correct unit. One solution would be to set a threshold on each word unit, so that the first word unit to reach threshold would send a signal to the decision system, declaring itself to be the winner. However, this solution is blocked by the assumption that activation is cascaded, which means that activation at one level is automatically passed onto the next level in a continuous fashion. Under those circumstances, the only alternative is to find the word unit with the greatest degree of activation. Computationally speaking, there are only two ways to do this. One is to serially scan all word units, checking to see whether the activation level in each unit is higher than in any previously scanned unit. This option loses all the advantages of parallel activation, and effectively turns the parallel model into a serial search model. The other method is to introduce a competitive process, in which each word unit attempts to drive the activation level in other word units down to zero. The one unit that survives will be the unit that matches the input best.

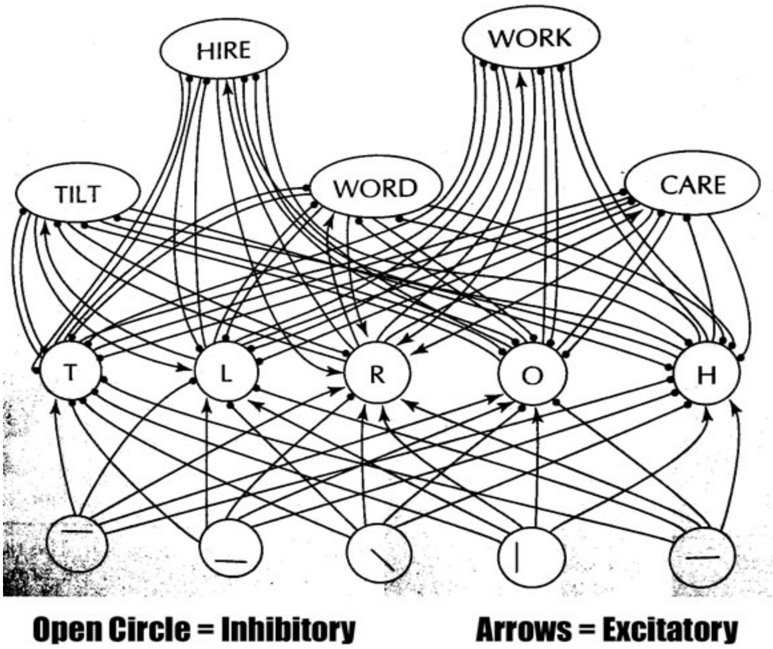

Figure 1.2. An illustration of McClelland & Rumelhart's Interaction Activation Model.

Without this competitive process, a cascaded parallel model has no way to identify the stimulus. In contrast, serial search models provide a different account (Forster, 1976; Paap, Newsome, McDonald, & Schvaneveldt, 1982; Morton, 1979). In these models, each word is considered as a lexical entry, and recognizing a word is like looking it up in a dictionary. The stimulus is compared with each lexical representation one by one, and a goodness-of-fit value is assigned after each comparison, which is further compared with the highest value obtained so far. If the current value exceeds the previous highest value, then the current lexical representation becomes the current best match. This serial comparison process is repeated until all representations have been considered, at which point the best match can then be determined (Forster, 1976). The competition process in the IA model is described as an elimination process of incorrect candidates in the search model. Specifically, when a close match is found it is flagged, the entry opening process is then initiated for the candidate, so that the detailed information contained within it can be checked against the input. As soon as an entry is flagged, the second stage of word recognition begins, which is referred to as the post-access check. In the post-access check, the flagged lexical entry is processed further to verify if the orthographic information of this entry represented an exact match to the orthographic code of the input. If the properties of the input and the properties of the lexical entry match, this entry is kept open and its contents become available for further processing, while other candidate entries are closed down (Forster et al., 2003). If the candidate does not match the input it is rejected and the comparison for the next candidate begins. The post-access verification is usually considered to be frequency-based, with high frequency words considered first, except that there is any candidate that reaches the level of a possible perfect match (as opposed to a close match), in which case the possible perfect match should be verified immediately.

In the masked priming situation, the process of looking for the best match triggered by the prime opens all entries that are close matches to the prime, which would include the target. Therefore when the target is presented, its entry will already be in the open state, and this leads to a savings in processing time. However, if the prime duration is long, each of the candidate entries for the prime would be evaluated, and those that were eliminated would be closed down (which would include the entry for the target word). This process of elimination of incorrect candidates corresponds to the process of competition referred to earlier, but with one important distinction --- search models' elimination (or resolution) account predicts no facilitation (or inhibition), but the IA model's competition account predicts inhibition.

The results reported by Forster & Veres (1998) supported the search model: in their first experiment, they compared the priming effects obtained from word primes and nonword primes (e.g., *converse-CONVERGE vs. convenge-CONVERGE)* at the prime duration of 500ms where the prime is visible. According to the model the long prime duration gives the system time to complete the resolution process when the prime is a word, lexical entries for other candidates are closed down, so the prime would not produce any saving effect on the recognition of the target. 3ms priming (no facilitation, nor inhibition) was found for word primes, but there was 58ms priming for non-word primes. However, the second experiment made the issue more complicated: the prime duration was reduced to 50ms, but 8ms priming was again obtained when the prime was a word, and 37ms priming was obtained when the prime was a non-word. It suggests that the effect of prime lexicality was found not only for non-masked primes, but also for the masked primes. Why is this the case? Their following experiments indicated that a critical variable is the use of non-word distractors. When the non-word distractors were only one letter different from a real word (e.g., *UMBROLLA*), the prime lexicality effect was found. But when it was altered to that they differed from a word by two letters rather than by one (e.g., *AMBROLLA*), priming for word primes were restored (32ms). But why should non-word distractors be responsible for the observed prime lexicality effect? This has something to do with the post-access check process. That is, when very close distractors are used, and word-nonword discrimination is difficult, an extensive post-access checking process is engaged, which obliterates any priming effect arising from a word prime but has no effect on priming from a non-word prime.

The Forster & Veres (1998) PLE was a case in which a null effect (no facilitation, nor inhibition) was observed for word primes. Later Davis & Lupker (2006) reported an inhibition effect using the same task in a masked priming paradigm, finding that related non-word primes facilitated lexical decisions to target words (18ms facilitation in average), whereas related word primes inhibited lexical decisions to the same target (-23ms inhibition in average). For the purpose of the current study we can put aside (temporarily) the issue of whether there should be inhibition or a null effect, and simply note that the finding that the lexical status of the masked prime determines the form priming effect is important because it provided a means to examine the lexical status of the newly learned words if we use them as primes. So if a Prime Lexicality Effect (henceforth PLE) is observed with newly learned words used as primes, one interpretation would be that these words have been represented lexically, which further suggests that the novel words have been lexicalized, and that they behaved more like words, rather than non-words.

Elgort (2007) tested this idea by examining the performance of L2 speakers. In her study, subjects were first instructed to learn a set of novel words that were one letter different from a real English word (e.g., *abstair*, *forfert*). Each new word was given a meaning that was created by the author, for example, *abstair* means "steps attached to poles and railings of scaffolding for construction workers to climb up and down", *forfert* means "a round open container, usually not very deep, used in building and industry, for example, for washing or mixing materials". The subjects were given word cards with the new words and their meanings on it, and were instructed to practice learning the meanings every day for one week. Then the subjects came back for the test at the end of the week. In the test the newly learned words were used as primes while the targets were the real words that are one-letter different from the new words (e.g., abstair-ABSTAIN, forfert-FORFEIT). She found a prime lexicality effect, i.e., the newly-learned words behaved more like word primes in that no priming was obtained (0ms after some data trimming), while nonword primes produced significant priming (75ms). It is clear that some kind of representation of the newly-learned words had been established, which competes with the already-existing representations of the target words, thus facilitatory form priming was not obtained for these items. .

This is a very encouraging finding. First, it proves the effectiveness of PLE as a diagnostic indicator of the lexical status of the items. Elgort (2007) found that the priming experiment result is consistent with the results from the new word retrieval test, where the researcher read the definitions of the new words in a random order, and the participants were asked to write down the new words corresponding to the definitions. The retrieval test results showed that an average of 45 new words were successfully produced, this represent 94% of the complete set of 48 new words (p. 107). Therefore both tests showed that new words were learned and certain representations were established. Second, this is the first study that replicated the PLE with L2 speakers. It suggests that the structural organization of the orthographic lexicon is likely to be similar for monolinguals and bilinguals, at least for advanced L2 users.

However, one weakness in Elgort's (2007) study is that the PLE was observed with unmasked primes rather than masked ones. This poses the problem that we do not know whether the knowledge of the newly learned words is accessed automatically or not. Presumably if the newly learned words have lexical representations, the access should be automatic, that is, no strategic processing is involved. However, it is obvious that unmasked form-priming allows the subjects to consciously process primes and may lead to the development and use of strategies. Previous studies showed that only masked priming paradigms offer the promise of “tapping automatic, strategy-free lexical processing” (Forster et. al., 2003). Therefore it would be enlightening if experiments can be carried out to examine PLE using masked primes. This is what the current study is going to do.

Since the issue of L2 vs. L1 speakers is another interesting and relevant variable in this discussion, the current study will test both native speakers and L2 English learners to examine the organization of L1 lexicon and L2 lexicon.

1.4. The L1 lexicon vs. the L2 lexicon

The previous discussion focused on visual word recognition in the first language, this dissertation will also consider the organization and function of the bilingual lexicon. The most relevant discussion concerning the L1 and L2 lexicon is (1) whether the two language systems are *separated* (language dependent) or *integrated* (language independent); (2) whether the L1 and L2 codes are accessed (or processed) in a *selective* or *non-selective* manner, i.e., whether bilinguals operate within one of their languages, or whether their other language(s) also become activated in the processes of comprehension and production. The first question is about the structure or organization of the bilingual representations, and the second is about the processing or the functioning of the bilingual system. These two sets of issues have often been considered together in the literature, but they are not identical, so the answers to them might not have perfect one-to-one correspondence.

Most studies generally acknowledge that different types of connections between L1 and L2 lexicons exist simultaneously. For example, there is the situation where the two lexical systems are directly connected to a common conceptual system; there is also the situation in which the two lexical systems are connected to separate language-dependent conceptual system; or there is another situation where the lexical items in the second language are connected only indirectly to the conceptual system via their translation equivalents in the first language (Weinreich, 1953; Jiang & Forster, 2001). The question was also considered from the point of view whether bilingual codes are integrated or shared at all levels of representations --- sublexical, lexical, semantic, and conceptual. Paradis (1997), for example, suggests that word forms and meanings are represented separately for the languages of a bilingual, but the conceptual representations are the same for the languages. It was also suggested that these different connections might be a factor of development: e.g., beginning L2 learners rely more on direct lexical links between L2 words and their L1 translation, while more proficient bilingual speakers rely on both lexical links and shared conceptual representations (Kroll & Stewart, 1994).

As for the processing issue, researchers who believe that L1 and L2 are represented by two independent systems also mostly consider access to these systems as selective or language dependent, while researchers who believe that L1 and L2 are represented by the same integrated system tend to consider access to these systems to be non-selective. However, evidence from recent bilingual studies seems to converge on the integrated conceptual system (see Van Heuven, Dijkstra, & Grainger, 1998), with supporting evidence including the ability of bilinguals to translate most words from one language to another, semantic priming across languages and bilingual semantic word interference effect in picture naming (Kroll, Michael, & Sankaranarayanan, 1998; Sholl, Sankaranarayanan, & Kroll, 1995; see Kroll & Sunderman, 2003, for a review).

Besides, studies that focus on the processing aspect found that strength of the links may vary depending on which language or direction of connection is involved. Specifically, two asymmetries are suggested. At the lexical level, the connection from an L2 word to its equivalent in the first language is found to be stronger than that from an L1 word to its L2 equivalent. At the conceptual level, however, the links between L1 words and the concepts are stronger than that between L2 words and the concepts (Kroll & Sunderman, 2003).

In addition to the discussion about separated/integrated systems and selective/non-selective approach in processing, it has been proposed in the bilingual literature that L1 and L2 may be utilizing qualitatively different memory types, such as implicit memory for L1 and explicit memory for L2 (Paradis, 1997), or semantic memory for L1 and episodic memory for L2 (Jiang & Forster, 2001). The latter is particularly relevant to the current study for the following reasons: firstly, we have pointed out that the question of the representation of newly learned words is in many ways a memory issue, thus evidence from the L2 speakers' performance should provide helpful input to investigate this issue. For example, what will happen if L2 speakers are taught made-up new words in their L2? Will the already-known L2 words compete with newly learned ones? If Jiang & Forster (2001) were right in that both L2 new words and L2 already-known words are stored in the episodic memory, do we get stronger competition because they are in the same memory system, or is there no competition because there is no competition in episodic memory? Secondly, can we find PLE after the same amount of training as has been given to L1 speakers? If not, what does this tell us about the L1 and the L2 lexicons?

In summary, the current study attempts to examine the representation of newly learned words in the mental lexicon of L1 and L2 speakers with the specific research questions as follows:

(1) From the memory perspective, what memory traces are left after participants learn the new words? Are newly learned words stored in the same memory system as the already-known words?

(2) From the word recognition perspective, what effect do the newly learned words have on their word neighbors? Is the Prime Lexicality Effect a reliable measure of the lexical status of the newly learned words?

(3) How will L2 speakers perform after learning the same set of new words? What differences will be found concerning the organization of the L1 lexicon and the L2 lexicon?

In order to answer the first question, two different ways of learning will be included in the current study: one is that participants are required to get familiar with the new words by typing them repeatedly and comparing the spelling with other words. In this *mere familiarization* stage, no meaning is provided to the novel items. Participants will not be told that these are new words in English, nor are they required to remember them, which altogether makes it an incidental learning task. It is hypothesized that in this case the possible memory trace established (if any) would be the most extreme case of non-lexical memory. A Prime Lexicality Effect will still be tested under such a situation. Experiments and results will be discussed in the second chapter.

In the second *real acquisition* stage, another group of participants will be tested. This time definitions and pictures will be provided for the words to be learned. The participants will be instructed to remember them as new English words, and are told they will be tested after a certain amount of learning. The assumption is that after the training, this time a lexical memory trace might be established. Therefore a PLE should be observed in the masked priming experiment. Details of the experiments and results with this type of training will be reported in the third chapter.

In the fourth chapter, real acquisition training will be used on a group of Chinese-English bilinguals, and the implications concerning the organization of the L1 lexicon and L2 lexicon will be discussed. The fifth chapter is a summary of the study.

CHAPTER 2 THE EFFECT OF MERE FAMILIARIZATION

2.1. Rationale

'Familiarization' in this study refers to a learning stage in which learners only get to be exposed to the new words, without being told what the new words mean, nor how they should be used. Even if a decision has to be made on the lexical status of these new items, the answer would be "No, they are not English words". Nevertheless, some learning is involved, for example, typing the new items repeatedly, or making same-difference judgments (both will be used in the following experiments). The nature of this kind of learning is becoming familiar with the novel items at the level of form only.

There are multiple reasons why we include familiarization as a stage of learning. Firstly, it might provide a chance to separate non-lexical memory traces established in learning new words from ultimate lexicalization, if the memory systems are separable. The second reason is more related to the explanation of previous results. Take the Elgort (2007) experiment as an example. This study examined the priming effect produced by newly learned words (used as primes) on their real-word neighbors. Since the newly-learned word primes produced little or no priming while non-word primes produced significant form priming (i.e., a PLE), the indication was that the newly learned words behaved more like real words rather than non-words. However, one thing we do not know is whether lexical representation is the necessary condition for PLE to occur, in other words, we do not know whether a non-lexically represented (e.g., familiarized) nonword prime might produce a PLE as well. This is important because if it is true, it would mean that non-lexical representations can compete with lexical entries, a finding that is very important because of the role competition is playing in word recognition.

This question has been a concern of other lexical acquisition studies as well. For example, in a study to test the effect of learning new words such as 'banara', Bowers et. al. (2005) asked participants to type the new words many times and then performed a semantic categorization task on its word neighbour BANANA. Interference was observed immediately after the training on Day 1, and the size of interference became larger on Day 2. These findings were taken as evidence in support of lexical competition, which exerted an inhibitory effect on visual word identification. An obvious objection to this conclusion, however, is that the observed inhibitory effects might be due to the biases or strategies based on episodic memory, rather than lexical competition.

The authors argued that the effect cannot be episodic because it is difficult to see how an episodic record of BANARA could influence a semantic judgment about BANANA. This is a valid argument. However, the way BANARA interferes with BANANA might not be through the process of semantic judgment *per se*, it might instead be through the process of recognizing BANANA, prompted by an uncertainty about whether BANANA had been perceived correctly: did I see BANANA or BANARA? It is even possible that the episodic record for BANARA includes the information that this is very similar to the word BANANA, i.e., subjects realized during the training session that these nonwords are all similar to real words. So one might say that the episodic trace established for BANARA interferes with the recognition (rather than the semantic categorization) of the target BANANA, therefore the experiment showed that episodically established neighbors have an inhibitory effect, but that doesn't say anything about whether the familiarized nonwords had been lexicalized or not.

In conclusion if we want to be certain that one effect is lexically based, it is necessary to test whether representations other than lexical ones will not produce the same effect. This is the purpose of this chapter: to examine the effect of mere familiarization, thus to have a comparison with the lexical effects that will be examined in the subsequent chapters.

2.2. General Method

Experiments in this chapter were conducted using the same method, especially the same training process, which is described in detail here.

2.2.1. Materials

The novel item set consisted of 48 nonwords which were constructed by changing one letter in a real word (e.g., *baltery* derived from *BATTERY*). The real word is referred to as the base word. The position of the letter being changed varied, but all novel items were orthographically legal and pronounceable.

The base words were all six to eight letters in length, relatively low in frequency, and had none or small numbers of neighbors (see Table 2.1. for detailed description). The length, frequency and neighborhood density of the base words were all considered in the selection of the items because they would influence whether a facilitation or inhibition would be obtained in the form priming experiments.

First, long base words were used so that the proportion of overlapping letters was high enough to ensure that priming should be obtained. When there was only one letter different between the new word and the base word, 6 out of 7 letters were the same in the 7-letter-long word, but only 3 overlaps in a 4-letter-long word. Form priming is easier to obtain when the proportion of overlapping letters is relatively high.

Second, as far as the frequency is concerned, it has been argued that perception of a low-frequency word with a high-frequency neighbor may require the active inhibition of that neighbor, that's why a low-frequency prime might have an inhibitory effect on a high-frequency target, but a high-frequency prime has less of an inhibitory effect for low-frequency targets (Colombo, 1986). Because of this reason, most base words in the current study were relatively low in frequency. However, a pilot study showed that after learning the novel items, the participants made many mistakes in recognizing the base word targets. We reasoned this was because the representation of the low-frequency words were not very stable, and the learning in this study therefore had a surprisingly strong influence on the recognition process. Therefore considering the involvement of learning, and the nature of the lexical decision task, we selected base words with medium frequency in this study. The mean CELEX frequency for the complete item set was 131 per million, with a range between 10 and 500 counts per million (without the two outliers of 700ms and 1400ms). The distribution of the frequency (and also neighborhood, and length) is illustrated in Table 2.1.

Another factor that affects whether the form priming is facilitatory or inhibitory is the neighborhood density. A facilitatory effect, for example, was observed when the target word had three or fewer neighbors, but either no effect or an inhibitory effect was found when the target word has more than seven neighbors (Forster et al., 1987). For this reason, relatively low-density base words were used to ensure that priming effects were not obscured by high neighborhood density. The mean number of orthographic neighbors of the base words was 1.1, with a range between 0 and 6. The distribution of the neighborhood density (and also frequency, and length) is illustrated in Table 2.1.

Table 2.1. The distribution of length, frequency, and neighborhood density of the 48 base words used to create the novel items.

	Range	*Number of instances*
Length (letters)		
	6 letters	19
	7 letters	27
	8 letters	2
Frequency (counts per million)		
	<50	14
	50-100	11
	100-200	11
	200-300	4
	300-400	4
	>400	4
Neighborhood density (numbers of orthographic neighbors)		
	0	24
	1	11
	2	7
	3-6	6

In each experiment, there was a training phase and a testing phase. The training phase consisted of familiarization with the non-words. The testing phase consisted of a masked form priming experiment, in which the base words (e.g. *BATTERY*) were used as targets. Each target was first associated with an unrelated control prime that differed from the target in all letter positions (e.g., *denssel-BATTERY*). The control primes were orthographically legal nonwords generated automatically using WinWordGen 1.0 (Duyck, Desmet, Verbeke & Brysbaert, 2004). A series of related primes was also constructed for each target word, depending on the conditions being tested in each experiment. In most cases two types of related primes were constructed in order to compare the effect of learning: one was the familiarized novel item such as *baltery*; the other was constructed by replacing the letter at the same position where the novel item differed from the base word, e.g., *bantery* as compared to *baltery* and *battery*, but no training was involved for *bantery*.

In addition to the word targets, a set of 48 orthographically legal non-words was constructed to act as nonword targets in the lexical decision task. These items were also six to eight letters in length. Since there was no learning involved for the nonword targets, in most cases the prime conditions were simplified to related primes (where the primes differ from the target by only one letter) and control primes (where the primes differ from the targets in all letter positions). The complete set of items is presented in the Appendices.

2.2.2.Procedure

The experiments reported in this chapter used the same training procedure. First novel items were presented on the screen one each time. The participants were asked to type them out. When they were typing, the word remained on the screen until the typing was finished, and the "enter" key was pressed. Participants were able to view the letters they typed and correct any error they made using the backspace key. The novel items were presented in a randomized order within one block. Altogether there were three blocks of typing.

After the typing task, a same-different matching task followed as one more way of familiarization. A novel item was first presented on the screen for 1000ms in lower case letters, followed by a series of hash marks (######) for 500ms, which were followed by another letter string which is either the same as the novel word, or totally different from it (no letter shared in the same position). The hash marks and the second letter string were both presented for 500ms. Therefore after a trial or two the participants would learn to take advantage of the long presentation of the novel words which would make it easier to decide whether they were the same or different afterwards. Whether the novel item was followed by the same or a different letter string was decided randomly. To make the format of each part of the experiment as similar to each other as possible, the second letter string was presented in upper case. There were altogether two blocks of same-different matching.

In the test phase, the participants were told to make decisions on whether the letter string they saw was a word or not. Whenever the necessity arose, they were told the novel items they typed and learned were not English words, thus a "NO" decision should be made on these items. All trials started with a forward mask --- a row of hash marks (########), presented for 500 ms. The mask was then replaced by the prime which was presented in lower case letters for 50 ms, which was then replaced by the upper-case target which was displayed for 500 ms. The combination of the forward mask and the backward masking provided by the target effectively prevented the conscious detection of the prime and no participant reported being aware of it (for details of prime visibility determined under similar conditions, see Forster et al., 1987).

In the analysis of data, incorrect responses were discarded, participants whose overall error rates exceeded 21% were rejected. Reaction times (RT) that were above 1500ms or below 300ms were excluded, outliers were treated by setting them equal to cutoffs of two standard deviations above or below the mean for each subject.

The experiment was controlled by a Pentium PC, using the Windows DMDX software developed by J.C. Forster at the University of Arizona (Forster & Forster, 2003). The learning and testing phase were implemented continuously one after another without interval. After each trial a feedback informed the participant of the speed and accuracy of their response. All items were presented in a different pseudorandom order for each participant. After the participant responded and the feedback was displayed, the next trial was initiated automatically. Prior to the experiment beginning, 12 practice items were used. Counterbalanced lists of items were prepared so that across lists, each target word appeared in all the related learned, related unlearned, and unrelated conditions, but not in the same list. Participants were assigned to lists in order of appearance at the laboratory.

2.3. Experiment 1: Mere familiarization and PLE

The purpose of this experiment was to examine whether mere familiarization will produce a Prime Lexicality Effect in the testing phase. If priming is reduced when a familiar nonword prime is used, then the effect found by Elgort (2007) is really a PFE (Prime Familiarity Effect), and says nothing about whether the primes had become lexicalized. To minimize the possibility of strategic influences, and to increase the likelihood that any priming effects are more likely to be the result of automatic processes, a masked priming paradigm was used (Forster & Davis, 1984). The prime duration was 50 ms.

2.3.1. Method

Participants. A total of 34 undergraduate students enrolled in an introductory Psychology course participated in the experiment, for which they received course credit.

Materials and Design. The complete novel item set consisted of 48 non-words which are one letter different from the English base words, as described in the General Method. In this experiment each participant learned 20 items in the learning phase, where 16 of them were novel items from the critical set as described in the General Method, while an extra four items were included in this experiment to reduce the proportion of learned items that have critical base words.

In the testing phase where a masked priming technique was used, each critical target had three types of primes --- the related familiarized prime (e.g., *baltery-BATTERY*), the related unfamiliarized prime (*e.g., bantery-BATTERY*), and an unrelated prime (e.g., *denssel-BATTERY*). The item with a familiar prime (*baltery-BATTERY*) was compared with the same target primed by an unfamiliar prime (*bantery-BATTERY)*, where the orthographic difference between prime and target (letter *t* was substituted by another letter) was held constant. The amount of priming was assessed in each case relative to the unrelated baseline item *denssel-BATTERY*. Nonword targets were primed by an identity prime (e.g., *truffic-TRUFFIC*), a one-letter different nonword prime (e.g., *troffic-TRUFFIC)* or a completely unrelated nonword (e.g., *inittal-TRUFFIC*). Three counterbalanced lists of items were prepared so that across lists, each target word appeared in all the related learned, related unlearned, and unrelated conditions, but not in the same list. The complete list of materials is presented in the Appendix A.

Procedure. The procedure was the same as described in General Method.

2.3.2. Results

2.3.2.1 The training phase

The training was composed of two parts: typing, and same-different matching. Participants were not told to type as fast as they can, so the time recorded for typing was not analyzed. Analysis was carried out on the matching time and accuracy recorded for the same-different matching task. The results are reported in Table 2.2.

The ANOVA analysis showed that participants were much faster in the second same-different matching block. The difference of the matching time between the two blocks was significant in both subject analysis and item analysis, $F1\ (1, 27) = 15.03$, $p < .001$; $F2\ (1, 57) = 20.32$, $p < .001$. No difference was found on the accuracy data between the two blocks. The average error rate for both subject and item analysis was only around 5%.

The results indicate that participants responded faster when they got to the second block of same-different matching, without sacrificing the accuracy. We can therefore conclude that a learning effect was found in Experiment 1. The mean choice time and error rates were presented in Table 2.2.

Table 2.2. Mean same-different matching times and error rates in the training phase of Experiment 1.

	First block	*second block*	*improvement*
Matching time	540	494	46***
Error rates	5.5	5.6	-0.1

*** p<0.001.

2.3.2.2. Testing phase

Four participants were excluded from the analysis because of their high error rates (higher than 21%). The following results were based on a total of thirty participants. The mean times and error rates are presented in Table 2.3.

Two analyses of variance were performed on the words and nonwords separately, one treating subjects as a random effect (F1), the other treating items as a random effect (F2). The factors for the word analysis were Groups (subject groups in the subject analysis, item groups in the item analysis), Familiarized/Unfamiliarized primes, and Priming (related vs. unrelated control). The Groups factor was included to remove variance due to the counterbalancing procedure, and was a non-repeated factor in both analyses. The factor of whether the prime has been familiarized or not was a repeated measures factor in the subject analysis, but not in the item analysis, whereas the Priming factor was a repeated factor in both analyses. All effects with a *p* value less than .05 are deemed significant.

Table 2.3. Mean lexical decision times and error rates (in parentheses) for word and non-word targets in the testing phase of Experiment 1.

	Related Prime		Control *(boozier-BATTERY)*	priming
Word targets	Learned novel items *(baltery-BATTERY)*	565 (6.3)	589 (6.1)	24** (-0.2)
	Unlearned items *(bantery-BATTERY)*	573 (3.6)	589 (6.1)	16 (2.5)*
Nonword targets	Repetition (*truffic-TRUFFIC*)	679 (13.2)	679 (9.5)	0 (-3.7)
	Form *(troffic-TRUFFIC)*	684 (10.8)	679 (9.5)	-5 (-1.3)

** p<.01, * p<.05

2.3.2.2.1. Reaction times and error rates for word targets

The mean lexical decision times and error rates are shown in Table 2.3. In the analysis of lexical decision times, the main effect of Priming for familiarized primes (24 ms) was significant, $F1 (1,27) = 8.39$, $p<0.01$; $F2(1,45) = 6.21$, $p<0.05$. The main effect of priming for unfamiliarized primes (16ms) was only approaching significance in the subject analysis, $F1(1, 27)= 3.71$, $p=0.06$; not in the item analysis, $F2(1, 45) = 2.64$, $p>0.05$. The difference of the priming effect between the familiarized and unfamiliarized primes (24ms vs. 16ms) was not significant, (both $Fs < 1$).

A one-way analysis of ANOVA indicated that familiarized primes produced more errors than unfamiliarized primes (e.g. *bantery*), the difference was significant in subject analysis, $F1 (2, 54) = 3.34$, $p<0.05$; but not in item analysis, $F2 (2, 90) = 1.60$, $p>.05$.

2.3.2.2.2.Reaction times and error rates for nonwords

No significant priming effects were observed for nonword targets, either repetition priming (0ms), or form priming (-5ms). As for the error rates, no significant differences were found either.

2.3.3. Discussion

The most striking and important aspect of the data obtained in Experiment 1 was that no significant difference was found between the priming effects from the familiarized primes compared with the unfamiliarized primes when the learning process is mere familiarization. The magnitude of priming even went in the wrong direction --- familiarized primes produced bigger priming than the unfamiliarized primes, although the difference was not significant.

As far as the prime lexicality effect is concerned, the results indicate that mere familiarization cannot produce a PLE, which further indicated that the PLE Elgort (2007) observed was unlikely to be due to familiarity. However, a very important difference between these two studies is that Elgort (2007) tested unmasked priming, while Experiment1 tested masked priming. Whether the different results were due to the visibility of the primes will be tested in later experiments.

It is perhaps not surprising that normal form priming was observed after the participants were familiarized with the primes. According to the entry-opening model , what happened was that the recognition process triggered by the prime (e.g., *baltery*) opened all entries that were close matches to the prime, which included the target (e.g., battery). When the target was presented, its entry was already in an open state, and this led to a saving in processing time. The same process applied to the unfamiliarized primes (e.g., *bantery*). This was the reason why no appreciable difference was found in the priming effects between these two conditions.

However, this raised a problem for the Bowers et. al.'s (2005) study. As we have described earlier, their study found that after *banara* was familiarized, the semantic categorization time on BANANA was significantly longer than the unfamiliarized condition. They concluded that familiarizing *banara* produced competition with the processing of BANANA. However, if competition was indeed involved, and the training enabled *banara* to compete with *BANANA*, then in a masked priming experiment, we should get less priming for *banara-BANANA* than for an item with an unlearned prime such as *banata-BANANA*. But this was not the case in the current experiment, the learned prime produced even larger priming (24ms) than the unlearned primes (16ms). In order to explain the results from these two studies, it seems one has to either give up the idea that *banara* competes with *BANANA*, or one gives up the idea that competition is relevant for masked priming.

In summary, no effect of familiarization on form-priming has been found in this experiment. This might be taken as showing that Elgort's PLE was not simply an effect of familiarization, although it could be argued that the training technique used in this experiment (typing and same-different matching) might not be sufficient to establish any kind of representation that was relevant to priming. For example, suppose that the familiarization procedure did not establish a strong enough representation of the familiar nonword prime to distinguish it from the unfamiliar prime. Both primes would then function as unfamiliar nonword primes, and hence equal priming is obtained. If this was the case, then if the primes are used as targets in a masked repetition priming experiment, neither would show an priming. But if a clear episodic record has been established, the familiar nonwords should show priming, but the novel nonwords should not. Experiment 2 tests on this hypothesis.

2. 4. Experiment 2: Mere familiarization and masked repetition priming

2.4.1. The masked repetition priming effect

The masked repetition priming effect is probably the most robust effect recorded with the masked priming paradigm (Evett & Humphrey, 1981; Forster & Davis, 1984; Forster et al., 2003). It has been found widely in English, languages other than English , L1 speakers, L2 speakers, high-frequency words, low-frequency words, and so forth . Among the issues about masked repetition priming, the one that is relevant to the current study is the finding that this effect was observed only on words, not on nonwords. Forster & Davis (1984), for example, found repetition priming for words, but not for non-words when the prime duration was 60ms. Kouider & Dupoux (2001) found significant priming effects for words with three prime durations (33, 50 and 67ms). However, non-words in the same study failed to produce significant priming effect at 33ms and 50ms, although they did produce significant priming (of 36ms) with the 67ms prime duration. The same pattern was also found for L2 speakers: no significant masked repetition priming for the L2 non-words was found by Jiang (1999), although they did find significant priming effect for L2 words. Furthermore, in experiments with Hebrew dominant Hebrew-English bilingual participants (Experiments 1 & 3) with a 50ms prime duration, Gollan, Forster,

& Frost (1997) did not find significant repetition priming either on Hebrew (within-L1) or English (within-L2) non-words.

The question that Experiment 2 asked was, was the representation of the *familiar* nonwords sufficient to show repetition priming in a lexical decision experiment when it was both the prime and the target? If it wasn't, then there would be no priming (as would be the case for the novel nonwords). If there is priming, it would indicate that the familiarization procedure in Experiment 1 must have established a clear enough representation to produce repetition priming when used as a target. The current experiment would serve as a good test on the lexical status of the familiarized nonwords and their possible influence on the masked priming effect.

2.4.2. Method

Participants. A total of 48 undergraduate students enrolled in an introductory Psychology course participated in the experiment, for which they received course credit.

Materials and Design. The 48 novel items were identical to those in Experiment 1. Each target had one related prime (identical to the target, e.g., *baltery-BALTERY*, *traffic-TRAFFIC*) and one unrelated prime (differing in all letter positions from the target, e.g., *denssel-BALTERY*, *inittal-TRAFFIC*). Four sets of materials were constructed to achieve counterbalancing of targets across the four priming conditions: familiar identity primes, familiar control primes, unfamiliar identity primes, and unfamiliar control primes. Each target appeared once in any particular list but in a different condition across the lists. For the training purpose, two lists of materials were constructed, so every two groups of participants learn one list, and that list of learning was followed by two corresponding lists of testing (identity primes and control primes). Each participant learned 24 novel items.

Since no meaning was provided for the novel items, the participants were instructed to say "no" to both the familiar and unfamiliar non-words. Therefore the novel items functioned as non-word targets in this experiment. The non-word targets in Experiment 1 were changed back to their base words (real English words), and used as word targets. There were altogether 48 non-word targets and 48 word targets. The complete list of materials is presented in the Appendix B.

Procedure. The procedure was the same as described in General Method.

2.4.3. Results

2.4.3.1.Training phase

As in Experiment 1, the training in Experiment 2 was also composed of two parts: typing, and same-different matching. We will use the matching time and error rates in the same-different matching as the criteria for examining the learning effect.

The mean matching time and accuracy data were presented in Table 2.4.

Table 2.4. Matching time and error rates for the same-different matching task in the learning phase in Experiment 2.

	First block	*second block*	*improvement*
Matching time	491	459	32*
Error rates	8.0	8.9	-0.9

*p<0.05

The ANOVA analysis showed that participants got much faster when they did the second same-different matching. The difference of the matching time between the two blocks was significant in subject analysis, $F1\ (1, 40) = 6.27$, $p < .05$; but not in item analysis, $F2\ (1, 92) = 1.64$, $p > .05$. Similar to what was found in Experiment1, no learning effect was shown in the error data, participants did not make less errors in the second block of same-different matching, the results actually went to the opposite. However, since a significant speed-up was found in the matching time, we concluded that the same-different matching results suggested that the learning was effective.

2.4.3.2. Testing phase

Because of the high error rates in this experiment, a higher cutoff of 30% was used in the data trimming. Four participants were excluded from the analysis because their overall error rate exceeded 30%. The mean reaction times and error rates based on 44 participants are presented in Table 2.5.

The initial ANOVA analysis had three factors for the non-word analysis (which was the critical analysis since the newly learned novel items were treated as non-words in this experiment): Groups, Familiarized/Unfamiliarized primes, and Priming (identity vs. control). There were four levels for the Groups factor, two levels for the other two factors. Two factors were considered for the word analysis: the Groups, and the Priming (identity vs. control).

Table 2.5. Mean reaction times and error rates (in parentheses) for word and non-word targets in Experiment 2.

	Related Prime		Control *(densselr-BALTERY)*	Priming
Nonword targets	Learned novel items *(baltery-BALTERY)*	640 (19.3)	666 (17.9)	26**
	Unlearned items *(dresent-DRESENT)*	661 (10.8)	662 (11.9)	1
Word targets	Related *(traffic-TRAFFIC)*	578 (10.1)	608 (16.3)	30***

*** p<.001, ** p<.01

2.4.3.2.1. Lexical decision times and error rates for nonword targets

The mean lexical decision times and error rates were shown in Table 2.5. In the analysis of lexical decision times, the main effect of Priming for familiarized primes (26 ms) was significant, F1 (1,40) = 12.96, p<0.01; F2 (1,44) = 6.69, p<0.05. The main effect of priming for unfamiliarized primes (1ms) was not significance in either the subject analysis, F1(1, 40)= 0.03, p>0.05; or in the item analysis, F2 (1, 44) = 0.14, p>0.05. The difference of the priming effect between the familiarized and unfamiliarized primes (26ms vs. 1ms) was significant in both subject analysis, F1 (1, 40) = 5.11, p<0.05; and item analysis, F2 (1, 88) = 3.96, p<0.05.

The error analysis indicated that familiarized primes introduced more errors than unfamiliarized primes, the difference was significant in subject analysis, F1 (1, 40) = 13.7, p<0.001; and in the item analysis, F2 (1,88) = 10.2, p<0.01.

2.4.3.2.2. Reaction times and error rates for words

Significant identity priming (30ms) was observed for the real word targets in both subject analysis, $F1 (1, 40) = 33.83$, $p<0.001$; and item analysis, $F2 (1, 92) = 14.34$, $p<0.001$. Significant identity priming was also shown in the error data, the priming effect was significant in both subject analysis, $F1 (1, 40) = 34.27$, $p<0.001$; and item analysis, $F2 (1, 92) = 6.35$， $p<0.05$.

2.4.4. Discussion

The critical result of this experiment was that repetition priming was found for familiarized non-words, but not for unfamiliar non-words. Compared to what we have discussed in the beginning, this finding seems incompatible with the belief that repetition priming can be found only for words. Although learning was involved, the familiar new items in this experiment were not indeed words, and in doing the lexical decision task, the participants' responses to these items were, in fact, "no, they are not English words". It was obvious that the repetition priming effect we observed here cannot be a lexical effect, it must be from different sources other than lexical level information.

In fact, a debate on the locus of masked repetition priming (or sometimes the locus of any priming effect) has been going on for a long time. The Bodner and Masson group has carried out a series of studies to argue that the priming effect is pre-lexical in nature (Bodner & Masson, 1997, 2001; Masson & Bodner, 2003; Masson & Isaak, 1999). They believed that primes only influence processing that takes place prior to lexical interpretation. In other words, priming is restricted to the recognition of the sub-lexical constituents of a word (e.g., letters, bodies, or syllables). Therefore initially words and non-words get almost the same amount of priming since there is no difference in their sub-lexical constituents. But why there is no priming observed for nonwords in a lexical decision task? Bodner and Masson argued that the prime increased the perceived familiarity of the nonword target, which induces a bias to respond "Yes" (meaning "yes, this looks familiar") although the correct response is "No". This contradiction introduces a delay in response time, which cancels out the sub-lexical facilitation effect nonwords should get. Therefore there is no priming for non-words .

Can Bodner & Masson's pre-lexical argument account for the current result? If their argument was true, the prediction for the current experiment would be like this: after typing, participants got very familiar with the new words, therefore there was a stronger tendency for them to say "yes, these are words" or "yes, they look familiar". This has been supported by the high error rates on the trained words --- participants made significantly more errors on familiarized targets than on unfamiliarized targets. However, the stronger the tendency to give a "yes" response, the less priming should be produced. Therefore they should predict that familiarized non-words should produce less priming than unfamiliar non-words, which was not supported by our results.

What could be a good explanation for the repetition priming we found in this experiment then? One possible explanation is that the training has established a clear enough representation that can be primed in a masked priming experiment. It can be in episodic memory, as proposed in Forster (1985), where it was found that after subjects memorized a list of non-words, a significant priming effect was observed in an episodic recognition experiment in which participants had to classify each item as "old" or "new".

This was a clear effect of episodic memory traces since the task (episodic recognition task) presumably contacted the episodic memory system. It was not clear what memory traces produced the masked repetition priming effect in the current experiment, but it was clearly not lexical because participants were classifying them as nonwords.

There are other studies that observed memory traces formed for non-words, especially after training. For example, Feustel, Shiffrin, & Salasoo (1983) and Monsell (1985) called the representation that newly studied non-words established as temporary "lexical nodes". In their study participants were asked to identify the items that they learned in the training session. They found that trained nonwords were recognized faster than untrained nonwords. They proposed that it was the formation of temporary "lexical nodes" that accounted for the speed-up in the result. Similarly, Rajaram & Neely (1992) also found facilitation in both lexical decision task and episodic recognition task for studied non-words, which replicated the results reported by Forster (1985).

Recently Norris & Kinoshita (2006) made a more liberal suggestion based on the Bayesian model of word recognition. They suggested that the only condition for priming to occur was the prior representation. As long as there was a representation, the process of accumulating evidence for perception started. This process, with the result similar to the priming effect observed in the experimental studies, was not directly determined by either the nature of the target (words vs. non-words), or even by the relationship between prime and target (p. 12). The same pairing of prime and target that produces substantial priming in one task may produce none at all in another. Instead the priming is mainly driven by the nature of the representations and decisions required by the task. However, they did not provide detailed explanations as to how the nature of the representation influenced the priming, which made it hard to pursue their argument.

All the above explanations focused on the establishment of certain representation for learned non-words, but there are other explanations that do not rely on the influence of new memory traces. For example, Forster (1998) found that non-words that were one-letter different from real words (e.g., *fagulous*) tended to show repetition priming. This effect was explained using the entry-opening model: since the base word *fabulous* was in a relatively sparse neighborhood, when the system saw the prime *fagulous,* the entry for *fabulous* would be opened. Then when *fagulous* was presented again as the target, in order for the system to say "no, it’s not a word", an orthographic check to make sure it was not *fabulous* was necessary. At this point, since the entry for *fabulous* has already been opened by the prime, less processing time was needed, and thus there was a priming effect.

If this argument were correct, it would predict that the learned primes produced faster responses than the unlearned primes. A planned comparison on the absolute RT in the present experiment supported this prediction: the learned primes did produce faster response (653ms) than the unlearned primes (661ms), but the difference was not significant in either subject analysis or item analysis.

In summary, the major result in Experiment 2 was that repetition priming was found for familiarized non-words even when the response was "no" in the lexical decision task. This contradicts a long-standing belief that repetition priming is found only for words, not for non-words. But various studies also found that if learning was involved for the non-words, certain representation (e.g., episodic representation, or temporary lexical node) might be formed, which will possibly produce the facilitation in the lexical decision experiment and episodic recognition experiment.

In addition to the priming effect, there were other interesting results worth mentioning. One concerned the magnitude of the repetition priming effect. Compared with a normal repetition priming effect for lexical items (about 50ms at the 50ms prime duration), the numerical value of the priming effect in this experiment (26ms) was relatively small. This might suggest that the established representation for familiarized non-words was not as stable as that for real words. But a more surprising finding was that the repetition priming effect observed for real words in this experiment was also as small as 30ms, so maybe the inclusion of familiar nonwords changed the way in which the decisions were made in this experiment.

The other interesting finding was from the error data. The subject error data showed that there was a significant difference between learned and unlearned conditions, that is, subjects made more errors on familiarized items (18.6%) than unfamiliarized items (11.4%). This suggested that the learning made them prone to say "yes it is a word". This difference was significant for both subject analysis and item analysis, $F1\ (1, 40)=13.80$, $p<.001$; $F2\ (1, 88)=9.48$, $p<.001$. This can be another indicator supporting the hypothesis that the learning was effective. After a certain amount of learning, participants started to think the newly learned items were real English words, or there is a bias to respond Yes to the familiar items.

2.5. Interim conclusion

No prime lexicality effect was found in Experiment 1, but a significant masked repetition priming effect was found in Experiment 2 for the learned nonword targets. This indicated that the absence of a PLE in Experiment 1 was not due to the fact that no relevant representation had been established for the newly learned items. Instead, a priming-relevant representation was clearly formed (thus the repetition priming effect in Experiment 2), but this was not sufficient to produce a PLE. Whether this was because this representation was not as stable as a normal lexical representation, or was not the right kind of representation is not clear. Nevertheless, it does seem clear that mere familiarization is not sufficient to produce a PLE. In what follows, we will consider a procedure in which participants learn the novel items in the real sense of learning, i.e., a meaning will be given to each new word, and more intensive learning is required.

CHAPTER 3 THE EFFECTS OF REAL ACQUISITION

In Chapter 2 we discussed the effects that familiarization at the level of form may have on the representation of newly learned words. Two experiments, one testing the PLE, the other the repetition priming effect, showed that familiarization at the level of form did not produce a PLE, but this was not due to the fact that no relevant representation had been established. Rather, the repetition priming effect observed in Experiment 2 demonstrated that a priming-relevant representation was clearly formed, but it was not sufficient to produce a PLE. This might be taken as evidence that the PLE Elgort (2007) found was not the product of mere familiarization. However, since Elgort tested only with visible primes, it could be argued that the PLE did not necessarily reflect automatic processing, and its source could have been either lexical or episodic as far as memory system was concerned (Damian, 2001). Therefore it would be important to test the PLE again with more intensive learning involved (e.g., a meaning is provided for each novel item, and participants must learn to associate the meaning with the appropriate item). This is what we intend to do in the three experiments in this chapter.

3.1. Description of the training

The experiments in this chapter all used the same materials and training procedure as described below, with the number of sessions of training differing from one experiment to another.

3.1.1. Materials

The 48 critical non-words described in Chapter 1 were again used as novel items for training. This time each novel item was assigned a meaning (in the form of a one-sentence-definition), together with a matching picture. Since the learners are native English speakers, the meanings for the new words had to be relatively unusual, to make them believe they were learning new English words on the one hand, and to make sure there is no meaning overlap with words they already know on the other. Therefore the novel items were defined as a rare animal, plant, special-purpose tool, or furniture etc. For example, *clight* is defined as "a rare sea animal that is a kind of worm", and *sweaber* is "a special clothing once used by NASA". Some items have more transparent meanings, such as "conrest" (meaning "a flexible, compact and comfortable 'shell' bed”). To make the meaning easier to learn, pictures were used to match the description of the meaning , so to help learners see what they learn. It is expected that the inclusion of pictures will facilitate the process of memorization and lexicalization (Paivio, 1986; Pressley, Borkowski, & Schneider, 1987).

The complete set of new words and their definitions are presented in the Appendix C.

3.1.2. Procedure

Every learning session was composed of seven blocks of trials: two blocks of simple presentation of new words with their corresponding pictures and definitions, followed by two blocks of word-picture matching, which was followed by one more block of simple presentation at a faster speed, one block of picture-word matching, and one block of word-definition matching.

In the blocks of simple presentation, each novel word was first presented at the top of a blank screen for 1660ms, then the picture for this word appeared below the word.

After about 1660ms, the definition of the word was presented at the bottom of the screen for 3320s. When the picture or the definition appeared, the word stayed on the screen. The participants were instructed to use as much information as they needed to memorize the new word. Second language acquisition studies have shown that simultaneous presentation of the word form and its meaning is beneficial during the first encounter with the word (Nation, 2001, p.79). Every participant was given the same amount of time for learning. Participants generally reported that the time was sufficient for them to memorize the new words.

In the word-picture matching task, novel words were first presented at the top of the screen for 1660ms, then two pictures (with one as the corresponding picture for the novel word) were presented side by side in the middle of the screen. When the pictures were added, the word remained on the screen. The participants were instructed to press the left or right button to indicate whether the picture on the left side or the right side matched the novel word.

This word-picture matching was given twice. After that, the simple presentation of the novel words with pictures and definitions was repeated for the third time. This time the presentation was speeded up. The duration for the word, picture and definition presentation were reduced from 1660m/1660ms/3320ms to 830ms/830ms/1660ms. Participants reported they did not have difficulty following the speeded presentation.

Finally one picture-word matching task and one definition-word matching task was administered. The procedure was the same as for word-picture matching, with the difference being there are two words to be selected to match the picture in the picture-word matching task, and two words to be selected to match the definition in the definition-word matching task. Example screens for the three matching tasks are presented in the Appendix D. The purpose of these tasks was to track how well the meanings of the novel words had been established.

3.2. Experiment 3: One-session of learning and PLE

The purpose of this experiment was to test whether real learning rather than mere familiarization is required to produce a Prime Lexicality Effect in the testing phase. As described in the previous section, the real learning involves blocks of presentation of the novel words with the definitions and pictures, plus several blocks of different matching tasks to help participants memorize the new words. If a strong lexical memory trace is formed after the learning, the new words will behave more like words, thus no priming should be obtained when the newly learned items are used as the primes.

3.2.1. Method

Participants. A total of 33 undergraduate students who were enrolled in an introductory Psychology course participated in the experiment, for which they received course credit.

Materials and Design. The materials and design for the training phase have been described above. In the testing phase, the base words of the 48 novel items were used as word targets, 48 non-word targets were included for "NO" response. Since it was found in Experiment 2 that no difference of the learning effect was found between learning the first half of novel items and the second half of the novel items, this experiment did not have learning as a counterbalanced factor. Specifically in this experiment every participant learned the same 24 novel items (half of the complete set of novel items), and in the testing phase, half of the participants made decisions on the word targets that had the novel items as related primes (e.g., *baltery-BATTERY*), and half made decisions on the targets with unrelated nonwords as primes (e.g., *danssel-BATTERY*). The other half of the novel words were used as unlearned primes, so the targets also had two types of primes --- the related prime (e.g., *dresent –PRESENT*, but *dresent* had not been learnt), and the control prime (e.g., *crosten-PRESENT*). The difference between the related and the control primes indicated the amount of priming, and the comparison of the amount of priming produced by learned primes with that produced by unlearned primes was an indication of the effect of learning. Two counterbalanced lists of items were prepared so that across lists, each target word appeared in the related learned and unrelated conditions, but not in the same list. The full set of materials is available in Appendix E.

Procedure. The procedure in the training phase was described in the previous section. The procedure in the testing phase was the same as described in General Method in Chapter 2.

3.2.2. Results

3.2.2.1. The training phase

Due to an error in editing the data, the data from the training phase in this experiment cannot be analysed. The same training procedure was used in Experiment 4, so the examination of the training effect will be carried out in Experiment 4.

3.2.2.2. The testing phase

The same data trimming has been applied in this data set as that in Experiment 1. Three subjects were rejected because their overall error rates were higher than 21%. To make the two groups equal in size, the last two participants tested in the second group were also excluded. The analysis was based on the data from 14 participants in each group. The mean reaction times and error rates for word and non-word targets are presented in Table 3.1.

Table 3.1. Mean lexical decision times and error rates (in parentheses) for word and non-word targets in the testing phase of Experiment 3.

		Related primes	Unrelated primes	Priming
Word targets	Learned	*baltery-BATTERY* 578 (7.3)	*danssel-BATTERY* 598 (6.3)	 20* (-1)
	Unlearned	*dresent-PRESENT* 571 (4.5)	*crosten-PRESENT* 593 (9.0)	 22*** (4.5)
Non-word targets		*troffic-TRUFFIC* 647 (10.8)	*inittal-TRUFFIC* 646 (10.7)	 -1 (-0.1)

*** $p<.001$, ** $p<.01$

3.2.2.2.1. Reaction times and error rates for the word targets

In the analysis of lexical decision times, the main effect of Priming for trials on which a learned prime was used (20 ms) was significant in subject analysis, $F1\ (1,26) = 7.39$, $p=0.01$; and marginally significant in item analysis, $F2(1,22) = 3.99$, $p=0.06$. The main effect of Priming when an unlearned prime was used (22ms) was significant in both subject and item analysis, F1 (1, 26)=11.66, p<.001; F2(1,22)=14.06, p<.001. The interaction was not significant, both Fs < 1. Thus, there was no indication of a PLE.

In the analysis of errors, no priming effect was found in the learned condition (less than 1% priming), Fs<1, but there was a significant priming effect in the unlearned condition (4.5%) in both subject analysis, F1 (1, 26) = 5.49, p<.05; and item analysis, F2(1, 22)=4.35, p<.05. A one-way ANOVA analysis showed that the difference between the error rates with related primes (4.5%) and the control primes (9.0%) was significant in both subject and item analysis, F1 (1, 26)=5.49, p<.05; F2(1, 22)=4.35, p<.05.

3.2.2.2.2. Reaction times and error rates for nonwords

No significant priming effects were observed for non-word targets in either the analysis of lexical decision times (-1ms) or the error rates (less than 1%), all Fs<1.

3.2.3. Discussion

The most important aspect of the data obtained in Experiment 3 was that no significant difference was found between the priming effects from the learned primes and the unlearned primes. In other words, no PLE was found when real learning was involved, especially when the meaning was given to the novel words, and participants were told to treat them as English words. This result contradicts the hypothesis that a PLE should be found if participants learned the novel words and registered them in their lexical memory system.

Of course it is not unreasonable to argue that the amount of training might not be sufficient, especially when only one session of training was involved. It is not hard to understand that it takes time for the novel items to be incorporated into the memory system and to have an effect on the real words that already existed in the system. Therefore learning multiple times will undoubtedly create more stable representation than one-time-learning. In addition, recent studies have found that newly learned items can be better incorporated into the memory system after an interval (without more training), which is interpreted as a consolidation effect according to memory literatures. For example, in Gaskell and Dumay's (2003) experiment, participants were exposed to novel spoken sequences that overlapped strongly with existing words (e.g., *cathedruke*, derived from *cathedral*). On the first day of training, the immediate effect of the learning was facilitatory, that is, the participants got faster in recognizing *cathedral* after repeated exposure to *cathedruke*. However, starting from the third day, robust competition (rather than facilitation) effects were observed, which suggested that learning multiple times might have created more stable and competitive representations of the novel words. More interestingly, Experiment 3 in Gaskell & Dumay's work showed that while lexical competition was not observed on the first day of training, when tested a week later with no further exposure to the novel items, evidence of lexical competition was observed. In addition, Bowers et al. (2005) also found that learning *banara* made it more difficult to semantically categorize its word neighbour *BANANA*, and more importantly, the interference was larger the following day without further training (evidence of consolidation), and even larger after more training on the second day (supporting the effect of multiple learning sessions).

Therefore it is reasonable to argue that a PLE might require solid lexical representation, and one session of learning is not sufficient to establish such a representation. It might require multiple sessions of learning, and a certain period of rest between the sessions for consolidation to occur. This hypothesis will be tested in Experiment 5.

Although there was no clear sign of a PLE in the RT data, there was an interesting suggestion in the error data. In the untrained condition, related primes (e.g., *dresent-PRESENT*) produced significantly fewer errors than control primes, but in the trained condition (e.g., *baltery-BATTERY),* such a difference disappeared. Presumably the results in the untrained condition should be regarded as a baseline condition, that is, because of the similarity in form, the related prime, such as *dresent* should have helped to reduce the errors in recognizing the targets *PRESENT*. This is not hard to explain using the entry-opening model. Firstly, errors occur when no matching candidate for the target is found. Secondly, for a non-word prime that is very similar to a real word (i.e., the target), it tends to open the entry for the target because of the overlap in form. Therefore if the target fails to register a match, at least the prime might have, so the chance of making an error is reduced. In contrast, when training on the non-word primes were involved, the prime became more distinguishable from the target, therefore the tendency for the prime to open the entry for the target was reduced, and the chances of getting more errors increased.

This finding in the error data is important, because potentially it can be counted as a kind of PLE --- training reduces the probability of the prime opening the entry for the target. It is possibly the case that we did not find evidence for an effect in RTs, but we do see an effect in errors.

This raises another possibility, namely, that a clear PLE might be such a small effect with this amount of training that it was only observable in certain conditions. One such condition, as suggested by Forster & Veres (1998), is when the primes are visible. According to the entry-opening model, a PLE is observed in the resolution process when incorrect candidates need to be eliminated. This process would normally occur at the transition from the prime to the target. However when the prime is masked, the transition is so fast that it prevents the resolution process for the prime from being completed, which means that the entry for the target is left in the open state, and hence priming occurs. However, if the prime is not masked and is clearly identifiable, the resolution process of the prime can be completed. So if the prime is a word, the system will identify it, and the entry for the target will be closed, since it is recognized as not being a satisfactory match for the current input (the prime). This will prevent any priming. But if the prime is a non-word, the system cannot find the best match, resolution is delayed, so the entry for the target word may still be open when the target is presented, which results in form priming. This hypothesis predicts that a PLE is easier to get if the primes are visible. If this is true, a PLE might be found if we use visible newly learned items as primes. Experiment 4 examines this hypothesis.

3.3. Experiment 4: One-session of learning and visible PLE

3.3.1.Method

Participants. A total of 30 undergraduate students, enrolled in an introductory Psychology course, participated in the experiment, for which they received course credit.

Materials, design and procedure. The materials and procedure were approximately the same as Experiment 3. One major difference was that the prime duration was extended from 50ms to 500ms, which made the primes visible to all participants. However, since the primes were completely visible to the participants, some changes had to be made in the design. Firstly, the novel items (used as primes in the testing phase) should not be always followed by word targets. Otherwise participants will not bother to read the targets, instead they can make decisions based on the primes --- as long as the prime was a novel item learned previously, it will be followed by a word target, and it is safe to respond "YES". Although this was not true for all word targets (word targets in the control condition were preceded by non-word primes), it is necessary to avoid any possibility of such a strategy. In order to solve this problem, two measures have been taken: first, novel items were used as primes for both word targets and non-word targets. Specifically, each novel item was seen twice in this experiment --- once being followed by a word target, the other time being followed by a nonword target; secondly, control primes for word targets were no longer non-words, instead they were the novel items as well. Consequently the four conditions for word targets were as follows: (1) word targets with learned related primes: e.g., *baltery-BATTERY (baltery* has been learned*); (2)* word targets with learned control primes: e.g., *cleate-CERTAIN* (*cleate* has been learned); (3) word targets with unlearned related prime: e.g., *dresent-PRESENT (dresent* has not been learned*);*(4) word targets with unlearned control prim, e.g., *quolity-CLOTHES* (*quolity* has not been learned). Similarly, nonword targets also had four types of primes: (1) learned related primes, e.g., *baltery-BANTERY; (2)* learned control primes, e.g., *cleate-CERGAIN*; (3) unlearned related primes, e.g., *dresent-TRESENT*; (4) unlearned control primes, e.g., *quolity-BLOTHES*. Two counterbalanced lists of items were prepared so that across lists, each target appeared in the related learned and unrelated conditions, but not in the same list. The entire list of items is presented in Appendix F.

3.3.2.Results

3.3.2.1. The learning phase

As in Experiment 3, the learning phase in Experiment 4 was composed of three blocks of simple presentation, and four blocks of matching. A comparison on the matching time would not be meaningful since different matching tasks were involved, therefore we would use the error rates in the four matching tasks as the criteria for examining the learning effect.

The mean accuracy data are presented in Table 3.2.

Table 3.2. The error rates for the four matching tasks in the learning phase in Experiment 4.

	First block (word-picture matching)	Second block (word-picture matching)	Third block (picture-word matching)	Fourth block (definition-word matching)
Accuracy	20.5	15	7	8.6

The ANOVA analysis showed that the participants made fewer errors when they proceeded from the first to the last matching task, the difference was significant in both subject and item analysis, $F1\ (3,84)=16.73$, $p<.001$; $F2(3,69)=23.87$, $p<.001$. There was a slight increase in the fourth block (8.6%), but that was not a significant difference from the error rate in the third block (7%), therefore for the current purpose, we will conclude that results from the training phase suggested a significant learning effect, which indicated that participants learned the novel items.

3.3.2.2. The testing phase

The same data trimming criteria has been applied in this data set as that in Experiment 1. One subject was rejected because the overall error rate was higher than 21%, the subsequent ANOVA analysis was based on the data from 15 participants in each file. The mean reaction times and error rates for word and non-word targets are presented in Table 3.3.

Table 3.3. Mean lexical decision times and error rates (in parentheses) for word and non-word targets in the testing phase of Experiment 4.

		Related primes	Unrelated primes	Priming
Word targets	Learned	*baltery-BATTERY*	*cleate-CERTAIN*	
		540	548	8
		(2.5)	(5.9)	(3.4)*
	Unlearned	*dresent-PRESENT*	*quolity-CLOTHES*	
		514	544	30***
		(5.0)	(5.5)	(0.5)
Non-word targets	Learned	*baltery-BANTERY*	*cleate-CERGAIN*	
		642	657	15
		(11.9)	(14)	(2.1)
	Unlearned	*dresent-TRESENT*	*quolity-BLOTHES*	
		633	644	11
		(10.6)	(9)	(-1.6)

*** p<.001, **p<.01, *p<.05

3.3.2.2.1. Reaction times and error rates for word targets

In the analysis of lexical decision times, the main effect of Priming for learned primes (8 ms) was not significant, both Fs<2, but the main effect of Priming for unlearned primes (30ms) was significant in both subject and item analysis, F1 (1, 28)=10.49, p<.001; F2(1,22)=13.19, p<.001. The interaction was significant in both subject and item analysis, F1(1, 28)=4.46, p<.05; F2 (1, 44)=4.55, p<.05, which indicated that when the primes were visible, the learned primes produced significantly less priming than unlearned primes, a difference that resembles the difference a word prime and a non-word prime would produce, thus a clear prime lexicality effect was found when the primes were visible.

The error analysis showed a result completely different from that in Experiment 3. The difference between the error rates with related primes (2.5%) and the control primes (5.9%) in the learned condition was significant in both subject analysis, $F1(1, 28)=4.5$, $p<.05$; and item analysis, $F2(1,22)=6.94$, $p<.05$. But there was no significant priming effect in the unlearned condition, both $Fs<1$.

3.3.2.2.2. Reaction times and error rates for nonwords

The analysis of lexical decision time showed similar main effect of Priming for learned primes (15ms) and unlearned primes (11ms). Both were not significant in subject analysis, but significant in item analysis: $F1(1,28)=3.33$, $p=0.08$; $F2(1, 22)=5.69$, $p<.05$ for learned primes; $F1(1, 28)=2.02$, $p>.05$; $F2(1, 22)=4.44$, $p<.05$ for unlearned primes.

No significant priming effects were observed in the analysis of error rates, all $Fs<1$.

3.3.3. Discussion

The most important result in Experiment 4 is that when the primes were visible, a PLE was observed after one session of learning. This result contrasts with the result in Experiment 3, where the same training was received, but the primes were masked, and no PLE was observed. This result fully supports the hypothesis that visible primes allow time for the resolution of the prime to be completed, therefore a prime lexicality effect was more likely to be found. If the prime is masked, the resolution process for the prime cannot be completed, and therefore a facilitatory effect is more likely to be found.

However, the fact that many masked priming experiments (Forster & Veres, 1998; Davis & Lupker, 2006) did find a PLE with real word primes suggested that the absence of a PLE in Experiment 3 still indicated that there was a difference between newly learned novel words and real words. Specifically, the newly learned words failed to establish a lexical representation that functioned in the same way as a real word representation. Nevertheless, if this is true, what is it that produced the PLE in Experiment 4? One possibility is that when the primes were visible, presumably the resolution process did not need to be about "this is an English word I know". Instead it is good enough if it said "this is the new word I learned just now", which is enough to close down all incorrect candidates including the target, and therefore producing the PLE we observed in this experiment. If this is true, it would pose a problem for Elgort’s (2007) conclusion, where a PLE with visible primes was used as an index of the lexicalization of newly learned words. Our results suggest that the same amount of training can produce a PLE with visible primes, but no PLE with masked primes. In addition, previous studies have shown that only masked priming paradigm offered the promise of "tapping into automatic, strategy-free lexical processing" (Forster et al., 2003). Presumably if the newly learned words have lexical representations, the access should be automatic, and the PLE should be obtained even in a masked priming experiment.

3.3.4. Further analysis

Is it possible that individual differences might be involved? That is, could it be that some participants learned better than others, and the good learners showed a PLE, but this was offset by the lack of PLE shown by the bad learners? In order to answer this question, further analysis of the individual data was carried out.

First, the error data in the fourth block was taken as an indicator of the learning effect, that is, the smaller the error rate was, the better the participant had learned those novel items. Second, an estimate of the PLE was calculated using the difference between the priming effects from untrained primes (labeled as "UNP" in Figure 3.1.) and trained primes (labeled as "TNP" in Figure 3.1.) (i.e., PLE= untrained priming-trained priming). Therefore the bigger the number is, the stronger the prime lexicality effect is. Presumably if only word primes showed the lack of priming, and this prime lexicality effect relies on the establishment of the lexical representation, the good learners (for whom the new words are more likely to be lexicalized) should show more PLE than the bad learners. Figure 3.1. shows the correlation of the learning effect (the X axis) and the PLE (each data point represents the prime lexicality effect of one participant).

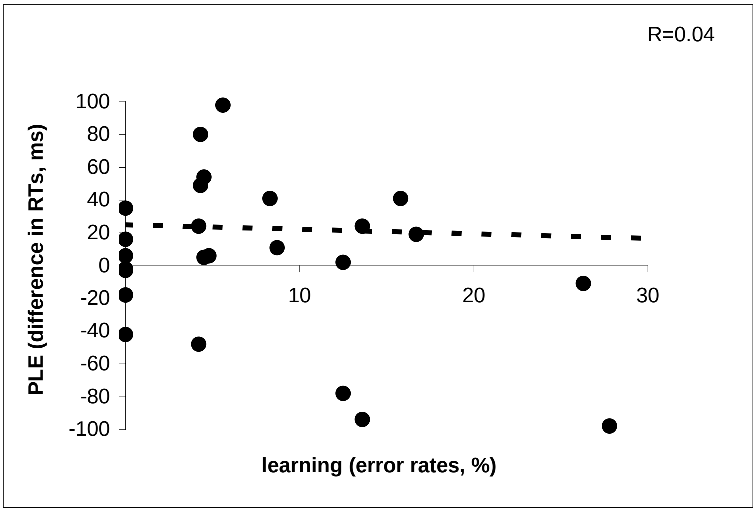

Figure 3.1. The correlation of the learning effect (indicated by participants' error rates in the last block of the learning phase) and the Prime Lexicality Effect (indicated by participants' performance in the priming conditions with trained primes vs. untrained primes) in Experiment 4.

It seems clear that the degree of learning does not correlate with the prime lexicality effect (with an R value of 0.04). However, a closer examination of the data showed that among the 30 participants, 2/3 of them (20 participants) had an error rate less than 10%. So if we take the 10% error rate as the dividing line between good and bad learners, it is the bad learners who showed inconsistent PLE: half of them (6 participants) showed positive PLE, ranging from 2ms to 115ms with the mean of 52ms PLE, and half of them (4 participants) showed negative PLE, ranging from –11ms to –98ms with the mean of –70ms PLE. The variance of this data set was as big as 5800, suggesting that this group of bad learners had very inconsistent performance as far as the priming effect was concerned. This might offset any pattern that we can observe in good learners. Indeed, this supposition was supported by the analysis on just the good learners (with error rates less than 10%). The PLE estimates observed with the good learners were more consistent with each other, with a high correlation between the learning and PLE approaching 0.6 (see Figure 3.2.). However, the trend was opposite to our prediction. What they showed is the fewer errors they made, the smaller was the PLE. There is no obvious explanation for this result.

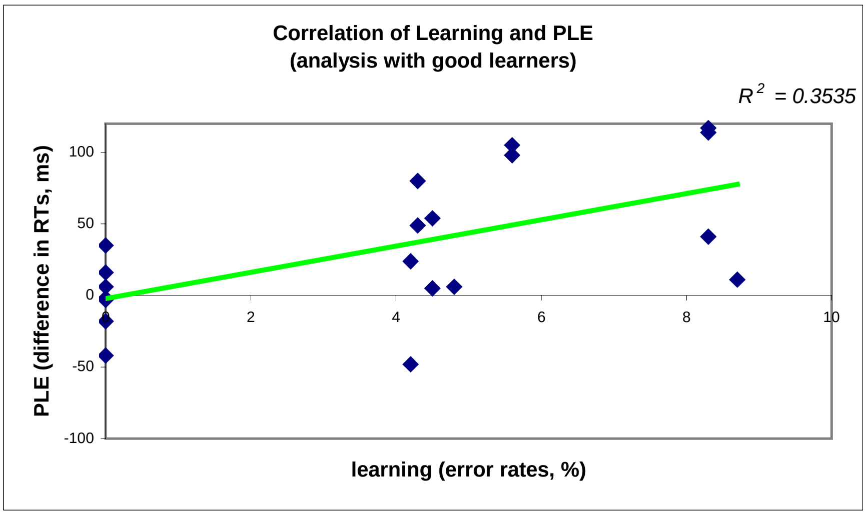

Figure 3.2. The correlation of the learning effect and the prime lexicality effect (using the same indicator as Figure 3.1.) on participants whose error rates were less than 10% in the last block of training phase in Experiment 4.

3.4. Experiment 5: Multiple sessions of learning and PLE

The lack of a Prime Lexicality Effect in Experiment 3 showed that there is no immediate generation of fully-fledged lexical representations after a one-time exposure to the novel items. It is possible that more exposure and rests between exposures may be necessary for lexicalization to occur (Gaskell & Dumay, 2003; Hupbach, Gomez, Bootzin, & Nadel, 2009). In order to test whether this was the case, a new experiment was designed with four sessions of learning and testing spread over a period of two weeks.

3.4.1. Method

Procedure, materials and design. Every participant came to the lab four times over a period of two weeks (ten working days). Each time, they did roughly 10 minutes of learning (presentation and matching) followed by 10 minutes of testing (lexical decision). Only a single session was scheduled for each day, the interval between successive sessions is less than four days. The most common schedule was that the first two sessions were in Week 1, and two more sessions in Week 2.

In the first session, the learning phase was exactly the same as in Experiment 3 and 4, which included two blocks of word-picture-definition presentations, followed by two blocks of word-picture matching, then one more block of word-picture-definition presentation, followed by one block of picture-word matching, and one block of definition-word matching. In the testing phase, since it was not desirable for the base words of the novel items (e.g., BATTERY) to be seen so that participants would establish a connection between the novel items and the base words, the original testing conditions and items cannot be used until the last session. However, in order to keep the format of the four sessions consistent, it was decided that the lexical decision task should still be included in the first three sessions. Therefore a new set of items for a lexical decision task was constructed. As in the original set, there were 48 word targets and 48 non-word targets. For the word targets, 24 were learned novel items (e.g., *BALTERY*), preceded by either a related prime, the base word (e.g., *battery-BALTERY*), or an unrelated word (e.g., *forever-BALTERY*). The participants were instructed to respond YES to the newly learned items. The other 24 word targets were real English words, which were preceded by either their one-letter-different word neighbor (e.g., *protect-PROJECT*), or an unrelated prime (e.g., *refresh-PROJECT*). The 48 non-word targets were preceded either by related word primes (e.g., *shelter-SHEPTER*), or unrelated word primes (e.g., *benefit-SHEPTER*). Two lists of materials were counterbalanced: each target appeared once in any particular list but in a different condition across lists.

Sessions 2 and 3 had the same conditions in the testing phase as in Session 1. There was one minor difference in the training phase, namely, the first two blocks of word-picture-definition presentation were excluded. The training included only one block of presentation, one block of word-picture matching, one block of picture-word matching, and one block of definition-word matching. This training format was used from session 2 to session 4.

In the fourth session, the testing was switched back to what has been used in Experiment 3 and 4. The 24 learned novel items were used as primes, so that the *battery-BALTERY* pairs were changed back to *baltery-BATTERY*, the critical condition to observe PLE. Since the newly learned items were no longer used as targets in Session 4, in order to avoid participants developing a strategy of responding “Yes” to anything that was similar to one of the newly learned words, 24 non-word targets were created, which differed from the newly learned items at the same position as they differed from their base words, for example, *bantery*. These non-word targets replaced 24 out of the 48 nonword targets. All other conditions were the same as Session 1 –3. Two counterbalanced lists of items were prepared so that across lists, each target appeared in the related learned and unrelated conditions, but not in the same list. The full set of materials is available in the Appendix E.

Participants. A total of 36 undergraduate students enrolled in an introductory Psychology course participated in the experiment, for which they received course credit.

3.4.2. Results

3.4.2.1. The learning phase

As in the previous experiments, the learning effect was examined using the matching time and error rates recorded in the word-picture matching (WPM), picture-word matching (PWM), and definition-word matching (DWM) tasks. Except that session 1 has two blocks of WPM, all other three sessions had three blocks of matching tasks, each task being carried out only once.

The mean matching time and error rates of the three matching tasks in four sessions are shown in Figure 3.3.

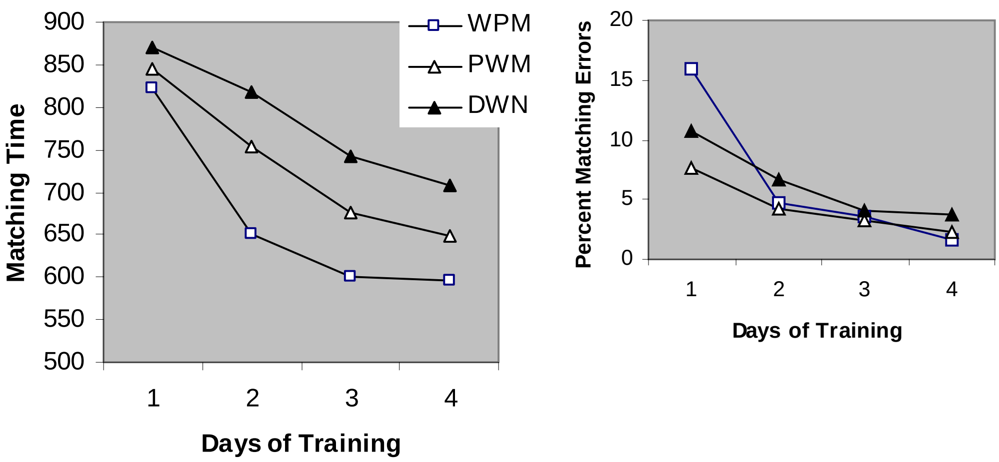

Figure 3.3. The mean matching time and error rates (in parenthesis) for the three typical matching tasks (word-picture matching (WPM), picture-word matching (PWM), definition-word matching (DWM)) in the learning phases on Day 1 to Day 4 in Experiment 5.

In all previous experiments when there was only one day of learning involved, we examined the learning effect by comparing the matching time from the first block

(WPM1) to the last block (DWM). However, because of the task difference, we found more than once that the last block (the definition-word matching task) took longer time than the other three blocks although at that stage (the last matching task) the participants were supposed to be more familiar with the new words. Now the multiple days of learning enabled us to make the comparison of the learning effect using the matching time and error rates for the same task, but across four days. This comparison is more convincing than the comparison across tasks.

2-way ANOVA analysis showed that both matching time and accuracy data indicated highly significant improvements from Day 1 to Day 4 in all the three matching tasks, all Fs > 10, Ps<.001. This indicated a clear learning effect, that is, participants were getting faster and faster, and made less and less errors on the newly learned words. The learning process was successful.

3.4.2.2. The testing phase

3.4.2.2.1. The first three sessions

The same data trimming criteria as in previous experiments were applied, e.g., participants whose overall error rates exceeded 21% were rejected, RTs that were above 1500ms or below 30ms were excluded, outliers were treated by setting them equal to cutoffs of two standard deviations above or below the mean for each subject. No participants were excluded from the analysis though. The analysis was based on the performance of 36 participants.

The first three sessions have the newly learned words as targets, this is different from the last session. Therefore the results will be reported in separate tables. The results of the real word condition and the nonword condition will be reported later because they were repeated throughout the four sessions. The mean reaction times and error rates for the newly learned word targets in the first three sessions are presented in Table 3.4.

Table 3.4. Mean lexical decision times and error rates (in parentheses) for word and non-word targets in the testing phase of Session 1-3 in Experiment 5.

	Novel word targets (e.g. BALTERY)		
	Related primes (e.g., battery)	*Control primes (e.g., forever)*	*Priming*
Session 1	680 (20.7)	692 (22.0)	12 (1.3)
Session 2	635 (13)	666 (12.4)	31*** (-0.6)
Session 3	603 (7.2)	640 (10.4)	37*** (3.2)*

*** p<.001; ** p<.01; *p<.05

The two-way ANOVA analysis on the performance on each separate session showed that the main effect of Priming was highly significant on both the second session (both Fs>1) and the third session (both Fs>1). It is clear that the priming effect increased as more learning was involved. This is slightly surprising because the newly learned words were currently primed by their competitors. If both *battery* and *baltery* are now in the same lexical system, competition should have been found, rather than facilitation. One possible explanation is that the newly learned words were not lexicalized, that is, *battery* would compete only with another real word, and there is no competition between something stored lexically (*battery*) and something stored episodically (*baltery*). Alternatively, another way to interpret the facilitation is that in the process of training, learners are using "*battery*" as a phonologically related mediator (word association) to establish and process the to-be-learned new word form (*baltery*). Such a just established direct link between similar word pairs may produce the strong priming effect. It probably would disappear only much later when the new words have fully been integrated in the lexicon and their access routes have become independent and automatized. Such an emphasis on the role of lexical associations and links is supported by models of vocabulary learning, such as the Parasitic Model of vocabulary acquisition (e.g., Hall, 2002; Hall & Ecke, 2003). In this model learners are assumed to initially and (most unconsciously) recognize and use similarity in new input patterns with already represented words to gradually build new representations.

3.4.2.2.2. The last session

First, we begin with the analysis on the real word condition. This condition was included in all four sessions in the current experiment, and the testing items were actually repeated. That is, exactly the same items were used from Session 1 to Session 4. Table 3.5. presents the results of this condition across the four sessions.

Table 3.5. Mean lexical decision times and error rates (in parentheses) for real word targets in the testing phase of Session 1-4 in Experiment 5.

	Real word targets (e.g. PROJECT)		
	Related primes (e.g. protect)	Control primes (e.g.,refresh)	Priming
Session 1	620 (9.3)	636 (9.7)	16* (0.4)
Session 2	601 (6.3)	603 (7)	2 (0.7)
Session 3	585 (6.5)	605 (6.8)	20*** (0.3)
Session 4	570 (2.4)	588 (4.4)	18** (2)*

*** $p<.001$; ** $p<.01$; *$p<.05$

The 2-way ANOVA analysis showed that priming was not obvious initially (slightly significant in Session1, but almost zero in session 2), but then a significant priming was found in both the third and the fourth session. One may argue that a PLE is not obtained with targets that have been tested repeatedly. Those targets may leave traces in the episodic memory after repetition, and thus the priming is likely to be mediated by the episodic representation. The results from the first two sessions might not have been contaminated by the episodic influence, and the priming effects of 16ms and 2 ms should produce a mean that is less than 10ms, would presumably is not a significant main effect. More importantly, the results would be clearer if we have the nonword condition to compare with. This factor will be considered in the later experiments.

The results from the nonword condition were clear-cut. As shown in Table 3.6., there was basically no priming for the nonword targets. This corresponds with the previous finding that there is no form priming for nonword targets (Forster, 2003). It was also possible that there was a repetition priming effect since the same items were repeatedly used in the four sessions. But the effect was not significant either (all ps<1).

Table 3.6. Mean lexical decision times and error rates (in parentheses) for non-word targets in the four sessions in Experiment 5.

	Nonword targets (e.g. SHEPTER)		
	Related prime (e.g., shelter)	Control primes (e.g., benefit)	Priming
Session 1	695 (17.7)	704 (15.2)	9 (-2.5)*
Session 2	671 (10.8)	680 (11)	9 (0.2)
Session 3	638 (7.7)	645 (7)	7 (-0.7)
Session 4	654 (5.8)	654 (7.6)	0 (1.8)*

Now we will consider the most important condition of the newly learned words. In this last session, these items were used as primes, whereas their real word neighbors were used as targets (e.g., *baltery-BATTERY*). The results are presented in Table 3.7.

Table 3.7. Mean lexical decision times and error rates (in parentheses) for novel words (as primes) condition in the fourth session in Experiment 5.

	Novel word condition (e.g., BATTERY)		
	Related prime (e.g., baltery)	Control prime (e.g., forever)	Priming
Session4	656 (18.6)	665 (19.6)	9 (1.0)

Two-way ANOVA analysis showed that the substantial priming observed in the third session (37ms) dropped dramatically to 9ms in the fourth session. However, it is important to remember that such a comparison is not meaningful because the targets were actually different --- newly learned words (e.g. *BALTERY*) were targets in Session 1-3, but *BATTERY* was the target in Session 4.

An important comparison is to check whether this 9ms priming effect is significantly different from the priming effect that would have been produced if there had been no training on *baltery*. Presumably if that was a significant difference, we can conclude that the newly learned items have been lexicalized, and thus producing a priming effect that resembles word primes instead of non-word primes. In order to test this, a supplementary experiment (Experiment5B) was carried out, in which no learning of the novel items was involved.

3. 5. Experiment 5B

Experiment5B used the same materials as the Session 4 of Experiment 5. Thirty-nine participants were tested following the same procedure and method, but with no learning sessions. Two participants were excluded because of high error rates (> 21%). One participant was excluded to make the two files have equal number of subjects in the analysis. The results are presented in Table 3. 8.

Table 3.8. Mean lexical decision times and error rates (in parentheses) for word targets with nonwords as primes in Experiment 5B.

	word targets (e.g., BATTERY)		
	Related nonword prime (e.g., baltery)	Control primes (e.g., forever)	priming
Experiment 5B	529 (6.5)	558 (5.4)	29*** (-1.1)

*** p<.001

The analysis of lexical decision times in Experiment5B showed a significant main effect of Priming for the novel primes (e.g., *baltery-BATTERY*) (29 ms), F1 (1,34)=13.65, p<.001; F2 (1,22)=13.05, p=.002. This priming effect is much greater than the 9ms priming effect obtained in Session 4 of Experiment 5. This difference was significant, *t*(70) = 1.79, p = .04 (one-tail). A one-tailed test here is considered justifiable on the grounds that the direction of the predicted difference is unequivocal, namely that the effect of training should be to reduce the amount of form priming. In addition, there was a significant difference between the absolute speed of response in Session 4 of Experiment 5 (660ms) and Experiment 5B (543ms), F1 (1, 68) = 26.05, p<.001; F2 (1, 22) = 345.89, p<.001. There was also a significant difference between the errors in Session 4 of Experiment 5 (19.1%) and Experiment 5B (6.0%), F1 (1, 68) = 56.76, p<.001; F2 (1, 22) = 30.31, p<.001. It can be argued that these are also evidence of a PLE.

3.6. General Discussion

The important question we asked in the three experiments in this chapter is whether there is any form priming for *baltery-BATTERY* when *baltery* was learned once or learned multiple times? The results are very clear (see Figure 3.4.for a comparison of the magnitude of the priming effects): both mere familiarization (no meaning provided) and one session of learning did not influence the effectiveness of the novel words as form primes. They both produced normal form priming in the masked priming experiments --- 24ms when the participants were only familiarized with the items, and 20ms when they were told the meaning, but only one session of learning was involved. However, the four sessions of learning in Experiment5 made a difference. With more intensive training spreading over a two-week period, the priming effect was reduced to 9ms, which was significantly different from the 29ms priming effect if no learning was involved. And this was the first time the novel words did not produce significant form priming on the base real words. Therefore our conclusion is that multiple learning sessions are necessary to produce a masked PLE, either mere familiarization or one-time-learning cannot produce that effect. However, a single session of real learning is enough to produce a PLE with a visible prime.

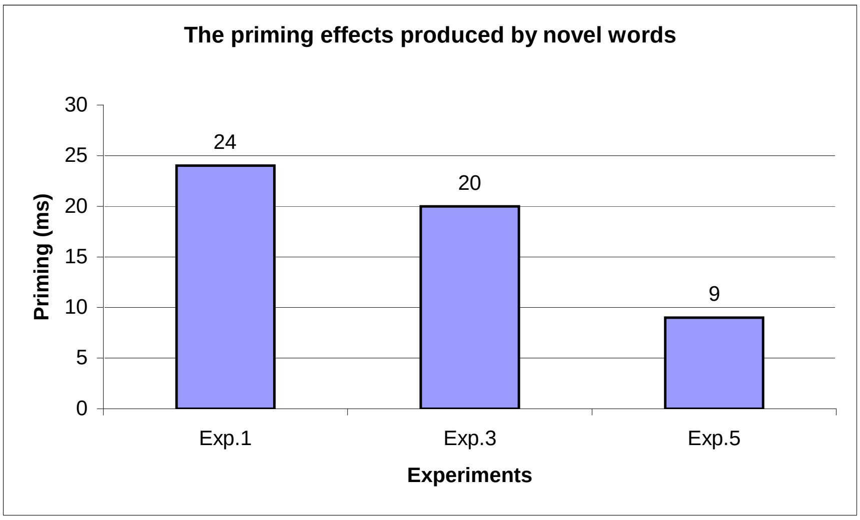

Figure 3.4. The comparison of the priming effects (ms) when newly learned words were used as primes (e.g., baltery-BATTERY) in the three masked form priming experiments in this study. Experiment1 used mere familiarization as the training, Experiment 3 used one session of learning, and Experiment5 used four sessions of learning.

How do we explain such a set of data? To answer this question we need to examine the possible interpretations of a PLE. Based on the previous discussion, we propose four interpretations for the PLE. The first one is the ***competition*** account as proposed in models based on the interactive activation model of McClelland & Rumelhart (1981), e.g. MROM (Grainger & Jacobs, 1996). According to these theories, letter units simultaneously activate all word units containing those letters to varying degrees. In order to decide which word unit is the correct unit, a competitive process was introduced, in which each word unit attempts to drive the activation level in other word units down to zero. The one unit that survives will be the unit that matches the input best. Without this competitive process, a cascaded parallel model has no way to identify the stimulus. The PLE follows from the competition account in that real words can be a good competitor of its word neighbor while a nonword cannot. But if this is true, how should we explain the PLE observed in Experiment 3 when (and only when) the primes were visible? The lack of PLE with masked primes indicated that the newly learned words have not been lexicalized, but a PLE was found with visible primes when the participants received the same amount of training. This poses a problem for the competition models, but it can be explained by the verification account.

The ***verification*** account emphasizes the importance of there being sufficient time for verification to occur. If there is time to verify the prime, the entry for the target will be closed down, and will have to reopened when the target is presented. Therefore there is no savings effect. Visible primes give enough time for the system to decide which is the exact match, hence once it is decided that 'baltery' or 'contrast' is the exact match, the entry for 'battery' and 'contract' will be closed down. Therefore there is no savings when the entry is reopened when the target is presented.

Another major theory is the "***system reset account***" which was adopted by Forster and Veres (1998). It says that when a real word (e.g. *contrast*) is presented as a prime for the target *contract,* the system detects both 'contract' and 'contrast' as potential exact matches, and since both prime and target are treated as a single event, this creates an error signal, so the system reset is necessary, which destroys any priming. In the current experiments, when the amount of learning on 'baltery' is relatively slight, the prime does not trigger any access to 'battery' so there is no need for system reset, therefore we get priming in the first couple of experiments. As for the PLE we observed when the primes are visible, this is explained by the fact that the prime is clearly distinguished from the target, and hence the perceptual system does not treat the prime and target as a single event. Therefore a system reset is not necessary.

Still another theory that can explain PLE is the ***discrimination*** account. This was similar to Pavlov's famous theory of "acquired distinctiveness of cues". In this theory, when a dog is given food whenever a sound at 1000 Hz is presented, the dog will soon establish the connection between 1000 Hz sound and food. However, if the dog is given food at 1000Hz, but no food at a sound of 900Hz. The dog needs to discriminate 900Hz and 1000Hz to make sure that no mistake being made. In our word learning case, before the training, ‘baltery’and ‘bantery’ should both activate ‘battery’ to some degree. Now after training on ’baltery‘, a finer discrimination would be necessary to make sure that “baltery” does not prime ‘battery’. However, untrained primes such as “bantery” could prime both ‘baltery’ and ‘battery’. The need for this discrimination requires a modification of the representation of ’battery’ and its new neighbor ‘baltery’ so that their overlap is reduced, and the recognition of both can be automatic and accurate. This theory is potentially a good candidate for word learning theories, so we will come back to it in the conclusion.

Now that we have specified the four possible interpretations of PLE, we should not forget the other focus of this study, namely, the memory system that the newly learned words are stored. Do we assume that newly learned words are represented in episodic memory first, and lexicalized only afterwards? How does this relate to the various interpretations of PLE? From the competition point of view, presumably we can argue that competition could only occur in lexical memory, not in episodic memory. This indicates that if a PLE is confirmed, then the prime and the target should have lexical representations. If the primes are newly learned words, that means they have been lexicalized. However, this argument is complicated by the fact that a PLE was observed with visible primes after a single session of learning, but not with masked primes. If the lack of a masked PLE indicated that the novel words did not have lexical representations, is the competition produced by the visible primes coming from their episodic representations? Clearly this is not a plausible assumption.

What argument could be developed for the verification model and the discrimination model? It seems both models are relevant only for lexical memory. For the increased discrimination it is essential to reduce overlap of the two candidates to a minimum, and there should be enough practice with the newly learned stimuli to achieve a recoding. As for the verification account, if the elimination occurs rapidly enough, the masked prime should be able to produce a PLE.

In conclusion, the three experiments in the current chapter showed that when real learning was involved, a masked PLE was not found after single session of learning, but it was found with visible primes. Masked PLE was found only after multiple sessions of learning were involved. This data can be accounted for by different theories such as competition, verification, system reset and increased discrimination, depending on which word recognition model you are following. The competition account can explain the masked PLE found after multiple learning, but it failed to account for the visible PLE after one session of learning. Verification accounts can explain both, the discrimination account is not sensitive to the visibility of the prime. The result might have suggestions as to the storage and the representation of the newly learned words, but nothing has been finalized to this point. The examination of the performance of L2 speakers will, hopefully, provide more insights into the memory issue.

CHAPTER 4 TESTING CHINESE-ENGLISH BILINGUAL

In the previous chapter we tested L1 speakers learning new L1 words. In this chapter we investigate the question of how bilingual speakers learn new L2 words, and how new L2 words are represented and integrated into the bilingual lexicon. To keep the conditions constant, we did not create a new set of novel words, instead we changed the speakers (Chinese-English bilinguals) and used the same materials as in the previous chapters. For bilingual studies there are some issues that are different from what have been considered in the monolingual literature. The structure of the bilingual memory is one of them, with the typical question being whether the architecture of bilingual memory contains separate systems for each language, or one shared system for both languages.

4.1. The separate vs. integrated view of the bilingual lexicon

The proponents of separate representations assume that lexical units representing words in different languages are stored in language-specific lexicons (Scarborough, Gerard, & Cortese, 1979; Kroll & Curley, 1988; Potter et. al., 1984). For the purpose of word recognition, the system needs to first determine the language that is required to perform a particular task, then a search is undertaken within this language. If a match is not found at this initial stage, the search continues in the other language.

This position was supported by early studies conducted with interlingual homographs (words that have the same orthographic make-up, but different meanings, e.g., ROOM in Dutch means 'cream'). It was found that the lexical decision times for these homographic non-cognates were not faster than control words (Gerard & Scarborough, 1989), suggesting that the homographs' "double-existence" in two languages does not facilitate recognition, hence the memory search in one language might function independently of second-language knowledge.

However, this finding was not replicated in later studies. Significant word recognition effects (as facilitation) for the homographs were found in later studies in the translation recognition and the lexical decision task (De Groot, Delmaar, & Lupker, 2000; Dijkstra, Grainger, & Van Heuven, 1999). These studies provide the evidence that supports an integrated view. However, if this is true, how do we explain the lack of facilitation for homographs in Gerard & Scarborough's study? The argument is that the initial access can be non-selective (supporting Gerard& Scarborough's results), but then the subjects need to check which language the accessed entry belongs to, so the final decision was made in a language selective mode (De Groot， et. al., 2000).

Other empirical evidence has also been found in support of the non-selective view (Van Heuven, et al., 1998; Beauvillain & Grainger, 1987). For example, it was found that the Dutch-English bilinguals' reaction times to English words were slowed by their Dutch neighbors (Van Heuven et al., 1998); similarly, the presentation of French homographic primes (e.g., *coin*, meaning "corner" in French) exerted a semantic priming effect on lexical decision to English targets (e.g., *money*) (Beauvillain & Grainger, 1987). With more evidence uncovered, many researchers proposed that in order to provide a successful answer to the question of separate vs. integrated language systems, it is necessary to distinguish between lexical and conceptual memory representations (De Groot et al., 2000; Kroll, 1993), because there is evidence that results obtained in the research studies which emphasized lower level representations and earlier stages of word access seem to point to the existence of separate language codes, while experiments that focused on conceptual representations and later stages of access appeared to favor a common memory approach.

This issue is important for the current study for the following reasons. Firstly, the current study mainly considers the earlier stages of word access and lower level representations, therefore we should postulate the possible involvement of two separate language systems: one for L1 and the other for L2. According to the separate view, we would predict a lack of influence from L1 on the recognition of L2, no matter facilitative or inhibitory effect. Secondly, this is particularly true in the current case because we are testing Chinese-English bilinguals, whose L1 and L2 involve different scripts. Such a difference in scripts helps us to make sure that the two lexicons are distinguished at least at the level of form, and that the newly learned words would be treated as L2 words. No influence from their L1 is likely to occur.

4.2. Episodic nature of L2 lexical representation

The discussion so far has been based on the assumption that L2 newly learned words will be stored in the lexical memory system in the same way as L1 newly-learned words. A possibility that has been largely ignored is that they might be stored in the episodic system, and this is not only true for newly learned words, but also for all L2 words. This proposal that L2 lexical representation might be episodic in nature was examined in a number of studies (e.g., Jiang & Forster, 2001; Jiang, 2000). In Jiang and Forster (2001), it was found that when Chinese targets were primed by their English translations, Chinese-English bilinguals did not show reliable priming in a lexical decision task. However, such an effect was indeed found for "old" items in an episodic recognition task, in which participants were asked to learn a list of Chinese words, and then were tested on a speeded old-new judgment task. How do we account for this task difference? It was suggested that maybe the L2-L1 lexical connections are formed in the episodic system and are therefore not involved in a lexical decision task. Bradley’s (1991) study on monolingual performance supports this hypothesis. In this study (based on a prior study by McKoon and Ratcliff, 1979), she first established episodic connections between unrelated word pairs such as *fairy-shark,* and then tested priming with masked primes. No priming was obtained in a lexical decision task, but strong priming effects were obtained in an episodic recognition task. This demonstrated that the association between *fairy* and *shark* was strong enough to produce a priming effect, but only when an episodic task was used.

Furthermore, Jiang & Forster found in their Experiment 4 and 5 that the episodic task showed a reversed priming asymmetry from the lexical decision task: whereas there was much stronger priming from L1 to L2 than from L2 to L1 in lexical decision, there was stronger priming from L2 to L1 than from L1 to L2 in episodic recognition. They proposed a possible model (illustrated in Fig. 4.1.) in which the knowledge of L2 lexical items is represented in a separate memory module (referred to as episodic memory), which was different from the lexical memory where L1 is represented. In the figure, L1 represents the lexical entry for a word that is an abstract linguistic representation, and L1* represents an episodic record of previous encounters with that word. L2* represents all L2 words, which do not have lexical entries, and only have episodic records.

Therefore in an episodic task, decisions will be based on activation in either L1* or L2*, and activation in the lexical module (L1) will be irrelevant. That's why there is stronger priming when the priming goes from L2 to L1 than L1 to L2. Similarly, if it is a lexical decision task, the decision system is "tuned" to inputs from lexical memory rather than episodic memory, therefore L1 primes will activate the L1*, then priming would occur when the L2 target is presented. But the L2 prime will only activate L1* in the episodic memory system, not the L1 that is stored in the lexical memory system, hence there is no priming.

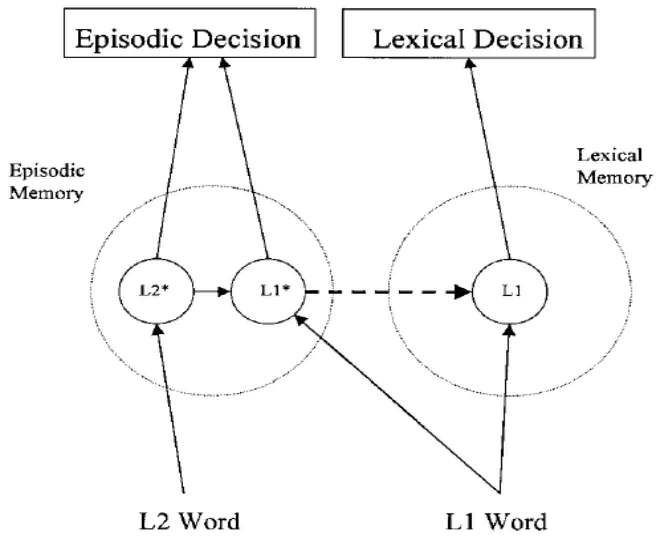

Figure 4.1. A model of the pathways involved in masked cross-language priming in late learners, taken from Jiang & Forster (2001).

Studies in other research areas also provided support for this hypothesis. For example, brain imaging studies of bilinguals showed striking differences in the cortical areas associated with L1 and L2 (e.g., Kim, Relkin, Lee, & Hirsch, 1997; Dehaene, Dupoux, Mehler, Cohen, Paulesu, Perani, van de Moortele, Lehericy, & Le Bihan, 1997;

Dehaene, Dehaene-Lambertz, & Cohan, 1998), suggesting that they might be two qualitatively different systems. In addition, a memory study found that when people learned new words as names for objects, if some participants were told that the words were made up, and some were told that they were real words, a difference was found in episodic recognition time compared to true-false RTs (Potts & Peterson, 1985). This provided support for the distinction between semantic/lexical memory and episodic memory.

4.3. A developmental view of the bilingual lexicon

The above discussion treats the architecture of bilingual memory as a stable and established system. What is more relevant to the current study is the question of how the L2 lexical representation is gradually established, and how a new L2 word interacts with old L2 items in the dynamic process of lexicalization.

There have been plenty of studies on how L2 vocabulary can be acquired under different learning conditions and what factors influence the effectiveness of L2 vocabulary acquisition (Ellis, 1994; Laufer & Hulstijn, 2001), but few studies have attempted to answer the question of how L2 lexical information is represented and integrated into the L2 mental lexicon. The only theory that explicitly deals with L2 lexical development is Jiang's (2000) three-stage model of lexical development in L2. In this model, L2 vocabulary acquisition is divided into three stages --- the formal stage, the L1 lemma mediation stage, and the L2 integration stage. At the formal stage, L2 lexical items have only form representations. There is little semantic, syntactic or morphological information in the entry. Therefore the use of L2 words involves mainly the activation of the form. The meanings of L2 words and some grammatical information may be available, but it needs to go through the activation of L2-L1 links. If we follow the distinction of lemma and lexemes as two components of a lexical entry (Garrett, 1975; Levelt, 1989), L2 lexical items at this stage can be considered lexical items without lemmas, or the lemma structure is empty (Jiang, 2000, p. 51). At the second stage, because of the repeated use, stronger associations are developed between L2 words and their L1 translation, thus there are repeated simultaneous activation of L2 word forms and the lemma information of L1 counterparts. Eventually the L1 lemma information is "copied" into the L2 entry, and the word reaches the second stage of development. At the final L2 integration stage, the semantic, syntactic, and morphological specifications of an L2 word are integrated into the lexical entry, and a fully-developed L2 entry is established, which is very similar to a lexical entry in L1.

This developmental model of L2 vocabulary acquisition provides a good explanation of why lexical items in L2 should be represented in the episodic system. Let's consider what happens in L1 acquisition first. When the native language is learned at a very young age, words and concepts are often learned together. Therefore the lexical form and semantic content are tightly integrated, and the lexical entry inevitably contains links to semantic properties. However, in the case of second language learners, they normally do not have sufficient and highly contextualized input in L2, which is nevertheless critical for semantic development. Besides, for late learners, L2 words are learned after the semantic system and the L1 lexical system have been established. Such an established semantic system in L1 constitutes a barrier for the semantic development in L2. Therefore the consequence is that learners do not develop a new concept when they learn a new word in L2. The word is understood through its L1 translation equivalent, explicitly or implicitly.

4.4. Experiment 6: Bilingual speakers learn L2 new words

In this experiment, Chinese-English bilinguals are trained to learn new English (L2) words. The question is whether these newly-learned words will interfere with already well-established L2 words. The hypothesis is (1) there should be a separate representation of L1 and L2 at the level of form because of the script difference (with Chinese as L1, and English as L2) , so no influence from L1 is expected; (2) L2 vocabulary acquisition is a long, developmental process. Several sessions of learning might not be sufficient to establish any stable representations in the mental lexicon, so the newly learned L2 words are very likely to behave like nonwords; (3) in spite of this, if Jiang & Forster's (2001) proposal was right, i.e., L2 words are always represented in the episodic memory, plus the possibility that newly learned words are also stored in the episodic memory, we may find a competition within the episodic memory system, hence a PLE might be found in this experiment.

4.4.1. Method

Participants. A total of 44 undergraduate students enrolled in the Shanghai University of Finance and Economics participated in the experiment. They were all native speakers of Chinese who had been studying English in an academic context for about 10 years. They received monetary compensation for participation.

Materials and Design. The same materials and design as Experiment 5 were used. The novel items and their meanings and the matching pictures were the same as in Experiment 5. The prime conditions were also the same. The only change is that in Session 2 – 4, different real word targets (as well as primes) were used in each session in the real word condition (e.g., protect-PROJECT). The reason for this change is that from the results in Experiment 5, we found a learning effect when the same items were repeatedly used from Session 1 to 4. To avoid such a learning effect, different materials were used in each session in the current experiment. This would not be a problem for novel targets because the learning effect is one of the main factors to be considered for novel word condition in this experiment. In addition, 24 unlearned items were added in Session 4. The purpose was to have a within-subject comparison between the reaction times on words that were primed by newly learned novel items with those primed by unlearned novel items. As in Experiment 5, two lists of materials were constructed for counterbalancing purposes, with each target appearing once in any particular list but in a different condition across lists.

Procedure. The same procedure as in Experiment 5 was followed in this experiment. The complete experiment was programmed in DMDX (Forster & Forster, 2003), and presented using a PC (Lenovo) with an LCD monitor (screen area: 1024 by 768 pixels; refresh rate: 16.6ms).

4.4.2. Results

4.4.2.1. The learning phase

As in the previous experiments, the learning effect was examined using the matching time and error rates recorded in the word-picture matching (WPM), picture-word matching (PWM), and definition-word matching (DWM) tasks. Except that session 1 has two blocks of WPM, all other three sessions had three blocks of matching tasks, each task being carried out only once (see Figure 4.2. for details).

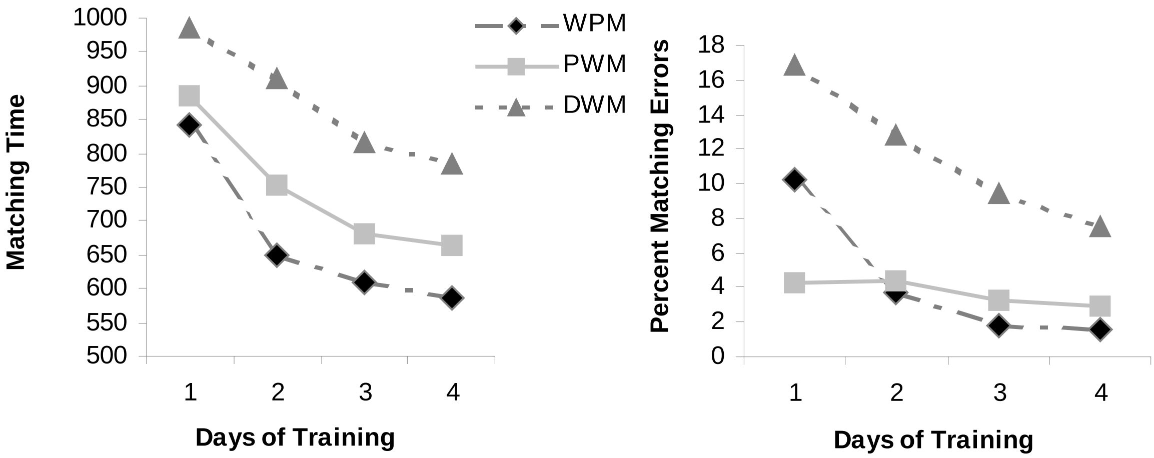

Figure 4.2. The mean matching time and error rates recorded in the word-picture matching (WPM), picture-word matching (PWM), and definition-word matching (DWM) tasks over four days of training.

2-way ANOVA analysis showed that except for the relatively small improvement in error rates in picture-word matching task, all other tasks showed significant improvement on both matching time and accuracy from Day 1 to Day 4, all Fs > 10.0, *p*

<.001. This indicated a clear learning effect, namely, participants were getting faster and better at making choices as they received more training on the novel words.

4.4.2.2. The testing phase

4.4.2.2.1. The first three sessions

Since this is a learning experiment, no participants were excluded from the analysis because of high overall error rates. However, because of computer failure, three participants' data from Session 1 was lost, and thus being excluded from the analysis of all four sessions. As a result, there was a total of 38 participants in the analysis.

In these sessions, the newly learned words were used as targets with their real word neighbor as primes (e.g., battery-BALTERY). The data in each session was initially analyzed separately in a 2-way ANOVA, the factors being Files (for counterbalancing) and Relatedness (related vs. control). Files was non-repeated factor in both the subject analysis with participants as a random factor (F1) and the analysis treating items as a random effect (F2). Besides, a 3-way ANOVA analysis was carried out so that Sessions as included as a factor. Since the same items were repeated in the three sessions, Files is still the only non-repeated factor in both the F1 and F2 analysis.

The mean lexical decision times and error rates for these novel word targets are shown in Table 4.1.

Table 4.1. Mean lexical decision times and error rates (in parentheses) for novel word targets in the testing phase in first three sessions of Experiment 6.

	Related (*battery-BALTERY*)	Control (*forever-BALTERY*)	priming
Session 1	862 (21.1)	906 (23.9)	44* (2.8)
Session 2*	831 (14.6)	867 (19.3)	36* (4.7)
Session 3	783 (8.0)	832 (11.6)	49** (3.6)

* The same prime-target pairs were used in the second and third session as the first. So a learning effect is likely to occur.

The analysis of lexical decision times showed that the main effect of Priming was significant in all three sessions (44ms in Session1, 36ms in Session2, and 49ms in Sessions3) in both subject and item analyses, all *p*s<.05. The analysis across three sessions also showed an overall significant main effect of Priming in both the subject analysis, $F1\ (1, 36) = 10.59, p<.01$; and the item analysis, $F2\ (1, 66) = 35.30, p<.001$. No significant priming was found in the error analysis. Besides, the analysis across three sessions showed that the absolute speed of reaction was significantly faster from the first to the third session (with means of 884ms, 849ms, and 808ms respectively). The difference was significant, $F1\ (2, 72) = 9.02, p<.001$, $F2\ (2, 66) = 2.82, p=0.06$. In the cross-session error analysis, significantly less errors were found in the third session than the first two sessions (with means of 22.5, 16.9, and 9.8 respectively), which was significant, $F1\ (2, 72) = 17.39, p<.001$; $F2\ (2, 66) = 6.13, p<.01$. The results suggest that: (1) when newly learned words were used as targets, their word neighbors can effectively prime them, and the priming effect did not decrease as more learning was involved. This finding requires more explanation in the later sections; (2) as more learning was involved, the participants were getting faster in making decisions on the lexical status of the newly learned words, and making fewer errors. It is possible that this reflects an acquisition effect, but it is also likely to be a repetition priming effect since the same items were repeatedly used in the three sessions. The analysis on the real word condition and the nonword condition will be reported with the results from the fourth session.

4.4.2.2.2. The fourth session

In the fourth session, *BATTERY* was used as the word target, which was primed by the newly learned word (*baltery*), to test whether *baltery* behaves more like a real word, or a nonword. In order to make the comparison, we need a control condition where unlearned nonword items were used as primes (*e.g., dresent-PRESENT*). If significantly smaller priming effect was found for the *baltery-BATTERY* pair than the *dresent-PRESENT* pair, we know that *baltery* behaves different from a common nonword.

Since items like BATTERY (a real English word) were used as the targets in this session, a subject rejection rate of 40% was applied in the analysis. As a result, four participants were rejected, which left a total of 40 participants in the analysis. The results are presented in Table 4.2.

Table 4.2. The mean lexical decision times and error rates for the new word condition in Session 4, Experiment 6.

	Related primes	Control primes	priming
Word targets (*BATTERY*) with newly learned words as primes	*baltery* 875 (14.5)	*forever* 940 (19.4)	65*** (4.9)
Word targets (*PRESENT*) with nonword primes	*dresent* 917 (25.0)	*outlook* 954 (32.3)	37** (7.3)*

Analysis on the lexical decision times showed that the main effect of Priming was highly significant when newly learned items were used as primes (65ms) in both subject and item analysis, F1 (1, 38)=18.35, p<.001; F2 (1, 22)=34.30, p<.001. The priming effect in the condition where unlearned nonwords were used as primes (37 ms) was significant only in the subject analysis, F1(1, 38)=11.31, p<.001, not in the item analysis, F2(1, 22)=2.65, p>.05. The interaction was not significant in either subject or item analysis, suggesting that the newly learned words behaved more like nonwords. The learning did not change their lexical status. Analysis on the error data showed a similar pattern: the priming effect for the newly learned words was significant in item analysis, F2 (1, 22)=9.3, p<.05, but only approached significance in the subject analysis, F1 (1, 38) =2.98, p=0.09. For the unlearned condition, there was a significant priming effect in both subject and item analysis, F1 (1, 38)= 6.8, p<.05; F2 (1, 22)=5.05, p<.05. The interaction was not significant in either subject or item analysis, supporting the conclusion from the RT analysis.

The analysis on the real word condition was slightly different from the above analysis. Different items were used in each session in this condition, therefore there was no repetition effect, and it was plausible to combine the four sessions and regard them as one large experiment with many items in it. Therefore a 4x2x2 (Sessions, Files, Relatedness) ANOVA analysis was carried out, with Files as non-repeated factor in the subject analysis (F1), and Sessions and Files as non-repeated factor in the item analysis (F2). The results are reported in Table 4.3.

Table 4.3. Mean reaction times and error rates for the real word condition in the combined analysis of sessions 1-4 in Experiment 6.

	Related primes (protect)	Control primes (refresh)	priming
Real word targets (PROJECT)	903 (34.4)	933 (37.1)	30*** (2.7)

The main effect of Priming (30ms) was significant in the subject analysis, F1 (1,36) = 13.30, p<.001; and in the item analysis, F2(1,88) =20.04, p<.001. Such a priming effect was also observed in the error data, which was significant in the item analysis, F2 (1,88) = 5.64, p<.05, and approaching significance in the subject analysis, F1(1,36) =3.41, p=0.07. The results suggested that a PLE was not observed even when real words were used as primes in the current experiment. This might be an L2 phenomenon because so far no study has attempted to test whether a PLE occurs for L2 speakers in a masked priming experiment (Elgort (2007) used unmasked primes). Or it may have something to do with the participants (e.g., their level of L2 proficiency) in this study. More discussion of this issue will be provided in the following section.

A similar 4x2x2 3-way ANOVA analysis was carried out on the nonword target data. Results are reported in Table 4.4.

Table 4.4. Mean reaction times and error rates for the nonword condition in the combined analysis of sessions 1-4 in Experiment 6.

	Related primes (shelter)	Control primes (benefit)	priming
Real word targets (SHEPTER)	968 (34)	963 (30.3)	-5 (-3.7)**

No significant priming effect was observed in the nonword targets with the RT data (-5ms), if there was any effect, it was interference rather than facilitation, although the effect was not significant in either subject or item analysis. However, a significant interference effect was found in the error data, which was significant in both subject analysis, $F1(1, 36)=11.09$, $p<.01$, and item analysis, $F2(1,46)=14.76$, $p<.001$. The result supported the common assumption that there was no priming for nonword targets.

4.4.3. Discussion

From session 1 to session 3, the newly learned items were used as targets and were primed by their real word neighbors (*e.g., battery-BALTERY*). Unexpectedly significant form priming was found throughout the three sessions. This result is not expected because in fact this condition can be taken as the strongest form of PLE-generating condition --- the prime was a real word with very stable lexical representation, therefore it should suppress the activation of its word neighbor (thus competition), and no priming should be obtained in this condition. But contrary to the prediction, we found significant form priming across all the three sessions. Does this suggest that *baltery* was not lexicalized? This suggestion was based on an important assumption, namely, a word would compete only with another real word. In order for the competition to occur between the word prime *battery* and the newly learned word target *baltery*, *baltery* has to be represented lexically. There can't be competition between something stored lexically and something stored episodically. Therefore the fact that there was significant priming between *battery-BALTERY* might indicate that *BALTERY* has not been lexicalized.

A more surprising finding was that even in Session 4, where *baltery* was used as prime and *BATTERY* was the target (the critical condition to test the lexical status of the newly learned words), a significant form priming of 65ms was found, which suggested that the newly learned words in L2 did not behave like real words, because they failed to interfere with the recognition of already known words. In fact, a reverse PLE was found, suggesting that the learning nevertheless has enhanced the effectiveness of the newly learned word primes. This is probably not so surprising if learning has improved the participants' ability to process the prime rapidly. However, this interpretation is weakened by the finding that unlearned novel word primes also produced a strong priming effect (40ms), and the interaction was not significant. This may suggest that the unlearned novel items were as effective as primes as the learned ones. Learning in the current experiment has not changed their lexical status and effectiveness as primes.

This finding conflicts with the claim of Elgort (2007) that newly learned L2 words can be lexicalized very quickly, and a PLE can be found for the L2 readers. However, it is important to remember that Elgort used unmasked primes whereas the current study used masked primes. This critical difference has been discussed in the previous chapter when a masked PLE was not found, but an unmasked PLE was found with the newly learned words when the same single session of learning was involved (see Chapter 2). Apparently the prime visibility is an effective explaination for the difference between our results and Elgort's.

However, another important comparison is that, using exactly the same materials and the same training scheme, L1 speakers showed the Prime Lexicality Effect in

Experiment 5 (the priming effect of 9ms), but L2 speakers showed a priming effect of 65ms! How should we account for this L1/L2 difference?

The first possibility is Jiang & Forster's argument that L1 and L2 utilize two qualitatively different memory systems, with L1 words stored in the lexical memory system, and L2 words stored in the episodic system. If this is true, newly learned L2 words will be stored in the episodic memory system after adequate training. This means that they do not have any status in the lexicon, and hence function just like a nonword, thus priming was observed.

However, according to Jiang and Forster, the already-known L2 words should also be stored in the episodic memory, thus one can still argue that competition may exist within the episodic memory system as well. However, this is not supported by the current results. No competition (thus more priming) was observed. If we compare this result with that obtained with L1 speakers, the newly learned words behaved like nonwords for L2 participants, whereas they behave like real words for L1 speakers. Why is this? One obvious explanation is that the training might be adequate for native speakers, but not for L2 learners. It is a longer process for L2 new words to have an effect on its neighbors. If this is true, we are suggesting that this is an L1/L2 difference, and it should be applied to different languages other than English. More experiments are necessary to test this hypothesis. Another possible explanation concerns the participants' language proficiency, and more importantly, their age when they started learning English (Age of Acquisition). Bilingual research finds that the architecture of the bilingual lexicon and lexical retrieval processes may be different for early and late bilinguals (Silverberg & Samuel, 2004;

Finkbeiner, Forster, Nicol, & Nakamura, 2004). Elgort's experiment had both early bilinguals (who started learning English before or at the age of 7) and late bilinguals (who started learning English after 7). Her post-hoc comparison showed that early bilinguals showed 13ms priming when the newly learned words were used as primes, which was not significant ($p>.05$), but there was 37ms priming observed for late bilinguals, which was marginally significant ($p=0.056$) (p. 137). Elgort took these results to mean that lexical representations of the new L2 words had been better integrated into the structure of the mental lexicon for early bilinguals than for the late bilinguals (p.137). If we examine the subjects in the present study, the majority of them are late bilinguals, due to the fact that in China formal English education starts at age 7. It is possible that some children started earlier, but compared to their mother tongue, they had limited access to the authentic second language. Thus the fact that they acquired English at an older age seems a possible reason why the newly learned words did not show competition in this experiment.

Another interesting finding is the substantial priming effect of 65ms that was much bigger than what is normally expected from a form prime (approximately 30ms). According to Forster, Mohan, & Hector (2003), form priming can be explained as a savings effect, therefore the amount of time saved can never be bigger than the time interval between onset of the prime and target (i.e., the SOA). An additional limitation on form priming is that it can never be bigger than the time it takes to open an entry, which is assumed to be approximately 30ms. So the limit is set to whichever variable is shorter, which in this case is 30ms (the SOA was 50ms). However, it has often been found that priming is bigger than the SOA for L2 participants, inexperienced readers, or children (De Groot & Nas, 1991; Finkbeiner et al., 2004; Jiang, 1999). One possible explanation is that the time taken to open an entry is longer than 30ms for inexperienced readers. Another possibility is that there is an additional component to the priming effect (Forster et al., 2003). For example, if very hard items are used as targets (or at least they are hard items for the particular group of participants), the initial attempt at access may fail. Some participants might make the decision that it is a nonword, but more conservative participants might initiate a second attempt at access. If the second attempt succeeds, the response will be correct, but the RT will be very long. In addition, a related prime will decrease the probability that a second attempt will be required, which leads to a much larger priming effect than just entry-opening, because now the amount of time saved equals the entry-opening time plus the time spent during the initial failed attempt at access.

In conclusion, it appears that the effect of training is very different for L2 readers from L1 readers if the primes are masked. Elgort (2007) found a PLE for L2 readers when unmasked primes were used. Another important difference is that Elgort's participants were in an L2-dominant environment, using English on a daily basis, whereas the participants in the current study were in an L1 environment, and did not use English on a daily basis.

CHAPTER 5 GENERAL DISCUSSION AND CONCLUSIONS

5.1. The representation of the newly learned words

The present study has addressed the questions of how newly learned words are represented in the mental lexicon and the way they interact with the already existing words. In particular, are newly learned words incorporated into the same processing system that serves L1, or are they represented quite independently in other types of system, such as an episodic memory system? This question is based on the important distinction between semantic memory and episodic memory proposed by Tulving (1982). If word knowledge is stored in the permanent and general lexical memory, information about a new word, or the episodes in which a new word is encountered must be initially registered in episodic memory. Subsequently when we begin to encounter the same word repeatedly in different contexts, an abstract or generalized representation of that new word might be formed within lexical memory, and the retrieval of the information about the new word would then go through the lexical memory system, rather than episodic memory system. If this is true, it is of interest to ask how newly learned words are represented (1) at the beginning stage of learning, (2) when more learning was involved, and (3) when the new words are lexicalized. For the last question, it is also important to ask how we can tell when the lexicalization happens --- do we have an index to show this qualitative change?

The research reported in this dissertation was based on the recent discovery by Elgort (2007) that newly learned words produce less form priming than novel nonwords. Elgort took this as evidence of lexicalization, considering the finding that words produce less priming than nonwords (Forster & Veres 1998). However, it should be noted that Elgort's experiments had visible primes, which possibly undermines the argument of real lexicalization. Strategic and controlled processing might be involved when the primes are visible. If the novel words are indeed lexicalized, the processing is automatic, therefore a "masked" effect should be observed.

Another scenario is that maybe all the effort Elgort put into teaching meanings was quite unnecessary. In other words, competition can happen even when participants only became familiar with the novel words. Odd as it sounds, a study has shown that familiarizing a nonword such as "*banara*" (by typing it repeatedly) would inhibit the semantic cateogrization time on "*BANANA*" even though no meaning was attached to "*banara*" (Bowers et al, 2005). This finding was taken as evidence for lexical competition, but it is possible to argue that the observed inhibitory effects might be due to the biases or strategies based on what has been stored in episodic memory. It has nothing to do with lexical competition, because *banara* is in no way represented lexically. In order to have a better understanding of the issue, two studies were carried out as control experiments, which tested participants' performance when the training is more superficial.

5.2. What is the effect of mere familiarization?

Experiments 1 and 2 tested whether familiarization at the level of form was enough to modify priming. In these experiments participants were given practice at typing the new words, and same-different matching, both tasks that required an accurate and detailed representation at the level of form.

Experiment 1 found that there was no significant difference between the priming effects from the learned primes (e.g., *baltery*) compared with an unlearned prime (e.g., *bantery)*. The magnitude of priming even went in the wrong direction --- learned primes produced bigger priming (24ms) than the unlearned primes (16ms), although the difference was not significant.

This result indicated that the PLE Elgort (2007) observed was unlikely to be due to increased familiarity. Familiarization did not produce a PLE. Now the next question is, did the familiarization procedure establish something, e.g., episodic memory traces, but they were just not relevant to priming? Or instead, it actually did not establish anything in the memory system? This is an interesting issue because if the former is what happened, it indicates that an episodic representation was established, but it did not successfully compete with its word neighbor stored in the lexical system, which further suggests that entries in two distinct memory systems do not compete with each other. This is a result that most word recognition models have to account for.

Experiment 2 demonstrated that the newly learned words showed a repetition priming effect when used as targets. What does this tell us? First, the masked repetition priming effect is the most robust effect recorded with the masked priming paradigm. Therefore if priming was found, it would indicate that the familiarization procedure in Experiment 1 must have changed the way the nonwords were represented. Second, masked repetition priming is normally observed only on words, therefore if the familiarized nonwords showed repetition priming, whereas the unfamiliarized nonwords did not, it would suggest that familiarization has certain effects on the nonwords. This was indeed the result of Experiment 2. Repetition priming was found for familiarized non-words (22ms), not for unfamiliar non-words (4ms). It seems clear that the familiarization procedure successfully established some kind of representation (maybe episodic) in the memory system. However, previous work (Forster, 1985) showed that repetition priming can be observed for nonwords in an Episodic Recognition Task, implying that episodic records can be primed as well. Therefore the priming we observed here might have been mediated by an episodic record.

In conclusion, the two experiments with familiarization as training showed that the familiarization training was not strong enough to establish something that is sufficient to produce a PLE, but the repetition priming observed in Experiment 2 showed that a priming-relevant representation was clearly formed. Whether such a priming effect was episodic in nature needs more evidence from future studies.

Finally, if familiarization alone does not form a representation that competes with the recognition of a real word neighbor, why did a similar training procedure interfere with the semantic categorization response to a neighbor in the Bowers study? One possible reason is that in the semantic categorization task, participants normally assume that all target items will be correctly spelled words, and hence the importance of a post-access spelling check is downgraded. But when many of the targets are so similar in form to a previously trained nonword (and presumably participants infer that there must be some connection between the training and test phases of the experiment), greater weight may be given to a spelling check, leading to longer RTs for those items. One might think that exactly the same argument applies to lexical decision, but if one accepts that under the conditions of this experiment, where all nonword targets were one-letter-different from words, a spelling check is *always* required, regardless of the similarity to a previously trained nonword.

Another possibility is that the typing task establishes a lexical representation at the level of form only, and that more is required to produce a PLE. Elgort (2007) obtained a clear PLE, but that might be due to the fact that she taught her participants meanings for the new words. If a PLE can be obtained by training participants to associate a meaning with the novel words, the implication would be that competition occurs at a semantic level rather than at a form level. Experiments 3 to 6 tested this hypothesis.

5.3. What does a single session of real learning achieve?

In Experiments 3 and 4, the new words were given definitions and matching pictures to see whether this can produce a PLE. The hypothesis was that learning the meaning and the corresponding picture would give new words a better chance to establish themselves in the lexicon, thus a PLE is more likely to occur. However, results from Experiment. 3 did not support this assumption. No significant difference was found between priming produced by the learned primes (21ms) and the unlearned primes (23ms). It seems that one session of real learning is still not sufficient to establish a lexical representation that can produce a PLE. This result does not support the findings that immediate learning effects can be found (Forster, 1985; Salasoo, et al., 1985), but it goes along with other studies that claimed the importance of consolidation (Gaskell & Dumay, 2003; Bowers et. al., 2005). The Gaskell study found that although no lexical competition was observed on the first day of learning, when tested a week later even without further exposure to the novel items, evidence of lexical competition was observed, suggesting that there was a pure effect of consolidation. This may simply be because of the importance of sleep in the consolidation of language learning (e.g., Hupbach, et al., 2009). What is important is that it suggests multiple sessions of learning may be critical for a PLE to occur.

There was one interesting finding in Experiment 3 that was observed in the analysis of errors. In the untrained condition, related primes (e.g., *dresent-PRESENT*) produced significantly fewer errors than control primes, but in the trained condition (e.g., *baltery-BATTERY*), such a difference disappeared. This effect can be regarded as a PLE in the form of errors. For example, suppose an error occurs when no matching candidate for the target is found. In order for this to happen when the prime is related to the target, neither the prime nor the target should detect a match. The probability of this happening is greater when the prime is learned than when it is not learned, because training reduces the probability of the prime opening the entry of the target. If this is true, this can be counted as a kind of PLE – sometimes the effect does not occur in RTs, but it does in errors. This might be an example.

PLE was not found in either Experiment 1 or Experiment 3, maybe the lack of a PLE is simply because this effect can only be found in certain conditions, e.g., when the primes are visible. This is reasonable because if PLE is the result of a verification process as suggested by the entry-opening model, the more time is given to the prime, the more likely that the resolution is completed. Once the resolution is completed, the candidate matches are closed, which includes the one for the target, hence a PLE will always be found. This hypothesis predicts that a PLE is easier to get if the primes are visible. Experiment 4 tested this hypothesis.

Exactly the same training and testing as Experiment 3 were used in Experiment 4. The only difference is that the prime duration was prolonged to 250ms instead of 50ms. The result supported the above hypothesis --- when the primes were visible, a PLE was observed after a single session of learning. This result requires some explanation, because it poses a problem for Elgort's (2007) conclusion, where a PLE with visible primes was used as an index of the lexicalization of newly learned words. Our combined results in Experiment 3 and 4 suggest that the same amount of training can produce a PLE with unmasked primes, but not with masked primes, which suggests that we should be cautious about using an unmasked PLE as an index of lexicalization.

5.4. The effect of multiple sessions of learning

The lack of a PLE in Experiment 3 showed that there was no immediate generation of fully-fledged lexical representations after a single session of learning of the novel items. It is possible that more exposure and rests between sessions may be necessary for lexicalization to occur (Gaskell & Dumay, 2003; Hupbach et al., 2009). Experiment 5 tested this hypothesis with four sessions of learning and testing spread over a period of two weeks.

Results showed that with more intensive training spread over a two-week period, form priming with a learned prime was reduced to 9ms, which was significantly different from the 29ms priming effect when there was no learning involved (as shown by

Experiment 5B). The newly learned words finally produced a PLE after all, and only after multiple sessions of learning. Considering the fact that other possibilities of PLE has been examined and excluded one by one from Experiment 1 to Experiment 4 (except for the unmasked case), this masked PLE seems to suggest a real lexicalization of the newly learned words.

Experiment 6, another multiple learning of new words, tested Chinese-English bilingual speakers' performance after learning the same set of new words in their L2 (English). There is some debate about whether L1 and L2 lexicon are integrated or separate, and the possible differences in their structure and function. Experiment 6 used exactly the same training as that has been given to L1 speakers in Experiment 5, but instead of producing a PLE, the training enhanced priming (9ms vs. 65ms). This indicates that the training has not changed the lexical status of the novel words (i.e., they still behave like nonwords). This finding, again, conflicts with the findings of Elgort (2007) that newly learned L2 words can be lexicalized very quickly, and a PLE can be found for the L2 readers. So the question now is to explain why L1 readers show a PLE with both masked and unmasked primes, but L2 readers show a PLE with unmasked primes (as shown by Elgort), but not with masked primes.

One possible explanation is that the architecture of the bilingual lexicon and lexical retrieval processes may be different for early (who started learning English before or at the age of 7) and late bilinguals (who started learning English after 7). Elgort's post-hoc comparison showed that early bilinguals in her study showed significantly less priming than late bilinguals. Considering the fact that in China, most participants start learning English after 7, therefore they are late bilinguals, whom, according to Elgort (2007), would not be able to integrate new words into the structure of the mental lexicon as well as the early bilinguals. In addition, the hyperpriming (65ms) also requires certain explanation, which might suggest that L2 speakers process the lexical items in a different manner than the native speakers.

In conclusion, the current study observes an interesting contrast, which showed that after training on exactly the same materials and following the same training scheme, L1 speakers showed the PLE in Experiment 5, but L2 speakers showed a priming effect of 65ms! This is likely an L1/L2 difference, or perhaps a language proficiency difference. But we want to argue that this result supports Jiang & Forster's proposal that L1 and L2 ARE two qualitatively different lexicons, and they might be using two qualitatively different memory systems. In particular, L1 words are stored in the lexical memory system, but L2 words are stored in the episodic system. In this case, newly learned L2 words will be settled in the episodic memory system after adequate training. There is no such thing as "lexicalization", and it is pointless to discuss the possibility of competition.

5.5. What are the possible interpretations of PLE?

The PLE has been repeatedly discussed throughout the current research. Now we are ready to use the new evidence we observed in this study to make more in-depth discussion on the nature of PLE and the possible interpretations of this effect.

5.5.1. Can PLE be reliably found in all kinds of conditions?

To answer this question, we first examine the condition when real words are primes for their real word neighbors, such as *contrast-CONTRACT*. Such a condition was included in Experiment 5 and 6 when multiple sessions of real learning were carried out for the novel words. In Experiment 5 the same set of materials were repeated from Session 1 to Session 4, with the results as presented in Table 5.1. In Experiment 6 the participants are Chinese-English bilinguals, and different items were used for each different session. The results are presented in Table 5.1. for the purpose of comparison.

Table 5.1. The mean RTs and error rates for real word condition in each session in Experiment 5 and Experiment 6.

Experiment		Results		
		Related	control	Priming
Experiment 5: Native speakers of English	1	631 (7.7)	644 (8.7)	13 (1.0)
	2	601 (6.3)	603 (7)	2 (0.7)
	3	585 (6.5)	605 (6.8)	20 (0.3)
	4	570 (2.4)	588 (4.4)	18** (2.0)*
Experiment 6: L2 speakers	1	850 (19.4)	900 (22.7)	50 (3.3)
	2	899 (40.6)	921 (42.5)	22 (1.9)
	3	893 (41.4)	929 (45.5)	36 (4.1)
	4	964 (30)	981 (33.8)	17 (3.8)

Look at the native speakers' performance first. Since the same items were repeated in each of the four sessions, it is more sensible to consider the results from the first session as the clearest result. Analysis showed that the main effect of Priming (13ms) was not significant in either subject or item analysis. This result supports the assumption that word primes produce either a null or a facilitatory effect (Forster, 1987; Forster & Veres, 1998). However, it goes against the prediction by the interactive activation model --- namely, related word primes should strongly activate lexical competitors of the target, therefore a lexical inhibition should be observed for word targets (Davis & Lupker, 2006; Davis, 2003). As more studies have been carried out, this issue has become increasingly complicated since some studies found facilitation (Forster, 1987; Forster & Veres, Experiment 3 & 4, 1998), some found null effects (Forster & Veres, Experiment 2, 1998), and some found inhibition (Davis & Lupker, 2006) (see Table 5.2. for a comparison of these studies).

Table 5.2. A comparison of results from studies that examined the PLE ("Close" distractors differ from real words by one letter, "distant" distractors differ by two letters).

	Study	Priming (by word primes)	Proposed interpretation by the author(s)
Facilitation	Forster (1987)	+38ms	Distant nonword distractors
	Forster & Veres (1998), Exp.3	+34ms	Distant nonword distractors
	Forster & Veres (1998), Exp.4	+32ms	Distant nonword distractors
Null effect	Forster & Veres (1998), Exp.2	8ms	Close nonword distractors
	Exp. 5, current study	13ms	Close nonword distractors
	Davis & Lupker (2006), Exp.1	-13ms	HighF targets preceded by LowF primes
	Davis & Lupker (2006), Exp.2	-7ms	No-shared neighbor
	Davis & Lupker (2006), Exp.3	-13ms	LowN nonword distractors
Inhibition	Grainger & Ferrand (1994), Exp.3	-23ms	Not explained
	Davis & Lupker (2006), Exp.1	-34ms	LowF targets preceded by highF primes (competition)
	Davis & Lupker (2006), Exp. 2	-35ms	One-shared neighbor
	Davis & Lupker (2006), Exp.3	-29ms	HighN nonword distractors

It is clear that a PLE is not uniformaly found. But why is it so? Davis & Lupker (2006) identified three factors that explained why Forster & Veres (1998) found facilitation while Davis & Lupker (2006) found inhibition: (a) the prime-target relative frequency; (b) the shared neighbors of the prime and target; (c) the neighborhood value of the nonword distractors. They point out that inhibitory influences can be maximized if these three conditions are met, i.e., the frequency of the prime is higher than the frequency of the target, the prime and target share a neighbor, and the nonword distractors have many neighbors. Forster & Veres used items that did not meet these conditions, which is why they did not find inhibition. In the current experiment, none of these factors were carefully considered, and this may have resulted in the null effects. In addition, it is also possible that with continued repetition, episodic representations of the targets were formed, and became the basis for the response. Therefore the lexical representation would not affect the identification, and a PLE would not be expected. Forster & Veres (1998) proposed that the difficulty of discrimination is important. For example, if the nonword targets are more than one letter different from the words (i.e., the discrimination is easier), PLE will disappear. But in any case, David & Lupker proposed that there should not be any priming with word primes at all, but Forster & Veres only propose null effect or insignificant facilitation. It is not necessarily inhibition.

5.5.2. What are the possible interpretations?

In Chapter 3, we described four possible interpretations: a competition account as proposed by the Interactive Activation model; a verification account as proposed by entry-opening model; the discrimination account, and the system reset account described in Forster and Veres (1998).

In cascaded activation models, there is no threshold that indicates which word unit is the correct one, hence it is not possible to uniquely identify the input. In order to achieve identification, competition is necessary. One candidate unit must drive down the activation level of other units to zero to "win out". Since a real word is a good competitor of its word neighbor, competition will occur, especially if the prime is higher in frequency than the target, hence there would not be any priming at all.

The verification account emphasized the time for verification to occur. If there is time to verify the prime, the entry for the target will be closed down, and will have to reopened when the target is presented. Therefore there is no savings effect. A successful verification can only occur if the prime is a word. The verification account provides a good explanation for why PLE is obtained when the primes are visible, whereas the competition account has difficulty in explaining such an unmasked PLE. In particular, in Chapter 3 it was found that after single session of learning, a PLE was not found in the masked priming condition, but *was* found when the primes were visible. According to a competition account, what is important is that the primes are words, it does not matter whether they are visible or not. It is hard to see why competition only occurs when the word prime was visible. This poses a problem for the competition models, but it can be explained by the verification account. According to the latter, visible primes give enough time for the system to decide which is the exact match, once it is decided that 'baltery' or 'contrast' is the exact match, the entry for 'battery' and 'contract' will be closed down, hence there is no savings when the entry is reopened when the target is presented.

As for the system reset account , an important notion is "error signal ". In particular, when a real word is presented as a prime (e.g. *contrast-CONTRACT*), the system detects both 'contract' and 'contrast' as exact matches, which creates an error signal because the same stimulus cannot be an exact match for two different words. As a consequence, a system reset is necessary, which destroys any priming. In the current experiments, when the training on ‘baltery’ is fairly superficial, there is no lexical representation formed, and hence *baltery* does not register as a perfect match, so there is no need for system reset, which is why we get priming in the first couple of experiments. Later when 'baltery' was lexicalized, the prime *baltery* would register as a perfect match, and the system reset becomes necessary, so priming disappeared. This system reset model does not say anything about the duration of prime. However, it does relate to the participants' strategy, or personality. Forster and Veres (1998) argued that a PLE would only occur if an error signal triggered a system reset, but if this was ignored, then priming would occur. Therefore if we compare the performance of cautious vs. risky participants, cautious participants would show less priming than the risky participants, who ignored the error signal, and would show strong facilitation.

The fourth theory that explains the PLE is the discrimination account. According to this account, when readers have to learn "*baltery*", their ability to discriminate "*baltery*" from "*battery*" is strengthened. The increased discrimination may result in the delay of recognition of "battery" (the PLE), it might also make it necessary to modify the representation of this word and its new neighbor so that their overlap is reduced, and the recognition of both can be automatic and accurate, as argued in Forster and Taft (1994). If the overlap is reduced to a bare minimum, then of course, no priming would occur. It is obvious that this theory has more concerns about the gradual change of the representations of the word and its NEW neighbor, which suggests that it is potentially a good candidate for word learning theories. So let's take a closer look at this account.

This account falls in a bigger theoretical framework that might be called **"The Big Fence Theory**" which is similar to the ideas developed in Forster & Taft (1994). The idea is that all sorts of information about a specific word are distributed in different memory locations. It is possible that these information sources might distribute like a circle, with the word as the center of this distribution. When the recognition process starts, all information moves toward the center, so that the system collects and integrates information from different memory locations and no information will be missed. However, if there is another word in the neighboring region, some information from these two words might overlap, and the information might merge. But theoretically speaking, the less overlap there is, the easier the recognition is. So if a new word is learned, the system will modify the representations of the new word and its pre-existing neighbors so that they don't have too much overlap. The analogy here is if somebody new moves into your neighborhood and is too close for comfort (e.g., you have to listen to their phone conversations), you will build a big fence to limit any interaction. Similarly, for better recognition, the system is always looking for a finer and more precise representation of each word.

How does the "Big Fence Theory" account for the PLE? Well, essentially every word is stored so that it occupies its own territory, and does not overlap with anybody else's territory. So the recognition of "*contrast*" will not have any effect on the recognition of "*CONTRACT*" since they both have very clear-cut, well-established territory. However, in the case of nonword prime, the system has never experienced these stimuli, and so it cannot avoid entering territory that belongs to somebody else, and then when that word was presented as the target, the recognition had a head-start, hence there is priming with these nonword primes.

As for the newly learned words, it happens this way: at the beginning stage of familiarization when the nonword is repeated several times, a representation in episodic memory is created. However, this will not have any effect on lexical representations because they are in completely different brain regions. We can describe this using the competition account --- there is no competition between entries in different systems. Or we could say that there isn't any need for a Big Fence. Later on, as more learning is involved, the new word enters into the lexical system, and a fence seems necessary to be built. Eventually the new word will settle in a separate different region, and the overlap with the real word is reduced, hence the priming is gradually reduced as well.

So the absence of a masked PLE in Exp. 1 and 3 could mean that we have not been successful in establishing the new words in lexical memory. The masked PLE in Experiment 5, therefore, suggests that the new words are finally lexicalized. If this works, why do we get a PLE when the prime is visible, as in Experiment 4? This might have something to do with the fact that once we construct a conscious representation of both the new word and its pre-existing neighbor in working memory, then they will interact with each other. It's like the Kouider and Dupoux argument that cross-modal priming is only obtained when subjects are aware of the prime. The reason is that now the primes and the targets are in the same module --- working memory, so they can interact with each other (Kouider & Dupoux, 2004).

Then what happened with the L2 readers? Presumably if a masked PLE was found, it might indicate that both the new words and their pre-existing English (L2) words are stored in the same system – i.e., episodic memory, which would provide support for the Jiang & Forster proposal that L2 words are episodically represented. However, this is not what we found. A hyperpriming effect of 65ms was found for L2 speakers after multiple sessions of learning. This would indicate either (1) the learning was not sufficient for L2 speakers to "fix" a territory for the new word in the lexical system, or (2) the pre-existing words are stored in the lexical system, but new words are stored in the episodic system, and there is no interaction between different systems.

In fact, the idea of *territory* and *building fences* has been discussed in different ways by other researchers. For example, Castles, Davis, Cavalot and Forster (2007) found that beginning readers (3rd Graders) showed priming (nonword primes) for high-N word targets, but older children (5th Grader) and adult readers did not. This is interpreted as a lexical tuning phenomenon, meaning that for young readers, one letter different and transposed letter primes may have been as effective in activating the representations for the target words as were the words themselves (p. 175). However, later on when the lexical space becomes more crowded, the word detection will eventually become more finely tuned. This hypothesis might not have much to do with PLE. It is the neighborhood density constraint, which says that in a dense neighborhood, form priming is reduced or elimited altogher, regardless of the lexical status of the prime. But according to the Big Fence Theory, PLE applies regardless of neighborhood density.

5.5.3. Is PLE a good index of lexicalization?

Elgort （2007）initiated the practice of using PLE as an index of lexicalization, and the current study follows up this idea with more stages of learning examined, and masked priming effects tested. Our results showed that masked PLE is a good index of lexicalization, but unmasked PLE is not. In particular, in Experiment 1 and 3 when little learning (mere familiarization at the level of form, and single session of learning) is involved, no PLE was observed with a masked prime, but a clear effect was observed with an unmasked prime. However, in Experiment 5 after readers learn the new words repeatedly, and the training happens on multiple days, a PLE was observed with a masked prime. This nice comparison matches people's general understanding of learning and lexicalization --- it takes time and efforts to learn a new word, and lexicalization is a gradual developmental issue. It is unlikely to happen at the early stages of learning.

The conclusion that unmasked PLE is not a good index of lexicalization is based on the comparison of Experiment 3 and 4. In particular, PLE was not found with masked primes in Experiment 3, but it was found with unmasked primes in Experiment 4 when the same training and testing procedure was followed. As has been discussed earlier, this difference was best account for by the verification theory. To put it simply, when the primes are visible, the system gets enough time for verification. Once the prime is identified, links to other candidates (including the target) will be closed down. However, if the prime is a nonword, no resolution will be reached, the system is still open for other candidates (including the target), hence a priming effect is found.

So far the only remaining question is about the L2 performance: since a PLE was found for L1 readers, it seems a good index of lexicalization when new words are learned, such a learning effect did not occur on L2 readers. Experiment 6 showed that L2 readers produced significant priming (65ms) after they learned the same materials, and received the same amount of training as L1 speakers. Does this suggest that there is no PLE in L2? This is not unlikely, perhaps because of the way that L2 words are represented (e.g., episodically). Anyway L1 and L2 may differ from each other in many ways and the difference might be so critical that it affects major processes in word recognition.

5.6. Future directions

It is obvious that there is a great deal of follow-up work to be done on these issues. To start with, the L2 readers should be tested again to make sure the surprising data are reliable. The huge difference between Experiment 6 and Elgort (2007) might be due to the visibility of the prime, but the participants' English proficiency is also a very important factor. The Chinese-English bilinguals might not be as good as European L2 speakers since the latter have more opportunity to be exposed to authentic English. China is comparatively a closed community in which Mandarin Chinese is the exclusive language most of the time.

In addition, an experiment can also be done on Chinese-English bilinguals using unmasked primes. If we think that the reason why Elgort's L2 readers show a PLE while ours did not is because of the proficiency difference, we could check this out by seeing whether we get a PLE with unmasked primes. If our L2 subjects don't show a PLE with unmasked primes either, then proficiency might be the critical variable.

But one might question whether proficiency has anything to do with lexicalization, because it is reasonable to think that the amount of training that participants get is not enough to produce a very high degree of proficiency, yet it still produces a PLE. So the fact that the L2 participants in the current study did not show a PLE suggests that it might be an L2 phenomenon.

If this is true, another experiment can be done to test Chinese-English bilinguals learning new words in their L1 (i.e., Chinese). If a PLE is found with Chinese subjects tested in their L1 rather than L2, then that would at least rule out the possibility that there is something peculiar with Chinese subjects.

Last but not the least, another possibility that is worth considering is doing an episodic recognition memory experiment, designed to test whether one gets a PLE in that task. The rationale is that an episodic recognition task requires particularly the feedback from the episodic memory system, so if no PLE is found in this task, it would mean that words stored in the episodic system do not interact with each other, which is presumably an important conclusion for all models we discussed before, including the competition model, the verification and discrimination models. In particular, if that is what we find, the competition model would say that competition only occurs in lexical memory, not in episodic memory. The discrimination model, on the other hand, will argue that increased discrimination is relevant only for lexical memory, where it is essential to reduce overlap to a minimum, and where there is enough practice with the stimuli to achieve a recoding. Episodic records do not have to be kept distinct, or there is insufficient practice with them to produce heightened discrimination. As for verification, the major concern is the speed of recognition because if it is slow, it means that system reset or second attempt of access might have been implemented, so it is important to find PLE that occurs rapidly enough with a masked prime, as that has been found for L1.

APPENDIX A ITEMS IN EXPERIMENT 1

(3-FILE DESIGN)

Related learned Prime	related unlearned prime	unrelated prime	TARGET
	Word Targets		
baltery	bantery	denssel	BATTERY
coultry	couctry	mainter	COUNTRY
bereath	beseath	boozier	BENEATH
chisper	thisper	holvent	WHISPER
mopern	mojern	feldin	MODERN
figteen	ficteen	renolve	FIFTEEN
dellow	nellow	barver	YELLOW
horget	sorget	jictan	FORGET
crouble	drouble	presper	TROUBLE
conpert	conlert	antaine	CONCERT
glound	ghound	fetter	GROUND
clight	klight	yarner	FLIGHT
cermain	cergain	goolish	CERTAIN
geberal	gederal	engaver	GENERAL
beturn	leturn	rutton	RETURN
macket	gacket	perkod	PACKET
cleate	cheate	ranett	CREATE
saciety	seciety	waisket	SOCIETY
derice	denice	straid	DEVICE
celter	cegter	cortry	CENTER
unstairs	ulstairs	dalimon	UPSTAIRS
dontest	montest	searlet	CONTEST
geople	heople	janair	PEOPLE
sweaber	sweaper	nictrial	SWEATER
dresent	tresent	crosten	PRESENT
unible	unoble	quoash	UNABLE
culdure	culsure	boanny	CULTURE
catrolic	catwolic	redaider	CATHOLIC
mocher	mosher	bizard	MOTHER
dencribe	depcribe	janetter	DESCRIBE
notting	notring	miratle	NOTHING

Related learned prime	related unlearned prime	unrelated prime	TARGET
commany	comgany	tovinic	COMPANY
altend	artend	sicket	ATTEND
sprind	sprink	mition	SPRING
sublect	subfect	junable	SUBJECT
tensior	tensiot	kirclet	TENSION
fagily	fabily	stanic	FAMILY
herson	merson	caseen	PERSON
plothes	blothes	politle	CLOTHES
seriod	feriod	snover	PERIOD
admance	adgance	strovee	ADVANCE
persect	perlect	sumitan	PERFECT
fortula	forbula	thilter	FORMULA
corning	lorning	sponer	MORNING
fibure	fiture	ziffer	FIGURE
suglest	sugfest	connkie	SUGGEST
fuality	muality	pealney	QUALITY
chought	shought	laytive	THOUGHT

Non-word Targets

Identity prime	related form prime	unrelated prime	TARGET
descrobe	discrobe	unstains	DESCROBE
contrist	contrict	catrolic	CONTRIST
glarions	glarious	imberval	GLARIONS
bangrast	bangrust	descible	BANGRAST
persunt	persuct	satiffy	PERSUNT
socceed	sacceed	dourway	SOCCEED
rimonce	rimance	clukter	RIMONCE
rifager	refager	trampet	RIFAGER
purtish	purnish	massion	PURTISH
admince	advince	vectory	ADMINCE
outbade	outbide	sentury	OUTBADE

Identity prime	related form prime	unrelated prime	TARGET
chumper	champer	fintion	CHUMPER
abstocle	absticle	raidsoad	ABSTOCLE
intersal	intergal	shetherd	INTERSAL
mestrict	mestract	stecimen	MESTRICT
camualty	canualty	scalptor	CAMUALTY
truffic	troffic	inittal	TRUFFIC
dinease	dimease	vession	DINEASE
tratedy	tramedy	campact	TRATEDY
poshible	postible	ulthough	POSHIBLE
elention	elension	insiance	ELENTION
recublic	mecublic	illiance	RECUBLIC
limidish	lemidish	etarnity	LIMIDISH
potular	rotular	contern	POTULAR
percopt	percapt	forsade	PERCOPT
vociety	lociety	concest	VOCIETY
lowsuit	lewsuit	gurrant	LOWSUIT
regelar	renelar	prement	REGELAR
vamnish	lamnish	proview	VAMNISH
manimum	ranimum	adgress	MANIMUM
starcle	stargle	noddril	STARCLE
pecaliar	peceliar	inserior	PECALIAR
comable	camable	apticle	COMABLE
clastal	crostal	circurt	CLASTAL
saperior	soperior	exteanal	SAPERIOR
faurfold	feurfold	orrinary	FAURFOLD
seaffirm	leaffirm	renolute	SEAFFIRM
ourgrow	oungrow	shoupen	OURGROW
hamchet	hanchet	siziler	HAMCHET
farward	ferward	sarious	FARWARD
quacity	quanity	jastice	QUACITY
pathern	patrern	noclear	PATHERN
acrount	acnount	skecial	ACROUNT

APPENDIX B ITEMS IN EXPERIMENT 2

(REPETITION PRIMING EXPERIMENT)

Novel word identity prime	unrelated prime	TARGET
	Nonword Targets	
baltery	danssel	BALTERY
coultry	mainter	COULTRY
bereath	boozier	BEREATH
chisper	holvent	CHISPER
mopern	feldin	MOPERN
figteen	renolve	FIGTEEN
dellow	barver	DELLOW
horget	jictan	HORGET
crouble	presper	CROUBLE
conpert	antaine	CONPERT
glound	fetter	GLOUND
clight	yarner	CLIGHT
cermain	goolish	CERMAIN
geberal	engaver	GEBERAL
beturn	rutton	BETURN
macket	perkod	MACKET
cleate	ranett	CLEATE
saciety	waisket	SACIETY
derice	straid	DERICE
celter	cortry	CELTER
unstairs	dalimon	UNSTAIRS
dontest	searlet	DONTEST
geople	janair	GEOPLE
sweaber	nictrial	SWEABER
dresent	crosten	DRESENT
unible	quoash	UNIBLE
culdure	boanny	CULDURE
catrolic	redaider	CATROLIC
mocher	bizard	MOCHER
dencribe	janetter	DENCRIBE
notting	miratle	NOTTING
commany	tovinic	COMMANY
altend	sicket	ALTEND

Identity prime	unrelated prime	TARGET
sprind	mition	SPRIND
sublect	junable	SUBLECT
tensior	kirclet	TENSIOR
fagily	stanic	FAGILY
herson	caseen	HERSON
plothes	politle	PLOTHES
seriod	snover	SERIOD
admance	strovee	ADMANCE
persect	sumitan	PERSECT
fortula	thilter	FORTULA
corning	sponer	CORNING
fibure	ziffer	FIBURE
suglest	connkie	SUGLEST
fuality	pealney	FUALITY
chought	laytive	CHOUGHT
	Word targets	
describe	unstains	DESCRIBE
contrast	catrolic	CONTRAST
glorious	imberval	GLORIOUS
bankrupt	descible	BANKRUPT
persuit	satiffy	PERSUIT
succeed	dourway	SUCCEED
romance	clukter	ROMANCE
Refugee	trampet	REFUGEE
punish	massion	PUNISH
advance	vectory	ADVANCE
outside	sentury	OUTSIDE
chamber	fintion	CHAMBER
article	raidsoad	ARTICLE
internal	shetherd	INTERNAL
restrict	stecimen	RESTRICT
casualty	scalptor	CASUALTY
traffic	inittal	TRAFFIC

identity prime	unrelated prime	TARGET
inhibit	ablique	INHIBIT
explain	messave	EXPLAIN
shooter	unferno	SHOOTER
library	postion	LIBRARY
athlete	envorce	ATHLETE
disease	vession	DISEASE
tragedy	campact	TRAGEDY
possible	ulthough	POSSIBLE
election	insiance	ELECTION
republic	illiance	REPUBLIC
diminish	etarnity	DIMINISH
popular	contern	POPULAR
percept	forsade	PERCEPT
society	concest	SOCIETY
lawsuit	gurrant	LAWSUIT
regular	prement	REGULAR
vanish	proview	VANISH
minimum	adgress	MINIMUM
startle	noddril	STARTLE
peculiar	inserior	PECULIAR
capable	apticle	CAPABLE
crystal	circurt	CRYSTAL
superior	exteanal	SUPERIOR
fourfold	orrinary	FOURFOLD
reaffirm	renolute	REAFFIRM
outgrow	shoupen	OUTGROW
hammer	siziler	HAMMER
forward	sarious	FORWARD
quality	jastice	QUALITY
pattern	noclear	PATTERN
account	skecial	ACCOUNT

APPENDIX C THE NOVEL WORD LIST

baltery	a plant called a 'black bat flower'
coultry	a heavy-duty tool that is used to attach wood to concrete
bereath	an early type of clothing in New Zealand
chisper	the world's largest flower
mopern	a rare black flower
figteen	a style of Ancient Chinese clothing
dellow	a rope dart that is easily concealed but deadly when unleashed
horget	a motorcycle helmet made from bamboo slivers
crouble	a kind of tropical tree that has a spiny trunk
conpert	a dramatic polyester coat by a contemporary designer
glound	a tire changer for motorcycles
clight	a rare sea animal that is a kind of worm
cermain	Europe's largest mammal
geberal	a style of furniture that has rich hand-made woodcarving
beturn	a tool for holding glass during glass blowing
macket	a portable multi-purpose power tool
cleate	a tool used to cut glass
soliety	a traditional Chinese sword that is soft, quick, and wichedly curved
derice	a special leg-shaped weapon
celter	a special kind of wild dog
upstaire	a rare gun that has an oval plate that screws onto the bottom of the butt
conrest	a flexible, compact and comfortable shell 'bed'
peotle	a special purple-colored moorhen
sweaber	a special clothing once used by NASA
dresent	a bright-colored beetle
unible	a special kind of hairless cat
culdure	an outdoor furniture
catrolic	tropical vines that have flowers like shooting stars
mocher	a special purpose vest made to carry bulky items
dencribe	a rare flowering plant which blooms every nine years
notting	a stand used for knitting
commany	a special table for playing backgammon
altend	a kind of pin extractor
sprind	a kind of flying lizard whose wings are actually expanded ribs
sublect	a weapon that has steel chain joints
tensior	a classic Chinese weapon that is designed for use in circular movement

fagily	a specialist firefighter boot
persot	European elk that has very large flat horns
plothes	a fast-growing vine that has special purple and white flowers
seriod	one of the oldest forms of party wear in India
admance	a new radiation weapon which produces very strong beams
persect	a unique yellow flower that resembles honeycomb constructions
fortula	a coat hanger that can hang between the floor and the ceiling
corning	a complex of scratching posts for cats
fibure	a multi-shape beanbag
suglest	a Native American tool which looks like a 'crooked knife'
qualoty	a special lounge and chair collection that can be used in any way you please
chought	a special weapon that pierces very hard shields

APPENDIX D EXAMPLE SCREENS FOR LEARNING

Simple presentation of novel words:

baltery **cermain** **sweaber**



a plant called "a black bat flower"

Europe's largest mammal

a special clothing once used by NASA

Word-picture matching:

baltery


cermain


Picture-word matching:

sweaber baltery

cermain crouble

chisper sweaber

definition-word matching**:**

Europe's largest mammal	**a special clothing once Used by NASA**
cermain peotle	**macket sweaber**

APPENDIX E ITEMS IN EXPERIMENT 3, 5 AND 6

Related learned prime	unrelated prime	TARGET
	Word Targets	
baltery	danssel	BATTERY
coultry	mainter	COUNTRY
bereath	boozier	BENEATH
chisper	holvent	WHISPER
mopern	feldin	MODERN
figteen	renolve	FIFTEEN
dellow	barver	YELLOW
horget	jictan	FORGET
crouble	presper	TROUBLE
conpert	antaine	CONCERT
glound	fetter	GROUND
clight	yarner	FLIGHT
cermain	goolish	CERTAIN
geberal	engaver	GENERAL
beturn	rutton	RETURN
macket	perkod	PACKET
cleate	ranett	CREATE
soliety	waisket	SOCIETY
derice	straid	DEVICE
celter	cortry	CENTER
upstaire	dalimon	UPSTAIRS
conrest	searlet	CONTEST
peotle	janair	PEOPLE
sweaber	nictrial	SWEATER
dresent	crosten	PRESENT
unible	quoash	UNABLE
culdure	boanny	CULTURE
catrolic	redaider	CATHOLIC
mocher	bizard	MOTHER
dencribe	janetter	DESCRIBE
notting	miratle	NOTHING
commany	tovinic	COMPANY
altend	sicket	ATTEND
sprind	mition	SPRING
sublect	junable	SUBJECT
tensior	kirclet	TENSION

Related learned prime	unrelated prime	TARGET
fagily	stanic	FAMILY
persot	caseen	PERSON
plothes	politle	CLOTHES
persect	sumitan	PERFECT
fortula	thilter	FORMULA
corning	sponer	MORNING
fibure	ziffer	FIGURE
suglest	connkie	SUGGEST
qualoty	pealney	QUALITY
chought	laytive	THOUGHT
	Nonword Targets	
describe	unstains	DESCROBE
contrast	catrolic	CONTRIST
glorious	imberval	GLARIOUS
bankrupt	describle	LANKRUPT
pursuit	satiffy	PURSUNT
succeed	dourway	SOCCEED
romance	clukter	RIMANCE
refugee	trampet	REFUGED
publish	massion	PURLISH
advance	vectory	ADMANCE
outback	sentury	CUTBACK
distant	fintion	DICTANT
obstacle	raidsoad	ABSTACLE
internal	shetherd	INTERSAL
restrict	stecimen	MESTRICT
casualty	scalptor	CAMUALTY
traffic	inittal	TRUFFIC
inhibit	ablique	INSIBIT
explain	messave	EMPLAIN
shooter	unferno	SHOTTER
library	postion	TIBRARY
athlete	envorce	ASHLETE
disease	vession	DINEASE
tragedy	campact	TRATEDY
possible	ulthough	POSHIBLE
election	insiance	ELENTION

Related prime	unrelated prime	TARGET
republic	illiance	RECUBLIC
diminish	etarnity	LIMINISH
popular	contern	POTULAR
percept	forsade	PERCOPT
society	concest	VOCIETY
lawsuit	gurrant	LOWSUIT
regular	prement	REGELAR
varnish	proview	VAMNISH
minimum	adgress	MANIMUM
startle	noddril	STARCLE
peculiar	inserior	PECALIAR
capable	apticle	CANABLE
crystal	circurt	CRASTAL
superior	exteanal	SAPERIOR
fourfold	orrinary	FOURTOLD
reaffirm	renolute	SEAFFIRM
outgrow	shoupen	OURGROW
hatchet	siziler	HAMCHET
forward	sarious	FARWARD
quality	jastice	QUACITY
pattern	noclear	PATHERN
account	skecial	ACROUNT

APPENDIX F ITEMS IN EXPERIMENT 4

(WITH VISIBLE PRIMES)

Related learned prime	unrelated prime	TARGET
	Word Targets	
baltery	glound	BATTERY
coultry	conpert	COUNTRY
bereath	figteen	BENEATH
chisper	mopern	WHISPER
mopern	horget	MODERN
figteen	crouble	FIFTEEN
dellow	chisper	YELLOW
horget	coultry	FORGET
crouble	dellow	TROUBLE
conpert	clight	CONCERT
glound	baltery	GROUND
clight	bereath	FLIGHT
cermain	cleate	CERTAIN
geberal	sweaber	GENERAL
beturn	macket	RETURN
macket	celter	PACKET
cleate	beturn	CREATE
soliety	peotle	SOCIETY
derice	upstaire	DEVICE
celter	geberal	CENTER
upstaire	soliety	UPSTAIRS
conrest	cermain	CONTEST
peotle	conrest	PEOPLE
sweaber	derice	SWEATER
dresent	sublect	PRESENT
unible	altend	UNABLE
culdure	mocher	CULTURE
catrolic	commany	CATHOLIC
mocher	catrolic	MOTHER
dencribe	tensior	DESCRIBE
notting	culdure	NOTHING
commany	notting	COMPANY
altend	sprind	ATTEND
sprind	dencribe	SPRING
sublect	unible	SUBJECT
tensior	dresent	TENSION

Related learned prime	unrelated prime	TARGET
fagily	fibure	FAMILY
persot	chought	PERSON
plothes	qualoty	CLOTHES
persect	fortula	PERFECT
fortula	fagily	FORMULA
corning	suglest	MORNING
fibure	corning	FIGURE
suglest	persect	SUGGEST
qualoty	admance	QUALITY
chought	persot	THOUGHT
	Nonword Targets	
baltery	glound	BANTERY
coultry	conpert	COUCTRY
bereath	figteen	BESEATH
chisper	mopern	THISPER
mopern	horget	MOJERN
figteen	crouble	FICTEEN
dellow	chisper	NELLOW
horget	coultry	SORGET
crouble	dellow	DROUBLE
conpert	clight	CONLERT
glound	baltery	GHOUND
clight	bereath	KLIGHT
cermain	cleate	CERGAIN
geberal	sweaber	GEDERAL
beturn	macket	LETURN
macket	celter	GACKET
cleate	beturn	CHEATE
soliety	peotle	SOPIETY
derice	upstaire	DENICE
celter	geberal	CEGTER
upstaire	soliety	UPSTAIRD
conrest	cermain	CONFEST
peotle	conrest	PEOKLE
sweaber	derice	SWEAPER
dresent	sublect	TRESENT
unible	altend	UNOBLE

Related prime	unrelated prime	TARGET
culdure	mocher	CULSURE
catrolic	commany	CATWOLIC
mocher	catrolic	MOSHER
dencribe	tensior	DEPCRIBE
notting	culdure	NOTRING
commany	notting	COMGANY
altend	sprind	ARTEND
sprind	dencribe	SPRINK
sublect	unible	SUBFECT
tensior	dresent	TENSIOT
fagily	fibure	FABILY
persot	chought	PERSOG
plothes	qualoty	BLOTHES
seriod	plothes	FERIOD
admance	seriod	ADGANCE
persect	fortula	PERLECT
fortula	fagily	FORBULA
corning	suglest	LORNING
fibure	corning	FITURE
suglest	persect	SUGFEST
qualoty	admance	QUALETY
chought	persot	SHOUGHT

REFERENCES

Beauvillain, C. and Grainger, J. (1987). Accessing interlexical homographs: Some limitations of a language-selective access. *Journal of Memory & Language,* 26(6), 658-672.

Bodner, G. E., & Masson, M. E. J. (1997). Masked repetition priming of words and nonwords: Evidence for a nonlexical basis for priming. *Journal of Memory & Language*, 37(2), 268-293.

Bodner, G. E., & Masson, M. E. J. (2001). Prime validity affects masked repetition priming: Evidence for an episodic resource account of priming. *Journal of Memory & Language*, 45(4), 616-647.

Bodner, G. E., & Masson, M. E. J. (2003). Beyond spreading activation: An influence of relatedness proportion on masked semantic priming. *Psychonomic Bulletin & Review*, 10, 645-652.

Bowers, J. S. (2000). In defense of abstractionist theories of repetition priming and word identification. *Psychonomic bulletin & review*, 7(1), 83-99.

Bowers, J. S., Davis, C., & Hanley, D. A. (2005). Interfering neighbours: the impact of novel word learning on the identification of visually similar words. *Cognition*, 97, B45-B54.

Castles, A., Davis, C., Cavalot, P., & Forster, K. (2003). Word recognition development in children: Insights from masked priming. In S. Kinoshita, & S. J. Lupker, (Eds.) *Masked priming: The state of the art*. Psychology Press: 345-360.

Colombo, L. (1986). Activation and inhibition of orthographically similar words. *Journal of Experimental Psychology: Human Perception and Performance*, 12, 226-566.

Coltheart, M. (1980). Reading, phonological recoding, and deep dyslexia. In M. Coltheart, K. Patterson, & J. Marshall (Eds.). *Deep dyslexia* (pp. 197-226). London: Routledge & Kegan Paul.

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (1977). Access to the internal lexicon. Dornic, S. (ed.). *Attention and performance VI*. Hillsdale, NJ. Erlbaum: 535-555.

Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning & Verbal Behavior*, 11(6), 671-684.

Craik, F. I., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, 104(3), 268-294.

Damian, M. F. (2001). Congruity effects evoked by subliminally presented primes: Automaticity rather than semantic processing. *Journal of Experimental Psychology: Human Perception and Performance,* 27(1), 154-165.

Davis, C. J. (2003). Factors underlying masked priming effects in competitive network models of visual word recognition. In S. Kinoshita & S. J. Lupker, (Eds.). *Masked priming: The state of the art*. Psychology Press: 121-170.

Davis, C. J., & Lupker, S. J. (2006). Masked inhibition priming in English: Evidence for lexical inhibition. *Journal of Experimental Psychology: Human Perception and Performance,* 37, 668-687.

De Groot, A., Delmaar, P., & Lupker, S. J. (2000). The processing of interlexical homophones in translation recognition and lexical decision: Support for non-selective access to bilingual memory. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology,* 53 (A), 397-428.

De Groot, A., & Nas, G. (1991). Lexical representation of cognates and noncognates in compound bilinguals. *Journal of Memory and Language,* 30, 90-123.

Dehaene, S., Dehaene-Lambertz, G., & Cohen, L. (1998). Abstract representations of numbers in the animal and human brain. *Trends in neurosciences*, 21(8), 355-361.

Dehaene, S., Dupoux, E., Mehler, J., Cohen, L., Paulesu, E., Perani, D., van de Moortele, P., Lehericy, S., Le Bihan, D. (1997). Anatomical variability in the cortical representation of first and second language. *NeuroReport,* 8 (17:1), 3809-3815.

Dijkstra, T., Grainger, J., & Van Heuven, W. (1999). Recognition of cognates and interlingual homophones: The neglected role of phonology. *Journal of Memory and Language*, 41, 496-518.

Duchek, J., & Neely, J. (1989). A dissociative word-frequency X levels-of-processing effect in episodic recognition and lexical decision tasks. *Memory & Cognition*, 17, 148-162.

Duyck, W. Desmet, T., Verbeke, L., & Brysbaert, M. (2004). WordGen: A tool for word selection and non-word generation in Dutch, German, English, and French. *Behavior Research Methods, Instruments and Computers,* 36, 488-499.

Elgort, I. (2007). *The role of intentional decontextualised learning in second language vocabulary acquisition: evidence from primed lexical decision tasks with advanced bilinguals*. Unpublished thesis. Victoria University of Wellington.

Ellis, N. C. (1994). Vocabulary acquisition: The implicit ins and outs of explicit cognitive mediation. In N. Ellis (Ed.). *Implicit and explicit learning of languages*. London, Academic Press: 211-282.

Evett, L. J., & Humphreys, G. W. (1981). The use of abstract graphemic information in lexical access. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, 33(4), 325-350.

Ferrand, L., Grainger, J., & Segui, J. (1994). A study of masked form priming in picture and word naming. *Memory and Cognition*, 22, 431-441.

Feustel, T., Shiffrin, R., & Salasoo, A. (1983). Episodic and lexical contributions to the repetition effect in word identification. *Journal of Experimental Psychology: General*, 112(3), 309-346.

Finkbeiner, M., Forster, K., Nicol, J., & Nakamura, K. (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory and Lanugage*, 51, 1-22.

Forster, K. I. (1985). Lexical acquisition and the modular lexicon. *Language and Cognitive Processes*, 1(2), 87-108.

Forster, K. I. (1987). Form-priming with masked primes: The best match hypothesis. In M. Coltheart (ed.). *Attention and Performance 12: The Psychology of Reading.* Hillsdale, NJ, Lawrence Erlbaum Associates: 127-146.

Forster, K. I. (1998). The pros and cons of masked priming. *Journal of Psycholinguistic Research*, 27(2), 203-233.

Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10(4), 680-698.

Forster, K. I., Davis, C., Schoknecht, C., & Carter, R. (1987). Masked priming with graphemically related forms: Repetition or partial activation? *The Quarterly Journal of Experimental Psychology*, 39A, 211-251.

Forster, K. I., & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior research methods, instruments, and computers*, 35, 116-124.

Forster, K. I., Mohan, K., & Hector, J.. (2003). The mechanics of masked priming. In S. Kinoshita, and S. J. Lupker (eds.). *Masked priming: State of the art*. Psychology Press: 3-37.

Forster, K. I., & Taft, M. (1994). Bodies, antibodies, and neighborhood-density effects in masked form priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20 (4), 844-863.

Forster, K. I., & Veres, C. (1998). The prime lexicality effect: Form-priming as a function of prime awareness, lexical status, and discrimination difficulty. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 24(2), 498-314.

Garrett, M.F.(1975). The analysis of sentence production. In G. Bower (ed.). *Psychology of Learning and Motivation*. New York: Academic Press.

Gaskell, M. & Dumay, N. (2003). Lexical competition and the acquisition of novel words. *Cognition*, 89, 105-132.

Gerard, L. & Scarborough, D. (1989). Language-specific lexical access of homographs by bilinguals. *Journal of Experimental Psychology: Learning Memory and Cognition*, 15, 305-315.

Grainger, J. & Ferrand, L (1994). Phonology and orthography in visual word recognition: Effects of masked homophone primes. *Journal of Memory and Language*, 33(2), 218-233.

Grainger, J., & Jacobs, A. M. (1996). Orthographic processing in visual word recognition: A multiple read-out model. *Psychological Review, 103*, 518-565.

Gollan, T., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: masked priming with cognates and noncognates in Hebrew-English bilinguals. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 23, 1122-1139.

Hall, C. J. (2002). The automatic cognate form assumption: Evidence for the Parasitic Model of vocabulary development. *International Review of Applied Linguistics*, 40, 69-87.

Hall, C. J., & Ecke, P. (2003). Parasitism as a default mechanism in vocabulary acquisition. In J. Cenoz, B. Hufeisen & U. Jessner (Eds). *The multilingual lexicon.* Dordrecht: Kluwer, 71-85.

Hupbach, A., Gomez, R., Bootzin, R., & Nadel, L. (2009). Nap-dependent learning in infants. *Developmental Science* (early view), 1-6.

Jacoby, L. L. (1983). Perceptual enhancement: persistent effects of an experience. Journal of Experimental Psychology: *Learning, Memory, & Cognition*, 9, 21-38.

Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language and Cognition*, 2, 59-75.

Jiang, N. (2000). Lexical representation and development in a second language. *Applied Linguistics*, 21(1), 47-77.

Jiang, N. & Forster, K. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language*, 44, 32-51.

Kim, K., Relkin, N., Lee, K-M., & Hirsch, J. (1997). Distinct cortical areas associated with native and second languages. *Nature*, 388, 171-174.

Kouider, S. & Dupoux, E. (2001). A functional disconnection between spoken and visual word recognition: Evidence from unconscious priming. *Cognition,* 82 (1): B35-B49.

Kouider, S. & Dupoux, E. (2004). Partial awareness creates the 'illusion' of subliminal semantic priming. Psychological Science, 15 (2), 75-81.

Kroll, J. & Curly, J. (1988). Lexical memory in novice bilinguals: The role of concepts in retrieving second language words. In M. M. Gruneberg, P. E. Morris and R. N. Sykes (Eds.). *Practical aspects of memory: Current research and issues* (vol. 2), pp. 389-395. London: John Wiley & Sons.

Kroll, J. F., Michael, E., & Sankaranarayanan, A. (1998). A model of bilingual representation and its implications for second language acquisition. In A.F. Healy & L. E. Bourne (Eds.), *Foreign language learning: Psycholinguistic experiments on training and retention*, pp. 365-395. Mahwah, NJ: Lawrence Erlbaum Publishers.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33, 149-174.

Kroll, J. F.,& Sunderman, G. (2003). Cognitive processing in second language learners and bilinguals: the development of lexical and conceptual representations. In C. J. Doughty & M. H. Long (Eds.), *The Handbook of second language acquisition*, pp. 104-129. Malden: Blackwell.

Laufer, B., & Hulstijn, J. (2001). Incidental vocabulary acquisition in a second language: The construct of task-induced involvement. *Applied Linguistics*, 22(1), 1-26.

Leach, L. & Samuel, A. (2007). Lexical configuration and lexical engagement: When adults learn new words. *Cognitive Psychology*, 55, 306-353.

Levelt, W. (1989). *Speaking: From intention to articulation*. Cambridge, MA: MIT Press.

Lupker, S. J., & Colombo, L. (1994). Inhibitory effects in form priming: Evaluating a phonological competition explanation. *Journal of Experimental Psychology: Human Perception & Performance*, 20, 437-451.

Masson, M. E. J., & Bodner, G. E. (2003). A retrospective view of masked priming: Toward a unified account of masked and long-term repetition priming. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: State of the art* (pp. 57-96): Hove, UK: Psychology Press.

Masson, M. E. J., & Isaak, M. I. (1999). Masked priming of words and nonwords in a naming task: Further evidence for a nonlexical basis for priming. *Memory & Cognition*, 27(3), 399-412.

Meyer, D. & Schvaneveldt, R. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental psychology*, 90, 227-234.

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: I. an account of basic findings. *Psychological review*, 88(5), 375-407.

McClelland, J. L., & Rumelhart, D. E. (1985). Distributed memory and the representation of general and specific information. *Journal of Experimental Psychology: General*, 114(2), 159-188.

McClelland, J. L., Rumelhart, D. E., & Hinton, G. E. (1986). The appeal of parallel distributed processing. In D. E. Rumelhart, J. L. McClelland, & the PDP Research Group (Eds.). *Parallel distributed processing: Vol.1. Foundations* (pp.3-44). Cambridge, MA: MIT Press.

McKoon, G., & Ratcliff, R. (1979). Priming in episodic and semantic memory. *Journal of Verbal Learning & Verbal Behavior*, 18(4), 463-480.

Monsell S. (1985). Repetition and the lexicon. In A. W. Ellis (Ed.), *Progress in the psychology of language*, Vol. 2 (pp. 147-196). London, England: Lawrence Erlbaum Associates.

Morton, J. (1979). Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), *Processing visible language 1* (pp. 259-268). New York: Plenum.

Nation, I. (2001). *Learning vocabulary in another language*. Cambridge: Cambridge University Press.

Nation, P. & Waring, R. (1997). Vocabulary size, text coverage and word lists. In Schmitt, N. and M. McCarthy (Eds.): *Vocabulary: Description, Acquisition and Pedagogy*, pp. 6-19. Cambridge: Cambridge University Press.

Norris, D. (1984). The effects of frequency, repetition and stimulus quality in visual word recognition. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 36A (3), 507-518.

Norris, D. & Kinoshita, S. (2006). Perception as evidence accumulation and Bayesian inference: Insights from masked priming.

Paap, K., Newsome, S., McDonald, J., & Schvanevelt (1982). An actication-verification model for letter and words recognition: The word superiority effect. *Psychological Review*, 89, 573-594.

Paivio, A. (1986). *Mental representations: A dual-coding approach*. Oxford University Press.

Paradis, M. (1994). Neurolinguistic aspects of implicit and explicit memory: implications for bilingualism and SLA. In Nick C. Ellis (Ed.). *Implicit and explicit learning of language*, pp. 393-419. London: Academic Press.

Paradis, M.(1997). The cognitive neuropsychology of bilingualism. In A. De Groot and J. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives*, pp. 331-354. Mahwah, NJ: Lawrence Erlbaum Publishers.

Potter, M., So, K., von Eckhardt, B,m & Feldman . L. (1984). Lexical and conceptual representations in beginning and more proficient bilinguals. *Journal of Verbal Learning and Verbal Behavior*, 23, 23-38.

Potts, G., & Peterson, S. (1985). Incorporation versus compartmentalization in memory for discourse. *Journal of Memory and Language*, 24, 107-118.

Presseley, M., Borkowski, J., & Schneider, W. (1987). Cognitive strategies: Good strategy users coordinate metacognition and knowledge. In R. Vasta & G. Whitehurst (Eds.), *Annals of child development* (Vol. 5, pp. 89-129). New York: JAI.

Rajaram, S., & Neely, J. (1992). Dissocative masked repetition priming and word frequency effects in lexical decision and episodic recognition tasks. *Journal of Memory and Language*, 31, 152-182.

Salasso, A.,Shiffrin, R. M. & Feustel, T. C. (1985). Building permanent memory codes: Codification and repetition effects in word identification. *Journal of Experimental Psychology*: General, 114, 50-77.

Scarborough, D. L., Gerard, L., & Cortese, C. (1979). Accessing lexical memory: The transfer of word repetition effects across task and modality. *Memory & cognition*, 7(1), 3-12.

Scarborough, D., Cortese, C., & Scarborough, H. (1977). Frequency and repetition effects in lexical meomory. *Journal of Experimental Psychology: Human perception and Per formance*, 3, 1-17.

Segui.J., & Grainger, J. (1990). Priming word recongnition with orthographic neighbors: effects of relative prime-target frequency. *Journal of Experimental Psychology: Human perception and Performance*, 16, 65-75.

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological review*, 96(4), 523-568.

Sereno, J. (1991). Graphemic, associative and syntactic priming effects at a brief stimulus onset asynchrony in lexical decision and naming. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 17, 459-477.

Sholl, A., Sankaranarayanan, A., & Kroll, J. F. (1995). Transfer between picture naming and translation: A test of asymmetries in bilingual memory. *Psychological Science*, 6, 45-49.

Silverberg, S., & Samuel, A. (2004). The effect of age of second language acquisition on the representation and processing of second language words. *Journal of memory and Language*, 51, 381-398.

Tenpenny, P. L. (1995). Abstractionist versus episodic theories of repetition priming and word identification. *Psychonomic Bulletin & Review*, 2(3), 339-363.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving. & W. Donaldson (Eds.). *Organization of Memory*. New York: Academic Press.

Tulving, E. (1983). *Elements of Episodic Memory*. Oxford: Clarendon Press.

Van Heuven, W., Dijkstra, T., Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language*, 39, 458-483.

Weinreich, U. (1953). *Languages in contact: Findings and Problems*. New York: Linguistic Circle of New York.