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Deliberate Learning and Vocabulary Acquisition in a Second Language

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This study investigates outcomes of deliberate learning on vocabulary acquisition in a second language (L2). Acquisition of 48 pseudowords was measured using the lexical decision task with visually presented stimuli. The experiments drew on form priming, masked repetition priming, and automatic semantic priming procedures. Data analyses revealed a prime lexicality effect (Experiment 1), repetition priming effect (Experiment 2), and semantic priming effect (Experiment 3) for the deliberately learned pseudowords. The outcomes of deliberate learning were further examined using a coefficient of variability (CV_{RT}) calculated for the participants' response latencies in Experiments 2 and 3. The results showed that the learned pseudowords were processed with a higher degree of automaticity than nonwords and low-frequency L2 words. Taken together, the findings provide evidence that deliberate learning triggered the acquisition of representational and functional aspects of vocabulary knowledge.

Keywords vocabulary acquisition; deliberate learning

In applied linguistics, learning in the behaviorist tradition of paired-associate learning involving repeated retrieval of the form and meaning of a word (such as learning from word cards) fell out of favor in the 1980s, when it was replaced by the communicative language teaching approaches that underscore the importance of meaningful contexts (Dupuy & Krashen, 1993; Elley, 1991) and learning through meaning-focused instruction (DeKeyser, 1998). One of the best known advocacies of learning from context put forward by Stephen Krashen goes as far as to claim that deliberate learning is not useful because it does not affect the acquisition of linguistic knowledge. Krashen (1989) argued that linguistic knowledge is *acquired* only when the learner's attention is focused on the message (not form)—for example, when reading or listening for

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meaning—and that only *acquired knowledge* is involved in authentic language use. Deliberate form-focused learning, on the other hand, according to Krashen, results in so-called *learned* knowledge, which can only be used to monitor performance under certain conditions (e.g., when there is no time pressure). More recently, however, it has been argued that naturalistic usage-based learning is insufficient to acquire second-language (L2) vocabulary (Cobb & Horst, 2004; Ellis, 2008; Laufer, 2005) and needs to be supplemented by deliberate form-focused learning (Elgort & Nation, 2010; Hulstijn, 2003; Nation, 2007) and by metalinguistic teaching approaches, including those based on contrastive analysis (Jiang, 2004).

Deliberate learning (DL) provides an efficient and convenient way of memorizing vocabulary. Learning from word lists and flashcards can be done outside of the language classroom and target vocabulary can be personalized to the needs and learning goals of individual learners. Nation (1980) showed that people are able to learn between 30 and 100 new words per hour from bilingual word pairs. Furthermore, retention rates under intentional learning are, on average, much higher than under incidental conditions (Hulstijn, 2003). However, the snag is that it cannot be automatically assumed that the quality of vocabulary knowledge gained through deliberate decontextualized learning is at the level that is needed for real language use (which brings us back to the learning/acquisition point made by Krashen, 1989). So the question remains whether DL is not only an efficient but also *effective* method of vocabulary acquisition. It appears, however, that little empirical evidence exists on which a definitive answer to this question can be based.

Past applied linguistics studies that explore L2 vocabulary learning outcomes as a function of various study conditions (e.g., Griffin & Harley, 1996; Laufer & Shmueli, 1997) tend to evaluate highly controlled knowledge of form, meaning, or use. In such studies, word knowledge is commonly measured using explicit knowledge tests (such as cued or free recall, translation, or tests of word-meaning association) or tests of controlled word use (such as sentence cloze tests or sentence anomaly tasks). Therefore, the findings of these studies provide little evidence about the kind of knowledge that L2 users need to access the meaning and form of these words fluently, in comprehension or production. For example, explicit association tasks used in some studies (Horst, Cobb, & Meara, 1998; Webb, 2005, 2007) require considerable reasoning and can involve many types of knowledge, only some of which are made available when a word meaning needs to be accessed online (McRae, de Sa, & Seidenberg, 1997).

In contrast, the present research investigates whether DL of L2 words done out of meaningful communicative context leads to the acquisition of implicit (procedural) linguistic competence of the kind that is characteristic of known words in the first or second language.

Research Questions and Methodology

For the purposes of this study, it is proposed that a vocabulary item is acquired if its representations are established and incorporated into the mental lexicon of the learner and if these representations can be accessed in an online (fluent) manner. This cognitive psycholinguistic conceptualization incorporates representational and functional aspects of vocabulary knowledge. In terms of representational knowledge, a further distinction is made between lexical representations of form (*formal-lexical)* and meaning (*lexical-semantic)* of vocabulary items. This distinction is maintained because studies of the bilingual lexicon have shown that these two knowledge domains may be organized differently in the mental lexicon of the language learner (Chen & Leung, 1989; Ellis, 1994; Kroll & Stewart, 1994; Potter, So, von Eckardt, & Feldman, 1984; Silverberg & Samuel, 2004). Formal-lexical and lexical-semantic representations in the memory are considered to be a part of the neurofunctional system of implicit linguistic competence (Paradis, 2007).

The overarching research question of the study is the following: *Does DL trigger the acquisition of vocabulary items in a second language?* This question is tackled by investigating (a) whether formal-lexical representations of L2 vocabulary items learned in a DL manner are established and integrated into the mental lexicon of the learners, (b) whether lexical-semantic representations of these items are established and integrated into the semantic system of the learners, and (c) whether the learners can access lexical representations of the newly learned vocabulary items fluently.

To measure representational knowledge and fluency of access to this knowledge, a laboratory research approach is adopted because it allows the researcher to elicit data directly relevant to the knowledge of the target items while minimizing opportunities for monitoring and conscious control. Behavioral laboratory studies have been used extensively to investigate access to the mental lexicon and its structure and composition, both in the first and second/foreign language. Such measures as error rates and reaction times (RTs) provide ways of assessing both the degrees of accuracy of word identification and production and fluency of access to word knowledge, independent of other aspects of the participants' L2 proficiency.

In addition, priming manipulations are incorporated into the design of the experiments because they can be used to implicitly emphasize formal-lexical or lexical-semantic representations of the experimental stimuli by varying the relationship between the prime and the target. For example, a semantic priming study may investigate whether access to the word *doctor* is faster when it is preceded by the related word *nurse* compared to the unrelated word *bread* (Meyer & Schvaneveldt, 1971), whereas a form priming study may explore the effects of the presentation of a related nonword prime *bunction* or related word prime *junction* on the recognition of the target word *function* (Forster & Veres, 1998). Priming studies, according to McRae, Hare, Elman, and Feretti (2005), can provide data on what aspects of target representations are activated by the prime when it is read or heard, avoiding the confounds of additional constraints that exist in normal reading of connected text or hearing connected speech.

In the present study, acquisition of representational knowledge has been operationalized using three types of primed lexical decision tasks. Form priming and masked repetition priming procedures were used to assess the acquisition of the formal-lexical representations, whereas a semantic priming procedure was used to assess the acquisition of the lexical-semantic representations of the newly learned vocabulary items. The gathered experimental data were analyzed to establish whether the newly learned vocabulary items produced a priming effect under the conditions where priming is produced by known words and whether no priming occurred in the conditions under which known words should not generate a priming effect. In addition, the results obtained for the deliberately learned vocabulary items were compared with those recorded in the same experiment for real English words and for nonwords (strings of letters that do not represent any existing English words).

Finally, the data from the masked repetition priming and the automatic semantic priming experiments were further analyzed to examine whether the participants were able to access lexical representations of the newly learned vocabulary items fluently, in an online manner. For this purpose, a coefficient of variability (CV) of the learner responses was used as an indicator of automaticity of processing (Segalowitz & Segalowitz, 1993). CV is calculated as the ratio of the standard deviation to the mean response latencies for individual participants. CVs for the deliberately learned items were compared with those of the real low-frequency English words and nonwords within the experiments.

The Study

Forty-eight study participants were instructed to learn 48 vocabulary items (English pseudowords) from word cards, following a recommended learning schedule. Each pseudoword was printed on one side of a card and its short definition on the other, so that the learners could not see both the form and definition at the same time. Learning from word cards can be done by retrieving a word's form from its meaning and by retrieving a word's meaning from its form. Using word cards represents deliberate learning because the learner is aware that the main goal of the activity is to learn the target words (Hulstijn, 2003). Furthermore, the learning is done "out of context"; that is, the learner does not encounter the target vocabulary in a range of meaningful contexts, as part of normal language use.

Participants

Only advanced L2 speakers were used as participants in this study. This is because a certain threshold level of L2 proficiency is needed for reliable automatic priming effects to occur, as these effects rely on the participants' ability to access and process lexical representations in an automatic manner, with a reasonable degree of accuracy. A number of bilingual studies have demonstrated that such a threshold is required for both form and semantic priming effects to be observed with bilingual participants (Bijeljac-Babic, Biardeau, & Grainger, 1997; Frenck-Mestre & Prince, 1997; Kroll & Stewart, 1994; Van Hell & Dijkstra, 2002). Favreau and Segalowitz (1983) also demonstrated that the level of L2 proficiency affects the degree of automaticity of access to vocabulary.

To select the final group of 48 participants from all volunteers, a receptive (multiple-choice) vocabulary size test of passive word knowledge (Nation, 2006) and two controlled productive (cloze) tests of active vocabulary knowledge (one sampled at the 5,000-word level and the other at the 10,000-word level) (Laufer & Nation, 1995, 1999) were used in the study. In the receptive vocabulary size test, words were drawn from nine base lists starting from the 5,000-word level and finishing at the 13,000-word-families level from the 10-million-word spoken section of the British National Corpus (BNC) (Leech, Rayson, & Wilson, 2001; Nation, 2006).

The mean age of the study participants was 29.3, ranging from 18 to 52 ($SD = 7.7$; median age = 28). There were 10 male and 38 female participants in the final group who were either working or studying in New Zealand. The mean age when the participants started learning English was 7.5 ($SD = 3.8$; median = 7.0), and the shortest period of exposure to English was 12 years (mean = 21.4 years; $SD = 7.3$). The participants' first language (L1) was not controlled for (Appendix A).

Items

Forty-eight English pseudowords were created as vocabulary learning targets for the study (Appendix B). The decision to use pseudowords rather than real words was made to ensure that deliberate learning out of context was the only mode of word learning in this study (i.e., that the participants were not exposed to the new words under any circumstances that could be interpreted as incidental learning in context). In addition, as Hulstijn (2003, p. 370) pointed out, if real words are used in experimental studies with participants who have some L2 knowledge, it is almost impossible to exclude the possibility that they already have partial knowledge of the words they are required to learn.

The pseudowords were created to represent two special-purpose vocabularies associated with the themes of (a) building, construction, and renovation and (b) medicine and the human body. These pseudowords signified processes and their participants. The principle of "thematic clustering" was used in creating the meanings of the pseudowords because it has been shown that vocabulary items arranged in thematic clusters (e.g., *frog, green, hop, pond, slippery, croak*) are easier to learn than groups of unrelated vocabulary items (Tinkham, 1997). The positive learning outcome of thematic clustering is explained by the effects of schemata on learning (Brewer & Nakamura, 1984). When words to be learned can be grouped under a broad categorical or thematic label (e.g., *eating*), learners can recruit their existing background knowledge of the topic to create connections and compare and contrast the new words they are learning with the words they already know, creating networks of concepts interconnected by relationships (Mezynski, 1983).

The pseudowords created for the study were all pronounceable nonwords constructed from English words by changing one letter of the original word (base word). Long base words (seven, eight, and nine letters long) were used because past studies have shown that form priming effects are better observed when the proportion of overlapping letters between the prime and the target is high (e.g., if stimuli are eight letters long, and the prime differs from the target by one letter, the overlap between the prime's and target's letters in congruent positions is 87.5% [7/8], whereas if the stimuli are four letters long, the proportion of this overlap is only 75% [3/4]). The pseudowords observed English spelling and pronunciation rules. For example, the pseudoword INFECENT (pronounced with a primary stress on the first syllable) was created from the real word *indecent* and MAXIDISE was created from the real word *maximise*. Sixteen 7-, 8-, and 9-letter pseudowords were created for the study. The pseudowords had between two and four syllables (mean number of syllables = 2.79; $SD = 0.68$). The position of the letter altered in the base words to create the pseudowords varied to cover the full range of letter and syllable positions.

The base words used to create the pseudowords were used as targets in the form priming experiment (Experiment 1). Neighborhood density is a factor that affects form priming in visual word recognition. No form priming, for example, was observed in the work of Forster, Davis, Schoknecht, and Carter (1987) for targets that had many neighbors (seven or more) (see also Forster & Davis, 1984). For this reason, the selected base words had no orthographic neighbors. In addition, their frequencies of occurrence in the language were low (Kučera & Francis, 1967: KF = 5.2 opm [occurrences per million], *SD* = 3.79; Baayen, Piepenbrock, & Van Rijn, 1993: CE = 9.94 opm, *SD* = 2.3). This is because any gains resulting from priming are more noticeable with low-frequency than with high-frequency words because high-frequency words are already approaching the threshold in terms of their recognition latencies, and few further gains can be achieved as a result of priming (Balota & Chumbley, 1984).

The Learning Phase

The selected study participants took part in the initial individual learning session during their first meeting with the researcher. The purpose of this session was (a) to introduce the pseudowords to the participants in an environment that allowed them to see the target pseudoword and its meaning and to listen to its pronunciation, (b) to verify that the participants had fully understood the concepts denoted by the pseudowords, (c) to practice the pronunciation of the pseudowords. and (d) to provide practice in working with word cards.

In the learning procedure, each pseudoword was presented individually in its spoken and written form using a computer program (E-Prime, v1.2; Schneider, Eschman, & Zuccolotto, 2002), with its meaning, an example of use in a sentence, and basic grammatical information displayed on the same screen. This information was modeled on a typical word entry in an English language dictionary (Figure 1). The participants were instructed to study each word and to repeat it aloud in order to engage their phonological memory in the learning process (Baddeley, 1993; Ellis & Beaton, 1993).

PROSTER /ˈprɒstə/ **Noun (countable) pl. prosters**

The part of the body comprising the hip, buttock, and upper thigh.

Example: This set of exercises focuses on the **proster** area.

Figure 1 Example of a pseudoword presentation.

The 48 pseudowords were presented in sets of 12. After each set, the participants had to pause for a short test in which they used word cards to look at the word and try and retrieve its meaning. There was no explicit time limit for the learning task, but the participants were aware of the overall time frame for the session, and it generally took between 40 and 60 min to complete the whole learning task (including the tests after each learning set).

At the end of the initial session, the participants were given a set of word cards to take home. They were required to practice passive (form-to-meaning) and active (meaning-to-form) retrieval, using these word cards for 1 week, following a suggested spaced-repetition schedule. A study by Gaskell and Dumay (2003) showed that lexical representations of newly learned words are not established immediately after the learning task, but they emerge over a period of about 1 week. In neurological terms, it has also been argued that new knowledge is incorporated into the existing knowledge structures during sleep. For these reasons and following the vocabulary learning recommendations of Schmitt (2000, pp. 129–132) and Nation (2001, pp. 66–81), it was suggested that participants do three learning sessions (in total) in the first 2 days (with at least one session conducted on the same day as the initial learning procedure), then one session per day for the following 2 days (days 3 and 4), and then one more session (on day 6) before attending the second meeting on day 8 (or day 9). The participants were asked to follow this schedule as closely as possible, but if they were unable to do a learning session as required, they were encouraged to do it as close as possible to the recommended time (either before or after). They were also required to keep a practice log.

At the end of the week, the participants came back to complete a series of tests, including the main experiments and an additional written productive retrieval test, administered in the form of a dictation, to check whether the target pseudowords were actually known explicitly. In this test, the definitions of the pseudowords were read out in a random order and the participants were required to write down the pseudowords corresponding to these definitions. The ability to retrieve a word when its meaning is provided in a decontextualized dictation task is considered to be an indication of the highest degree of explicit knowledge of the word and controlled access to this knowledge (Coady, Carrell, & Nation, 1985; Laufer & Goldstein, 2004).

The participants ($n = 2$) who received scores of less than 66% (two thirds of the pseudowords) on the productive retrieval test were excluded from the final analysis of the experimental data and replaced by new participants to make up the required number ($n = 48$). On average, as recorded in their learning logs, the participants who successfully completed the study did 5.8 learning sessions (*SD* = 1.5), spending approximately 4 hr (243 min) learning the pseudowords (*SD* = 2.5 hr). For the successful participants, the average score was 45 pseudowords (median = 47; *SD* = 4.2) or 94% of the pseudowords. The results of this test showed that the final group of participants had gained *explicit* knowledge about the form and meaning of the studied vocabulary items and had created explicit form-meaning associations for these items.

In addition, the pseudowords that could not be retrieved correctly in the dictation test by more than 20% of all accepted participants ($n = 4$) were excluded from the final analyses of all three main experiments. This is because explicit knowledge of the deliberately learned vocabulary items was a prerequisite for doing further testing aimed at seeing whether these items were also integrated into the lexical networks of the learners and became available for online access. Finally, one pseudoword was misspelled by more than 80% of the participants and therefore was excluded from the data analysis of the form priming experiment (Experiment 1) for the same reason.

Main Experiments

The outcomes of DL were evaluated experimentally using the speeded lexical decision task (LDT), which requires participants to make a word/nonword decision as quickly and as accurately as possible. The LDT is one of the most established paradigms for studying processes involved in word recognition and the structure of the mental lexicon. The three main study experiments were conducted using E-Prime (Schneider et al., 2002) on an Intel® Celeron™ personal computer with a Philips LCD monitor (screen area: 1,280 × 1,024 pixels; refresh rate: 75.126 Hz, as measured using the E-Prime program; refresh duration: 13.31 ms). Experimental stimuli were presented in the middle of the screen using black 18-point Courier New font against a white background. The participants were instructed to indicate their decision using the response box connected to the computer. They had to press the *Yes* button if the string of letters on the computer screen was an English word and to press the *No* button if it was not a word. The participants were instructed to treat the deliberately learned pseudowords as English words. The participants used their dominant hand to register a positive response. At the beginning of each experiment, the participants were given a set of practice trials to familiarize themselves with the task and to ask questions about the experiment, if required.

Analyses of variance were run on the RT and response accuracy data (dependent variables), with the prime type used as the independent variable. The results were analyzed by participants (F1) and by items (F2). Incorrect responses were excluded from the RT data analyses. To avoid the influence of outliers, RTs more than two *SD*s above or below the mean for a given participant were trimmed to the cutoff value of 2 *SD*s for that participant. A similar outlier treatment is used in Forster and Veres (1998) and McRae and Boisvert (1998)—the two studies used as a basis for Experiments 1 and 3, respectively. One participant whose error rate was higher than 30% in one of the experiments was rejected and replaced by a new participant.

Experiment 1. Form Priming: The Prime Lexicality Effect

Experimental Design

The orthographic makeup of the newly learned pseudowords was foregrounded in the first experiment by using the form priming paradigm based on similarity between the orthographic structure of the prime and the target. This experiment was closely based on the form priming experiment described in Forster and Veres (1998, Experiment 1), which demonstrates that when word targets are preceded by orthographically related *nonword* primes [*bunction–FUNCTION*], they are responded to significantly faster than when they are preceded by unrelated primes [*bathroom–FUNCTION*]. However, this facilitation does not occur if the orthographically related prime is a word [*junction–FUNCTION*]. This effect is known as the *prime lexicality effect* (PLE), because it depends on the lexical status (word/nonword) of the prime. The PLE has been successfully accounted for using the Interactive Activation (IA) model of word recognition (McClelland & Rumelhart, 1981) and the entry-opening model (Forster & Davis, 1984; Forster & Veres, 1998).

Evidence gathered in both monolingual and bilingual word recognition research indicates that when an input letter-string is visually presented, representations of all words that differ from this letter-string by one letter (*orthographic neighbors*) become engaged in the word recognition process. Based on the IA model, in a form priming paradigm, where the prime differs from the target by one letter in the same letter position, presenting the prime activates the lexical representation of the target word as one of its orthographic neighbors. If the prime is a word [*junction–FUNCTION*], its presentation also strongly activates its own lexical representation, which competes for recognition with the lexical representation of the target. This competition (otherwise referred to as lateral inhibition at the level of lexical representations) is likely to cancel out the initial preactivation of the lexical representation of the target word or may even result in inhibition (slower recognition of the target compared to the neutral condition when it is preceded by an unrelated prime [*bathroom–FUNCTION*]). If the prime letter-string is not a word [*bunction–FUNCTION*], it will preactivate the lexical representation of the word target as its orthographic neighbor, but there will be no competition because there is no lexical representation of the prime in memory. This will result in facilitation compared to the neutral condition; that is, the time it takes to recognize the target will be reduced if the prime is not a word. Of course, this is a simplified account of what is a complex process involving such variables as the comparative prime/target word frequency, number of shared orthographic neighbors between them, stimulus length in letters, presentation paradigms (masked/unmasked), amount of time that elapses between the presentation of the prime and target, and type of nonword distractors used to create the LDT (Davis & Lupker, 2006).

Another way to account for the PLE is from the standpoint of the entry-opening model of priming. In this model, formal-lexical representations of orthographic neighbors of a visually presented prime are initially "flagged" or "opened" for further analysis (verification) as possible candidates for the final selection. If the prime is a word (*junction*), once the lexical representation corresponding to the prime letter-string in memory is selected (i.e., the prime is *recognized*), the lexical entries of all orthographic neighbors of the prime are released (after a possible short refractory stage), returning to their normal neutral state. Thus, if a related word prime is presented long enough to be recognized, no facilitation should occur for the form-related word target. However, if the prime is not a word (*bunction*), the recognition process cannot be completed because there is no lexical entry corresponding to the prime letter-string in memory. For this reason, the lexical entries of the orthographic neighbors of the prime letter-string remain "open" for a while. In a form priming paradigm, when such a "flagged" neighbor of the nonword prime is presented for recognition as a target (e.g., *FUNCTION*), it is recognized faster because its entry has already been open for verification. In this model, positive priming is interpreted as a time-savings effect (Forster, Mohan, & Hector, 2003) because the first stage of word recognition is completed by the time the target is presented. One of the key conditions for observing the PLE, in this interpretation, is that prime resolution has enough time to reach completion for the condition where the form-related prime is a word.

Because it is the lexical status of the prime (word/nonword) that determines whether form priming occurs, this experimental design was used in the present study to evaluate whether the formal-lexical representations of the pseudowords learned in a DL manner had been acquired. These newly learned pseudowords were used as related form primes in Experiment 1. The hypothesis was that if the formal-lexical representations of the pseudowords were established and integrated with the existing formal-lexical representations of L2 words, there would be no statistically significant positive priming for related word targets preceded by these primes. On the other hand, form-related nonword primes should generate a reliable form priming effect.

Materials

The original set of stimuli from Forster and Veres (1998, p. 501) was included in the experiment to confirm that the PLE occurs for the study participants when real L2 word and nonword primes are used. The set from Forster and Veres was used in its entirety with some minor adjustments (four prime–target word pairs from the original set were replaced with words that were more likely to be familiar to the L2 participants). In this set, each word target was paired with three types of prime: (a) a related orthographically legal *nonword* prime, one letter different from the target (*gracetul–GRACEFUL*) [r-nw-w]; (b) a related *word* prime, one letter different from the target (*grateful–GRACEFUL*) [r-w-w]; and (c) an unrelated word prime that differed in all or all but one letter position from the target (*mushroom–GRACEFUL*) [u-w-w]. An equal number of nonword targets was included in the set. Each nonword target was paired with the following types of prime: (a) a related word prime (*absolute–ABSONUTE*) [r-w-nw]; (b) a related nonword prime, one letter different from the target nonword and two letters different from the base word (*abtonute–ABSONUTE*) [r-nw-nw]; and (c) an unrelated word prime (*orthodox–ABSONUTE*) [u-w-nw].

Additionally, a new set of stimuli (henceforth referred to as the pseudoword set) was created for Experiment 1. This set included pseudowords as form-related primes. Each word target in this set was also paired with three types of primes: (a) a related *pseudoword* prime, one letter different from the target (*teometry–GEOMETRY*) [r-pw-w: related pseudoword prime–word target]; (b) a related *nonword* prime, one letter different from the target (*geobetry–GEOMETRY*) [r-nw-w: related nonword prime–word target]; and (c) an unrelated word prime that differed in all, or all but one, letter positions from the target (*abdicate–GEOMETRY*) [u-w-w: unrelated word prime–word target]. This design provided a critical test of the PLE for the newly learned pseudowords. The nonword targets followed the same pattern as used in the Forster and Veres (1998) set. The average length of the word targets in this set was eight letters ($SD = 0.83$). All targets were low-frequency words (KF = 5.2 opm, $SD = 3.8$; CE = 4.9 opm, $SD = 2.3$; mean 1,000-word base list = 5.3, $SD = 1.6$). Nonword targets were constructed by changing one letter of a low-frequency English base word with no orthographic neighbors (Appendix C).

A counterbalanced Latin square design was used to construct three presentation lists in such a way that the targets were only used once in each list and were presented under the three priming conditions across all lists. The participants were tested individually and assigned to one of the three lists in the order of their participation (average scores on the dictation test were comparable for the three list groups: 45, 44, and 46 items). An equal number of participants were assigned to each list. Each list contained 20 practice trials (the same for all three lists) and 192 test trials. One half of the test trials (96) were made up of the stimuli from Forster and Veres (1998), including 48 word and 48 nonword targets. The other half of the trials (96), created especially for this study, also contained 48 word and 48 nonword targets and included the deliberately learned pseudowords used as form-related primes.

Procedure

In each trial, first a string of hash marks (#), equal in number of characters to the prime, was presented for 522 ms (40 monitor scan cycles; in all three experiments, the number of monitor scan cycles was calculated using a procedure recommended in the E-Prime manual; Schneider et al., 2002, p. 99). Then the prime was displayed for 522 ms. This relatively long presentation of the prime was chosen in order to allow for the prime resolution to reach completion because, in the entry-opening account of form priming, this resolution is considered to be a key condition of the PLE. The target was displayed for 522 ms immediately after the prime. The target was replaced by a blank screen displayed until response. Participants were given up to 2,500 ms to respond. The prime stimuli were displayed in lowercase letters and the targets were displayed in uppercase letters to reduce their physical likeness to each other and to minimize the possibility of the priming effect being generated by the graphical shape overlap (Humphreys, Evett, & Quinlan, 1990).

The participants were instructed to read the lowercase letter-string (prime) silently and then make a decision about whether the uppercase letter-string (target) was a word by pressing either the *Yes* or the *No* button on the response box.

Results and Discussion

In the analysis of RTs for the word targets in the Forster and Veres (1998) set of stimuli, the PLE was clearly replicated with the study participants (Table 1). A reliable facilitation of 61 ms was observed when a word target was preceded by a related nonword prime. Numerically, this result is very similar to the facilitation effect of 58 ms found by Forster and Veres (1998) with native speakers. The numerical inhibition effect of −15 ms observed on the trials where a word target was preceded by a related word prime was not significant. The analyses

Table 1 Means and standard errors for reaction times (ms) and percent error rates for word targets as a function of the type of prime for Experiment 1

	New pseudoword set						Forster and Veres set					
	r-nw-w		r-pw-w		u-w-w		r-nw-w		r-w-w		u-w-w	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Error rates	7.3	0.01	10.6	0.01	10.0	0.01	4.3	0.01	12.0	0.01	9.5	0.01
RT	705	6	760	7	780	6.5	678	6	753	6	739	6
Priming	75	9	20	9			61	8	−15	8		

Note. r-nw-w = related nonword prime/word target (e.g., geobetry–GEOMETRY); critical condition; r-pw-w = related pseudoword prime/word target (e.g., teometry–GEOMETRY); critical condition; u-w-w = unrelated word prime/word target (e.g., *abdicate–GEOMETRY*); control condition.

by participants and by items showed the presence of a significant priming effect, $F1(2, 46) = 22.809$, $p < .0005$, partial $\eta^2 = .559$; $F2(2, 46) = 29.146$, $p < .0005$, partial $\eta^2 = .498$, whereas the post hoc comparisons (Bonferroni) of the two priming conditions with the control condition confirmed that priming was only significant when word targets were preceded by related nonword primes ($p_1 < .0005; p_2 < .0005$). A small inhibition effect observed for the trials with related word primes was not significant in the analysis by participants or by items ($p_1 = .310; p_2 = .432$).

In the analyses of the RT data in the pseudoword set, orthographically related nonword primes produced a significant facilitation effect of 75 ms, whereas the learned pseudowords generated a much smaller numerical facilitation (20 ms), which did not reach significance (Table 1).

Reaction time analyses of the data showed a significant main effect of priming, $F1(2, 46) = 44.485, p < .0005$ partial $\eta^2 = .659$; $F2(2, 41) = 23.392$, $p < .0005$, partial $\eta^2 = .533$, whereas post hoc comparisons (Bonferroni) of the two priming conditions with the control condition revealed that the priming effect was only significant when word targets were preceded by related nonword primes ($p_1 < .0005; p_2 < .0005$) and the numerical facilitation observed when word targets were preceded by related pseudoword primes was not reliable ($p_1 = .100; p_2 = .451$). Furthermore, the results recorded for the two priming conditions (r-pw-w and r-nw-w) were significantly different from each other in the analyses by participants, $F1(1, 47) = 25.067$, $p < .0005$, partial $\eta^2 = .348$, and by items $F2(1, 42) = 19.844, p < .0005$, partial $\eta^2 = .321$, indicating that the behavior of the pseudowords did not pattern with the nonwords in this experiment. A similar pattern of results was observed in the analyses of the response accuracy data: No significant effect was observed for the related pseudoword-word (r-pw-w) pairs in either the analysis by participants or that by items, whereas more accurate responses were observed in the related nonword-word (r-nw-w) condition compared to the unrelated condition. The participants' response accuracies in the two priming conditions (r-pw-w and r-nw-w) were reliably different from each other in the analysis by items ($p < .05$), and the difference was marginally significant in the analysis by participants ($p = .059$). Overall, the results of Experiment 1 demonstrate the presence of the PLE in the pseudoword set and suggest that the pseudowords were perceived as words by the participants, generating no reliable facilitation as form-related primes.

Although not statistically significant, the mean numerical facilitation observed in the analyses of the RT data for the critical pseudoword-word pairs in Experiment 1 muddied the results somewhat. After carrying out data analyses with a number of additional factors that could have affected this outcome, it

Table 2 Mean reaction times (ms) for word targets by number of letters and priming condition for Experiment 1

No. of letters	Condition	Mean RT	SE	Priming
7	r-nw-w	700	25	93
	r-pw-w	782	29	11
	u-w-w	793	26	
8	r-nw-w	697	21	65
	r-pw-w	751	25	11
	u-w-w	762	28	
9	r-nw-w	715	27	54
	r-pw-w	716	25	53
	u-w-w	769	28	

became clear that this numerical facilitation was caused by the behavior of the nine-letter stimuli (Table 2). ANOVA with *number-of-letters* entered as an additional factor revealed a significant interaction between number of letters and priming, $F1(4, 44) = 2.888, p < .05$, partial $\eta^2 = .208$.

When the data from the nine-letter stimulus trials were removed from the analysis, the overall priming pattern exhibited a classic PLE as is predicted with related word primes; that is, no reliable difference was found between the critical trials with related pseudoword primes and the control trials ($p = .953$), whereas the facilitation effect in the related nonword-word condition remained highly significant ($p < .0005$).

These findings indicate that the formal-lexical representations of the seven- and eight-letter pseudowords were established and integrated with existing entries in the mental lexicon of the participants. There are a number of reasons that could have caused the divergent result recorded for the nine-letter stimuli, but a detailed discussion of this result is outside of the scope of the article. In general terms, the facilitation observed for the targets preceded by the related nine-letter pseudoword primes could have been caused either by the fact that formal-lexical representations of these pseudowords had not been acquired or by one or more conditions that interfered with the PLE for the nine-letter stimuli. A hypothesis that seems most appealing is that the duration of the prime was not long enough for the resolution of the newly learned nine-letter pseudoword primes to reach completion, as the nine-letter word length is known to be at the threshold of visual acuity (New, Ferrand, Pallier, & Brysbaert, 2006). In the present experimental design, where the PLE hinged on prime resolution, a failure to fully process some or all of the nine-letter pseudoword primes by at least some of the participants would have been sufficient to cause the PLE to be attenuated. From the IA model's perspective, one of the key determinants of the degree of facilitation in visual form priming is the extent of the letter overlap between the prime and the target: The larger the overlap, the greater the facilitatory boost of the prime on the target (Davis & Lupker, 2006). It is possible, then, that for the nine-letter stimuli, the facilitation generated by the letter overlap between the related pseudoword primes and the word targets was greater than the lateral inhibition caused by competition at the level of lexical representations. Finally, it is also plausible that some combination of these factors led to this result.

Experiment 2. Repetition Priming

Experimental Design

The outcomes of DL of the L2 vocabulary items were further evaluated in Experiment 2, which utilized a well-established masked repetition priming paradigm (Evett & Humphreys, 1981; Forster & David, 1984). The effect of masked repetition priming has been shown to be robust both in the L1 and in within-L2 repetition priming studies and has been observed with bilinguals of different L1 backgrounds, including Hebrew (Gollan, Forster, & Frost, 1997) and Chinese (Jiang, 1999). In repetition (or identity) priming, the prime is identical to the target (although, when visually presented, the two letter-strings are often displayed in different letter cases or font sizes to ensure they are perceived as two separate stimuli). In masked priming, the prime is presented very quickly and is preceded and/or followed with a mask, usually resulting either in a complete lack of awareness of the presence of a prime or in a significant reduction in prime visibility to the participants. Because this procedure dramatically reduces opportunities for participants to monitor their performance, masked priming is considered to tap into automatic lexical processing, and the priming effect obtained this way is also considered automatic.

The masked repetition priming effect occurs because a word target is recognized faster when preceded by an identical word prime compared to the unrelated condition (i.e., when it is preceded by a prime unrelated to it in its form or meaning). In simple terms, this is because visually presenting a word prime, even for a very short time, preactivates (or preselects) the lexical representation of this word and makes it easier to access this representation when the same letter-string is presented for recognition as target (Grainger, Diependaele, Spinelli, Ferrand, & Farioli, 2003). This effect does not occur for nonwords because there are no lexical representations for nonwords in memory that can be preactivated. Forster and Davis (1984), for example, found no repetition priming for nonwords when primes were masked and displayed for 60 ms. No significant masked repetition priming for the L2 nonwords was found by Jiang (1999) with Chinese-English bilinguals (the 7-ms facilitation was not significant). In experiments with Hebrew-dominant Hebrew-English bilingual participants (Experiments 1 and 3) with a 50-ms prime duration, Gollan et al. (1997) also observed no significant repetition priming either on the within-L1 (Hebrew) or on the within-L2 (English) trials with nonwords. There is some disagreement in the literature about the nature of repetition priming: Although the involvement of formal-lexical representations in generating this effect is uncontroversial, some models of lexical access (e.g., distributed memory models) assume that lexical-semantic representations also contribute to this effect. In this study, the use of a very short prime duration and SOA (stimulus onset asynchrony) foregrounds the formal-lexical representations of the stimuli.

Because of the evidence that the nature of masked repetition priming is essentially lexical (Forster et al., 2003), it was predicted that a positive masked repetition priming effect would only occur if lexical representations had been established for the pseudowords and if the participants were able to access these representations in an automatic manner.

Materials

Three experimental lists were constructed for Experiment 2 using the Latin square design. Each list contained 32 pseudoword targets: 16 in the repetition condition (r-pw) and 16 in the unrelated condition (u-w-pw). Each pseudoword target appeared once in a repeated and once in an unrelated condition across the three lists (Table 3). English words unrelated to the pseudowords in their form or meaning were used as primes in the unrelated condition. In this experiment, the participants were assigned to one of the three experimental lists in such a way that they only encountered the pseudowords they had not seen in Experiment 1

Table 3 Counterbalanced repetition priming design for pseudoword targets in Experiment 2

Primes						Targets
List 2A		List 2B		List 2C		Pseudowords
obsolate	r-pw	-		mythical	u-w-pw	OBSOLATE
acclaim	u-w-pw	custony	r-pw	-		CUSTONY
-		steepness	u-w-pw	altograph	r-pw	ALTOGRAPH

(i.e., it was their first encounter with these 32 pseudowords during the testing phase).

Each list contained (a) a practice set; (b) the main experimental set of stimuli consisting of the trials with pseudoword, word, and nonword targets; and (c) an additional filler set containing unrelated word and nonword trials. The experimental sets for each list included 32 pseudoword trials and 32 word trials [16 in the repetition condition (r-w) and 16 in the unrelated condition (u-w-w)] (Appendix D). In addition, 64 unrelated word pairs were used as filler trials to reduce the overall proportion of related trials, in an attempt to eliminate the prime validity effect (Bodner & Masson, 1997, 2001).

For the purposes of constructing a LDT, 128 nonword trials were added to each list (64 critical test trials and 64 additional unrelated filler trials) to increase the proportion of unrelated trials and equalize the number of word and nonword targets used in the experiment. The critical trials contained two types of nonwords: those that were constructed by altering one letter of a real English word—the nw-1 set (INVORCE), which will be referred to as *close* nonwords—and those that were not based on real English words but were pronounceable orthographically legal nonwords constructed using WordGen software (Duyck, Desmet, Verbeke, & Brysbaert, 2004)—the nw set (FUSTIPOT), which will be referred to as *distant* nonwords. Each of the two experimental nonword sets contained 32 trials: 16 trials in the repetition condition (16 r-nw-1 and 16 r-nw) and 16 trials in the unrelated condition (16 u-nw-nw-1 and 16 u-nw-nw).

Overall, each list contained 75% unrelated and 25% related trials. A low proportion of related trials was used in this experiment to avoid the prime validity effect (Bodner & Masson, 1997, 2001) and to minimize the use of task-related strategies in making lexical decisions.

All stimuli used in this experiment were seven, eight, or nine letters long, with the mean length of eight letters for word, pseudoword, and nonword stimuli. All stimuli had low neighborhood density, as Perea and Rosa (2000) observed that the repetition priming effect was stronger for hermits (words with no neighbors) than for words with many neighbors (see also Forster et al., 1987). The word targets used in this experiment were low-frequency words (KF = 6.5 opm; CE = 7.9 opm) that were nevertheless within the first nine frequency base lists of English word families (Nation, 2006).

Procedure

In Experiment 2, the pseudoword, word, and nonword targets were preceded either by identical or by unrelated primes. The experiment used the standard three-field masking paradigm (mask-prime-target) (Forster et al., 1987). The mask—a string of hash signs (#) of the same length as the prime stimulus—was first presented for 522 ms in the center of the screen. The prime in lowercase letters was presented immediately after the mask for 56 ms (five monitor scan cycles) in the same place on the monitor screen and was followed by the target in uppercase letters, displayed for 522 ms. The target screen was replaced by a blank screen, which was displayed until the word/nonword decision about the target was made by the participant (but no longer than 2,500 ms). Primes and targets were presented in different letter cases to ensure that they were perceived as two stimuli, following Forster et al. (2003).

Results and Discussion

The results for the pseudoword stimuli in Experiment 2 were clear-cut (Table 4). A robust repetition priming effect was observed for the learned pseudowords in the analysis of RTs, with participants' responses being 52 ms faster in the repeated condition compared to the unrelated condition. This repetition priming effect was significant in the analyses by participants, $F1(1, 47) = 56.597, p_1 < .0005$, partial $\eta^2 = .546$, and by items, $F2(1, 43) = 58.700, p_2 < .0005$, partial $\eta^2 = .577$. The pattern of results observed for the pseudowords was similar to that produced by the word stimuli in the same experiment; that is, a significant positive priming effect of 75 ms was observed for the word stimuli on repetition trials compared to unrelated trials, $F1(1, 47) = 103.281$, $p_1 < .0005$, partial $\eta^2 = .687$; $F2(1, 31) = 89.342, p_2 < .0005$, partial $\eta^2 = .742$. Priming did not occur in Experiment 2 for either close ($F1 < 1$; $F2 < 1$) or distant ($F1 < 1$; $F2 < 1$) nonwords.

The results reported in Table 4 show that the behavior of the pseudowords in Experiment 2 clearly patterned with the words and was dissimilar from the nonwords. This suggests that lexical representations were established for these vocabulary items and integrated into the lexical memory of the participants. In addition, based on the automatic nature of the masked priming effect, we can conclude that the participants were able to access these representations in an automatic manner.

To further explore prime awareness and visibility in Experiments 2, in the postexperimental debrief the participants were asked a number of standard prime visibility questions. First, they were asked to describe the trial procedure exactly as they had seen it. If the participants did not mention the prime at this stage, an additional question was asked whether they had noticed anything between the row of hash marks and the uppercase word. If the answer was *no*, no further questions were asked. If the participants reported that there was a prime in their initial description of the procedure, they were asked if they could

Table 4 Means and standard errors for RTs (ms) and percent error rates for all types of target as a function of the priming condition (repeated/unrelated) for Experiment 2

		Words		Pseudowords		Close nonwords		Distant nonwords	
		r-w	u-w-w (control)	r-pw	u-w-pw (control)	r-nw-1	u-nw-nw-1 (control)	r-nw	u-nw-nw (control)
Error rates		7.6	11.1	1.8	3.8	11.2	8.9	3.9	2.5
RT	*M*	615	690	590	642	713	709	652	643
	SE	6	6	5	5	6	6	5	5
Priming	*M*	75		52		−4		−9	
	SE	8		7		9		8	

r-w = repetition condition/word target; u-w-w = unrelated condition/word prime/word target; r-pw = repetition condition/pseudoword target; u-w-pw = unrelated condition/word prime/pseudoword target; r-nw-1 = repetition condition/close nonword target; u-nw-nw-1 = unrelated condition/nonword prime/close nonword target; r-nw = repetition condition/distant nonword target; u-nw-nw = unrelated condition/nonword prime/distant nonword target.

see any of the letters, if they thought that the prime string contained either only letters or also numbers and other symbols, and if they could tell whether the primes were words or nonwords. Finally, they were asked whether they had ever been able to identify the whole prime. No additional prime visibility tests were conducted to avoid creating test fatigue, as the same population was used in all three experiments, and they also had to complete the productive retrieval test and two posttests, all in one session.

In this experiment, 82% of the participants reported either being completely unaware of the existence of the prime or being able to see very little precise information about the prime. This provides further support of the conclusion that the participants were able to access lexical representations of the studied items automatically. Further analyses of the RT data with both the priming condition and the coded prime visibility as independent variables showed no significant interaction between priming and prime visibility for the pseudowords, indicating that the remaining 18% of the participants who reported being able to identify one or more letters of the prime (the higher awareness group) did not demonstrate a larger repetition priming effect. This suggests that the masked repetition priming effect recorded for the pseudowords was automatic. Furthermore, a significant interaction between priming and prime visibility was observed in the analysis of the RT data by participants for the word stimuli, $F1(2, 45) = 3.979, p < .05$, partial $\eta^2 = .150$, but similar to the results observed in Grainger et al. (2003, p. 1,261), the analysis revealed that the priming effect was significantly smaller for the higher awareness group than for the rest of the participants. This means that the participants who reported being able to occasionally identify some of the letters in the primes showed less repetition priming when responding to the word stimuli (Table 5). This finding provides further evidence in support of the automatic nature of the masked repetition priming effect.

Discussion of automaticity of access to the representations of the newly learned pseudowords will be further developed in the section Fluency of Access to Lexical Knowledge.

There is one further point that is worth making in relation to the priming results observed in Experiment 2 (Table 4). Although both priming effects (for the low-frequency words and newly learned pseudowords) were very robust, the former stimulus type generated a larger priming effect than the latter (75 ms compared to 52 ms).

In the L1, the size of the facilitation effect of masked repetition priming (when the prime is briefly presented for 50–60 ms) is typically about 50–60 ms. In fact, Grainger et al. (2003), who explained repetition priming using the IA

Table 5 Mean RTs (ms) for word targets by prime visibility and priming condition (repeated/unrelated) for Experiment 2

Prime visibility	Priming condition	*M*	*SE*	Priming
0	repetition	621	23	67
	unrelated	688	23	
1	repetition	599	24	71
	unrelated	670	23	
2	repetition	679	35	28
	unrelated	707	34	

Prime visibility codes: 0 = were not aware there was a prime, 1 = knew there was a prime but could not see any precise information, and 2 = were aware of the prime and could identify some of the letters.

model of lexical processing, suggested that recognition of a word target is given a "head start" by a prior presentation of the identical prime, compared to the unrelated condition. This is because if the target is presented immediately after the presentation of the identical prime, its representation is already preactivated; therefore, less time is required for the target word to reach the necessary level of activation for it to be recognized, compared to when a target is preceded by an unrelated prime.

However, in bilingual and L2 studies (and even some L1 experiments), larger repetition priming effects have also been recorded (De Groot & Nas, 1991, Experiment 2; Finkbeiner, Forster, Nicol, & Nakamura, 2004, Experiment 2; Jiang, 1999, Experiment 3). It has been suggested (Forster et al., 2003) that priming larger than 60 ms in a standard masked repetition priming paradigm may indicate the presence of an additional extralexical component. For example, larger repetition priming effects in the L2 compared to the L1 may suggest that participants are less confident when processing L2 words. If this is true, two outcomes are possible: (a) L2 participants who are risk-takers would show more false positives and faster RTs in their decisions in the unrelated condition and would show a smaller priming effect (close to the 56-ms SOA); (b) L2 participants who are more cautious would show slower response latencies but higher accuracy (the speed accuracy trade-off) and exhibit *hyperpriming*.

To test this prediction, two analyses of the accuracy and RT data by participants were conducted on the word stimuli. First, a significant positive correlation (using Pearson's r) between mean RTs and accuracy of responses to the word stimuli was found in the unrelated condition (r = .469, p = .001, two-tailed, $n = 48$), which indicates that the participants who were more accurate in their responses took longer to respond to the word targets in the unrelated condition. Second, the RT data were organized into three groups based on response accuracy, with participants whose accuracy was less than 85% being in group 1 ($n = 13$), participants whose accuracy was higher than 85% but less than 100% being in group 2 ($n = 21$), and participants whose accuracy on the unrelated trials was 100% being in group 3 ($n = 14$). ANOVAs were run on the RT data for each of these groups separately. The results showed significant repetition priming in all three groups, but the mean priming effect was 60 ms in group 1, 70 ms in group 2, and 74 ms in group 3. This corroborates the hypothesis that more cautious L2 participants tend to demonstrate *hyperpriming* when responding to low-frequency English words. This finding may be useful to keep in mind when conducting future similar studies with L2 participants. In relation to the findings of the present experiment, it would not be unreasonable to argue that the 52-ms facilitation recorded for the learned pseudowords reflect the actual lexical priming (for the 56-ms SOA), whereas the 75-ms facilitation observed for the low-frequency English words incorporates both the lexical and extralexical components. A logical extension of this would be to suggest that the L2 participants were more confident in their responses to the learned pseudowords compared to the low-frequency words in this experiment.

Finally, ANOVA was conducted on the RT data of Experiment 2 to see if, similar to Experiment 1, there was a significant interaction between the length of the pseudowords in letters and the priming effect. This analysis revealed no such interaction (i.e., repetition priming was equally significant for the seven-, eight-, and nine-letter stimuli). This suggests that the anomalous result for the nine-letter stimuli in Experiment 1 was unlikely to have been caused by the participants' failure to acquire formal-lexical representations of the nine-letter pseudowords.

Experiment 3. Semantic Priming

Experimental Design

The outcomes of DL were further examined in Experiment 3, where lexical-semantic representations of the pseudowords were foregrounded through the use of a semantic priming procedure. A positive semantic priming effect is observed when recognition of a word target is facilitated by prior presentation of a word prime related to it in meaning, compared to the unrelated or neutral conditions. This facilitation effect is fairly robust and is taken to reflect the properties of lexical knowledge, where the meanings of semantically related words are interlinked (Collins & Loftus, 1975; McClelland, 1987; McRae & Boisvert, 1998).

The prediction was that if lexical-semantic representations of the pseudowords had been acquired, the use of these pseudowords as primes would facilitate recognition of semantically related word targets, compared to the unrelated condition. Semantic relationships in this experiment were operationalized either as a featural overlap (e.g., *microwave-toaster*—overlapping features include <found in kitchens>, <used for warming up food>; McRae & Boisvert, 1998; McRae, Cree, Seidenberg, & McNorgan, 2005)—or as a functional relationship (e.g., *broom-floor*; Moss, Ostrin, Tyler, & Marslen-Wilson, 1995). For the verb stimuli, relationships based on thematic roles were used as the main basis of priming (e.g., *interviewing-reporter, convicting-criminal*; Ferretti, McRae, & Hatherell, 2001).

Materials

On critical trials, 48 word targets were preceded by semantically related pseudoword (r-pw-w) or word primes (r-w-w), and on control trials, they were preceded by unrelated word primes (u-w-w) (Appendix E). This experimental design created conditions for a comparison of the semantic priming effect produced by the newly learned pseudowords and by known L2 words (Table 6). To create a more balanced comparison, related word primes were chosen to mimic, as much as possible, the corresponding pseudoword relationship with the same target and were low-frequency words (KF = 7.0 opm, *SD* = 9.10; CE = 8.4 opm, *SD* = 12.93; mean 1,000-word base list = 5.9, *SD* = 2.97). Both types of related primes were also matched as closely as possible with

Table 6 Counterbalanced semantic priming design for Experiment 3

Primes						
List A		List B		List C		Targets
veranda	r-w-w	scalpel	u-w-w	reatangle[a]	r-pw-w	**balcony**
pulse	u-w-w	forfert[b]	r-pw-w	basin	r-w-w	**bucket**
maxidise[c]	r-pw-w	diagnose	r-w-w	glazing	u-w-w	**symptom**

[a] An overhang that projects over a window or outside door and serves as protection from the rain and snow.
[b] A round open container, usually not very deep, used in building and industry (e.g., for washing or mixing materials).
[c] To determine the nature of an illness in a patient through an interview, physical examination, medical tests, or other procedures.

the targets in relation to word length in letters; the average length in letters of the targets was 7.9 ($SD = 1.5$) and of the word primes was 7.6 ($SD = 1.6$). Using the Latin square design, three presentation lists were constructed in such a way that each target appeared only once in each list and was presented in all three conditions across the three lists.

Additional filler stimuli were added to each list to reduce the proportion of related trials and to construct a balanced LDT. The final presentation lists consisted of 192 pairs of stimuli: 48 experimental pairs and 144 filler pairs. In each list, paired stimuli ("paired" here stands for pairing by design rather than for a paired presentation, as stimuli were presented one by one in a continuous listwise presentation) were arranged in a pseudorandom order, which was the same for all participants. The proportion of related trials was .17 of all trials, and .25 of the trials that included a word.

The related word-word pairs were checked against three word association norms—The Edinburgh Associative Thesaurus (Coltheart, 1981; Kiss, Armstrong, Milroy, & Piper, 1973), the Birkbeck association norms (Moss & Older, 1996), and the University of South Florida (USF) Free Association Norms (Nelson, McEvoy, & Schreiber, 1998)—to keep associative relationships between primes and targets on the related word-word trials low. This is because when a semantic relationship is accompanied by a normative association, a larger semantic priming effect is observed due to the so-called *associative boost* (Lucas, 2000; Moss et al., 1995). Because normative associations are assumed to reflect the effect of co-occurrence of words in context, they are likely to be present for real words but not for pseudowords. Keeping associative links between semantically related word-word pairs low created conditions for a more balanced comparison of the semantic priming effect produced by the newly learned pseudoword primes versus that produced by the real word primes.

Among the semantically related word pairs, 27 pairs (56%) were not listed as associated in any of the word association norms,[1] 12 pairs (29%) had low forward or backward associative scores (<.10), and 7 pairs (15%) were moderately associated (between .10 and .40). Among the moderately associated word pairs, the forward association strength of the pairs *blueprint-architect* (Birkbeck norms) and *allergy-sneezing* (USF norms) were the highest (.4), followed by *veranda-balcony* (.27 in the Birkbeck norms), while the association scores for the rest of the pairs were at or under .2.

In the design phase of Experiment 3, the semantic relatedness of related word-word pairs was checked using a relatedness rating task completed by a group of 25 native English speakers. A 5-point scale was used in this task, where

1 stood for "completely unrelated" and 5 for "very closely related." The related pairs were rated significantly higher than unrelated pairs: The mean rating of the related pairs was 3.94 ($SD = 1.03$) and that of the unrelated pairs was 1.17 ($SD = 0.49$). The difference was significant in the analyses by participants and by items, $F1(1, 24) = 953.682$, $p_1 < .0005$, partial $\eta^2 = .975$; $F2(1, 47) = 1383.120$, $p_2 < .0005$, partial $\eta^2 = .967$. The same relatedness rating task was given to the study participants after the three main experiments. The mean rating for the related items was 4.31 ($SD = 0.94$) and that for the unrelated items was 1.14 ($SD = 0.56$). This difference was significant in the analyses by participants and by items, $F1(1, 47) = 2285.438$, $p_1 < .0005$, partial $\eta^2 = .980$; $F2(1, 47) = 2991.856$, $p_2 < .0005$, partial $\eta^2 = .985$.

Procedure

The design of Experiment 3 was based on Experiment 1, reported in McRae and Boisvert (1998). A single-item continuous presentation and low proportion of related trials were used in this experiment to minimize opportunities for the participants to deploy decision strategies (McNamara & Altarriba, 1988; Perea & Rosa, 2002; Shelton & Martin, 1992). These experimental conditions increase the likelihood of the semantic priming effect being created by the processes of automatic interactive activation of word representations in memory.

In the experimental procedure, both primes and targets were presented to the participants as lowercase letter-strings, one stimulus at a time. The participants were instructed to make word/nonword decisions on every stimulus as quickly and as accurately as possible. The stimuli appeared automatically after a 203-ms intertrial interval (16 monitor scan cycles), during which a blank screen was displayed.

Results and Discussion

The RT data analyses revealed that the pseudoword primes facilitated participants' responses to the related word targets by about 22 ms, compared to the unrelated condition, and that this priming effect was statistically reliable, $F1(1, 47) = 5.573$, $p_1 < .05$, partial $\eta^2 = .106$; $F2(1, 42) = 6.977$, $p_2 < .05$, partial $\eta^2 = .142$ (Table 7). This suggests that the lexical-semantic representations of the newly learned pseudowords had been established and integrated into the existing network of lexical-semantic representations of the participants.

The results also showed a significant semantic priming effect of 37 ms for the related word-word pairs, $F1(1, 47) = 22.519$, $p_1 < .0005$, partial $\eta^2 = .324$; $F2(1, 42) = 17.879$, $p_2 < .0005$, partial $\eta^2 = .299$. The comparison of the two priming conditions showed that the participants responded significantly

Table 7 Mean RTs (ms) and percent error rates for word targets by priming condition for Experiment 3

	r-w-w		r-pw-w		Control u-w-w	
	M	*SE*	*M*	*SE*	*M*	*SE*
Error rates	2.7		3.0		2.3	
RT	624	5	639	5	661	5
Priming	37	7	22	7		

Note. r-w-w = related word prime/word target (e.g., veranda–**balcony**); r-pw-w = related pseuoword prime/word target (e.g., reatangle–**balcony**); u-w-w = unrelated word prime/word target (e.g., scalpel–**balcony**).

slower in the related-pseudoword–word condition than in the related word-word condition, $F1(1, 47) = 5.431, p_1 < .05$, partial $\eta^2 = .104$; $F2(1, 42) = 5.593, p_2 < .05$, partial $\eta^2 = .118$, and that the priming effect generated by the pseudowords was less robust than that produced by the word primes.

The results of Experiment 3 suggest that DL from word cards triggered the acquisition of lexical-semantic representations for the pseudowords but that these representations were probably less stable than those of known L2 words and that their integration into the lexical-semantic memory system of the participants was in its early stages. Dagenbach, Carr, and Barnhardt (1990) argued that if the experimental design requires participants to actively attend to a prime that is not fully acquired, the semantic priming effect may be inhibitory, whereas if the primes are acquired, the effect is facilitatory. According to Dagenbach et al., this is because in order for a weakly established semantic representation to be recognized, all of its "competing semantic neighbors" need to be temporarily inhibited. Therefore, if one of the semantic neighbors of a partially acquired prime is presented immediately after the prime, it will be recognized more slowly than when it is preceded by an unrelated prime. In the present study, even though a majority of the pseudowords were successfully retrieved by the participants, 28 participants scored lower than 100% on the final productive retrieval test. It is possible then that the pseudowords, which had not been fully acquired by individual participants, caused inhibition instead of facilitation at least on some of the related trials, making the overall priming effect in the related pseudoword–word condition less reliable.

The findings of the semantic priming experiment suggest that although DL out of context (such as learning from word cards) triggers the acquisition of the meaning aspects of L2 vocabulary knowledge, other types of learning are needed to develop more stable lexical-semantic representations of the new words and to fully integrate them into the lexical-semantic networks of the learner.

Overall, the combined outcomes of the three priming experiments show that DL resulted in the establishment of formal-lexical and lexical-semantic representations for the deliberately learned vocabulary items and that these representations were integrated into the existing architecture of L2 lexical representations for the study participants.

Fluency of Access to Lexical Knowledge

So far the discussion has primarily focused on the acquisition of representational knowledge. This section addresses functional aspects of acquisition—that is, whether the knowledge of deliberately learned L2 vocabulary items can be accessed fluently by the learners. This has been partially addressed in the presentation of the results of Experiment 2. The robust automatic masked repetition priming effect revealed for the pseudowords in this experiment, under the conditions that deterred the participants from deploying conscious strategies, was taken to mean that the participants were able to access their formal-lexical representations fluently.

Automaticity of access to the lexical representations of the pseudowords was also measured directly in Experiment 2 and 3, using CVs of participant responses. CV is calculated by dividing the *SD* (standard deviation) of the RTs by the mean RT; that is, CV is an index of the relationship between mean RT and its *SD*. Shorter absolute RTs are often taken to be indicative of an improvement in performance fluency. However, shorter RTs may result either from a simple speed-up of some or all processes involved in word recognition or from a *qualitative* change in the nature of these processes (e.g., optimization of processes using mechanisms of knowledge compilation proposed in the ACT* theory of acquisition; Anderson, 1983). Because mean RT represents a mixture of controlled and automatic processes involved in word recognition, "to warrant the conclusion that there has been a change in the blend of underlying mechanisms—and not just a speed-up effect—there needs to be a reduction in SD that is more than proportional to the reduction in RT" (Segalowitz, Watson, & Segalowitz, 1995, p. 125); that is, if the mean RT is reduced as a result of a simple speed-up of component processes, this reduction will be accompanied by a proportional reduction in *SD* (something commonly observed in behavioral experiments), in which case, the CV should remain constant. However, if the mean RT is reduced as a result of a qualitative change in the processing system (e.g., due to reduced reliance on resource-intensive controlled mechanisms—which are known to be more variable than automatic processes), the CV will also be reduced. To sum up, the CV can be viewed as an indicator of the relative deployment of controlled and automatic processes by the participants in making lexical decisions (Segalowitz, 2000; Segalowitz & Segalowitz, 1993), with lower CVs indicating a more automatized way of processing information and less involvement of controlled processes. Therefore, if the CV_{RT} is lower for the stimuli of type A than type B, for the same group of participants performing the same task, and when the stimuli are matched for various characteristics that are likely to affect response latencies, this lower CV_{RT} can be interpreted as an indicator that type A stimuli are processes with a higher degree of automaticity by these participants, compared to type B stimuli.

In Experiment 2, CVs were calculated for individual participants for the learned pseudoword, word, and nonword targets in the unrelated condition (i.e., preceded by unrelated primes). In Experiment 3, CVs were calculated for the pseudowords, words, and nonwords (used as primes in the experiment) and preceded by unrelated stimuli in the list presentation. Because the influence of an unrelated stimulus on the automaticy of access to the following stimulus is likely to be minimal, the unrelated condition is suitable for conducting the CV analysis (cf. Phillips, Segalowitz, O'Brien, & Yamasakia, 2004). It was reasonable to compare the CVs of responses to the pseudowords and words in Experiments 2 and 3 because the key intervening variables (such as word length in letters, word frequency, number of orthographic neighbors) were controlled for. In addition, in Experiment 3, the words and pseudowords were matched for grammatical class.

In Experiment 2, a significant effect of stimulus type was revealed in both the CV, $F(3, 40) = 9.854$, $p < .0005$, partial $\eta^2 = .425$, and the RT, $F(3, 40) = 46.400$, $p < .0005$, partial $\eta^2 = .777$, data analyses (Table 8).

Table 8 shows that responses to the pseudowords were characterized by the smallest variability. Further analyses (pairwise comparison, Bonferroni)

Table 8 Mean RTs (ms) and CVs by type of stimulus for Experiment 2

Stimulus type	*M*	*SE*	CV	*SE*
Pseudoword (PW)	641	16	.130	.007
Word (W)	693	17	.161	.007
Distant nonword (NW)	652	16	.157	.007
Close nonword (NW-1)	712	18	.173	.007

Table 9 Pairwise multiple comparisons of CVs by type of stimulus for Experiment 2

(I) CV	(J) CV	Mean difference (I−J)	*SE*
PW[a]	W	−.0306*	.007
	NW	−.0263*	.006
	NW-1	−.0428*	.009

Note. See Table 8 for the abbreviations.
*Mean difference is significant at the .05 level.

Table 10 Mean RTs (ms) and CVs for all types of prime for Experiment 3

Stimulus type	*M*	*SE*	CV	*SE*
Pseudoword (PW)	650	13	.156	.008
Word (W)	671	12	.189	.011
Nonword (NW)	757	19	.244	.014

confirmed that the CVs of participant responses to the pseudowords were significantly lower than for all other types of stimuli (see Table 9).

In Experiment 3, there also was a significant effect of stimulus type in both the RT, $F(2, 41) = 29.645$, $p < .0005$, partial $\eta^2 = .591$, and the CV, $F(2, 41) = 16.183$, $p < .0005$, partial $\eta^2 = .441$, data analyses, with mean RT and CV being lower for the pseudowords than for the words and nonwords (Table 10).

Planned comparisons (Bonferroni) showed that it took the participants significantly longer to make lexical decisions for the nonwords than for the pseudowords ($p < .0005$) and the words ($p < .0005$) and, more importantly, that their decision latencies for the nonwords were characterized by a significantly higher coefficient of variation (CV_{RT}) than those for the pseudowords ($p < .0005$) and for the words ($p < .05$). Furthermore, both the mean RT and CV_{RT} were lower for pseudowords than for low-frequency English words (Table 11).

The results of the CV analyses in Experiments 2 and 3 are straightforward: Participants' responses to the pseudowords were significantly less variable than their responses to the nonwords and even to the low-frequency L2 words. These findings indicate that the study participants were able to process the deliberately learned pseudowords with some degree of automaticity and that DL triggered the acquisition of the functional aspects of vocabulary knowledge. Because the experimental design necessitated the use of low-frequency (rather than high-frequency) L2 words, the findings are not sufficient to conclude that access

Table 11 Pairwise multiple comparisons of CVs by type of stimulus for Experiment 3

(I) CV	(J) CV	Mean difference (I–J)	*SE*
PW	W	−.0329*	.012
	NW	−.0879*	.016
W	NW	−.0550*	.018

Note. See Table 8 for the abbreviations.
*Mean difference is significant at the .05 level.

to the lexical representations of the deliberately studied pseudowords was fully automatized. Nevertheless, these pseudowords were certainly accessed more frequently than low-frequency English words.

Limitations and Suggestions for Future Research

Participants in the present study were advanced L2 users. Because cognitive literature on L2 vocabulary acquisition suggests that there may be important differences in the organization of the bilingual lexicon, access to representations of L2 words, and even the nature of vocabulary acquisition processes for beginner and advanced L2 users, our ability to generalize the findings of this study to learner populations at early stages of English language proficiency is limited. To be able to do this, similar research needs to be conducted with less proficient bilinguals.

Additionally, the participants' ability to access the lexical representations of the new items was examined only in the bottom-up (data-driven) processing direction, from operations at the lower-level domains of cognition (i.e., processing visual signals and accessing sublexical representations of graphemes) to those involving the word level of representations. For this reason, it would be premature to extrapolate the findings of the study to top-down (conceptually driven) processes of productive vocabulary use (e.g., in writing or speaking) that involve a progression from intention to articulation or written expression (Levelt, 1989). Further research is needed to test whether deliberately learned vocabulary items become available for online retrieval in production.

Another limitation is that acquisition of vocabulary was evaluated using tasks where the stimuli were not imbedded in larger meaningful contexts involving phrases, sentences, or texts. Because words have been shown to be recognized earlier when they are presented in such contexts (Stanovitch & West, 1983; Tyler & Wessels, 1983), it would be useful to see whether vocabulary items acquired using word cards are integrated in meaningful contexts in the same way.

Finally, although this study has been restricted to tasks involving visual word recognition, this mode of presentation does not mean that phonological codes were not activated in the course of word recognition. In fact, it has been shown that phonological recoding is an automatic process that starts immediately when visual perceptual input is received (e.g., Brysbaert & Dijkstra, 2006; Brysbaert, Van Dyck, & Van de Poel, 1999; Dijkstra, Grainger, & Van Heuven, 1999; Frost, 1998; Lukatela & Turvey, 1994; Perfetti & Bell, 1991). However, it would be interesting to explicitly evaluate whether the method of learning words from word cards leads to the acquisition of phonological representations. Additionally, with digital multimedia technologies now widely available, this research can be extended to evaluate whether the use of sound-capable mobile devices to provide auditory (as well as visual) input while learning words from flashcards facilitates the establishment of more stable phonological representations, further promoting the acquisition of L2 vocabulary.

Conclusion

The outcomes of deliberate decontextualized learning of L2 vocabulary have been at in the center of the present investigation. Deliberate word learning from word lists and cards (a method that was used intuitively by language teachers and learners in the past) came under criticism in the 1980s with the advent of communicative learning methodologies. The purpose of this research was to establish whether vocabulary knowledge gained through DL is stored and accessed in a manner that is similar to existing L1 and L2 lexical knowledge, which L2 speakers draw on in real language use. The results reported in this article show that DL is not only an efficient and convenient but also a very effective method of L2 vocabulary acquisition. This suggests that, as far as L2 vocabulary is concerned, the hypothesis regarding the learning/acquisition dichotomy is not justified.

On the other hand, the fact that DL can trigger L2 vocabulary acquisition does not mean that L2 lexicons are or should be acquired exclusively by this method. Other types of learning are likely to be needed to enhance the initial acquisition of vocabulary from DL. The literature on vocabulary learning suggests that the process of acquiring meaning can be enhanced by learning activities that encourage deep processing, such as keyword mnemonics and semantic mapping (Beck, McKeown, & Omanson, 1987; Hulstijn, 1997; Levin, Levin, Glasman, & Nordwall, 1992; Pressley, Levin, & Miller, 1981) by establishing meaningful syntagmatic relationships—for example, when learning words together in *thematic clusters* (such as *conditions, apply, frequently*) and by generative use (Joe, 1998). These learning approaches create richer conceptual knowledge of the new L2 words and promote integration of their meanings with existing semantic and conceptual representations. Another way of consolidating vocabulary acquisition is through exposure to and use of new words in a variety of meaningful contexts, such as through reading or interaction with members of target language communities. This usage-based learning approach provides opportunities for learners to develop pragmatic and sociocultural knowledge needed to understand and use L2 vocabulary successfully.

Because DL of L2 vocabulary that encourages recurring meaning-form and form-meaning retrieval increases the learning rate and improves accuracy of vocabulary knowledge, this method is particularly appropriate when speedy acquisition of a finite set of words is needed (e.g., when preparing to take a course of study or to start a new job in another country where the L2 is spoken or when engaging in a business relationship with a foreign company). This is because the knowledge of technical vocabulary in a specialized area can contribute significantly to understanding discipline-specific communications (Chung & Nation, 2003; Nation, 2001; Ward, 1999). Additionally, such learning situations create opportunities to combine the advantages of this high-return-on-investment vocabulary learning method with the advantages of encountering target words in meaningful contexts, which creates opportunities for deep processing of the newly acquired words.

Even in more general language learning contexts, deliberate form-focused learning needs to be a part of a balanced learning approach. Such an approach has been proposed by Nation (2007), who suggested that equal amounts of time should be devoted in a language course to four strands: meaning-focused input, meaning-focused output, language-focused learning, and fluency development, where language-focused learning includes deliberate learning and form-focused instruction. The findings of this study confirm that the inclusion of deliberate learning in a foreign language or L2 program of study is well justified.

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Note

1 Although the absence of a particular pairing of words from the published norms was taken as an indication of a low associative relationship, admittedly this is not a full guarantee of the latter.

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Appendix A

Participants

Table A1 Participants' L1

Mother tongue (L1)	No. of participants	AoA = 1	AoA = 2
Bahasa Indonesia	1		1
Bengali	1	1	
Chinese (Cantonese, Mandarin, dialects)	5	5	

(*Continued*)

Table A1 Continued

Mother tongue (L1)	No. of participants	AoA = 1	AoA = 2
French	8	1	7
German	7		7
Hebrew	2	2	
Korean	1		1
Malay	8	7	1
Filipino (Tagalog, dialects)	3	3	
Polish	2		2
Portuguese	1		1
Russian	3		3
Singhalese	1	1	
Spanish	1	1	
Tamil	3	2	1
Urdu	1	1	
Total:	48	24	24

AoA: age of acquisition, indicates the age when the participants started learning English. AoA = 1: early bilinguals, who started learning English before the age of 7. AoA = 2: late bilinguals, who started learning English after the age of 7.

Table A2 Participants' characteristics by AoA group

Characteristics	AoA = 1 (early acquisition group)	AoA = 2 (late acquisition group)
No. of participants	24	24
Mean AoA (*SD*)	4.3 (2.1)	10.8 (1.9)
Mean years of L2 (*SD*)	21.7 (5.7)	21.1 (8.7)
Mean Age (*SD*)	25.9 (5.8)	31.8 (8.3)

Appendix B

Pseudowords and Their Definitions

ABSTAIR: Steps attached to poles and railings of scaffolding for construction workers to climb up and down.

FORFERT: A round open container, usually not very deep, used in building and industry (e.g., for washing or mixing materials).

INFECENT: Light gray powderlike substance added to building material, such as concrete mix, to facilitate the setting processes.

SIRCASTIC: A portable woodcutting saw with a removable blade; can be used with a variety of blades depending on the application.

ERRAMIC: Paving material, such as cobblestones or shingle, used for garden paths and sidewalks.

PROLLEY: A large strong beam, often of steel or iron, forming a main supporting element in a framework of buildings or bridges.

SUNSCRIBE: A low-qualified laborer, whose job it is to assist professional builders and construction workers with various jobs.

DESIGLATE: Remove earth or soil by digging and scooping it out within a clearly marked area.

AUFLICT: A mechanical device designed for lifting people or heavy objects.

REATANGLE: An overhang that projects over a window or outside door and serves as protection from the rain and snow.

SHRINGENT: A device for measuring angles and distances in technical drawing.

BRIENING: A horizontal piece of wood or stone that forms the bottom of an entrance and offers support when passing through a doorway.

DISCRENT: A washable floor covering, which provides a hard glossy transparent coating for wooden or concrete floors.

OFFICACY: A system of maintaining a set temperature in a building.

ALTOGRAPH: A device which measures and records electric current and voltage.

BANKRUST: A person whose job is to lay tiles (such as floor or wall tiles).

IMIGATE: Unblock clogged drains or pipes, usually by creating a vacuum and extracting the blockage.

CUSTONY: A pattern or design on a wall, ceiling or above the skirting board, usually created using a stencil.

PIQUIDATE: A construction vehicle with tracks or large wheels and a wide blade used for moving earth or debris.

APORTLE: A small hand tool with a short handle and a wide flat blade used for spreading plaster, or other fillers, and smoothing the surface before painting.

SCOTHER: A hand tool that is used to hold or twist a nut or bolt.

CONFULATE: Treat glass to make it nontransparent, usually only in one direction, by applying a metallic or plastic coating that reflects light.

ANIMOTE: A metal or synthetic medium that carries electricity over a distance, following a particular route.

GATEBAY: A small, simple building, often made of wood, in forest or mountain areas.

IMPUTATE: Prepare plants and herbs to be used for medicinal purposes.

MERCUSY: A slimy fluid formed and discharged as a result of an inflammation of the inner ear.

INSUSTENT: A liquid spray used to soothe irritated or inflamed internal parts of the nose, mouth, or throat.

SINTERITY: A strong hypersensitivity reaction, which does not last. Symptoms may include sneezing, watery eyes, itchiness and swelling.

TEOMETRY: A branch of medical sciences concerned with the study of the internal organs, their functions and diseases.

ANASYTIC: A natural remedy for lung disorders and diseases, in the form of a light yellow liquid.

SPEETRAL: An infection of the skin or connective tissue characterized by reddening and itching and may lead to tissue destruction and scarring.

MAXIDISE: To determine the nature of an illness in a patient through an interview, physical examination, medical tests or other procedures.

ANTIDOTH: Sterile cotton covering soaked in an antiseptic solution that is put on a wound to protect it from infection or further damage.

PROSTER: The part of the body comprising the hip, buttock, and upper thigh.

TELERANT: A medical specialist in the disorders and diseases of babies and toddlers.

RECUNDANT: A special lens to correct vision in people with astigmatism.

LUDIEROUS: Used to describe natural and chemically produced substances that alleviate pain without loss of consciousness.

OBSOLATE: Inhibit or contain growth of the abnormal mass of tissue by severing or tying off blood supply to the affected area.

ELENATOR: A special type of syringe with a very thin needle, used for injecting medical substances directly into internal organs, or for hypodermic injections (e.g., inoculations).

DIVEAGENT: Coming out of general anesthesia; a stage straight after the operation when the patient feels dizzy, nauseous, and very weak.

REGRAIN: A type of blood clot that may partially or completely block an artery or a vein, causing a heart attack or stroke.

PREACHET: A junior doctor engaged in a period of specialized training in clinical medicine or surgery in a hospital on completion of an internship.

UTILISK: A surgical instrument that holds back the edges of a surgical incision.

INDUPTION: A type of forceps used by dental surgeons for extracting teeth.

ENTRAVE: Administer a drug or fluids using a syringe, inhaler, or orally.

LYPOCRISY: A severe mental disorder in which contact with reality is lost or highly distorted.

BRACENET: A painful injury to the tendons or ligaments of a joint caused by wrenching, twisting or overstretching.

SAPIRICAL: A machine used in hospitals to maintain breathing, especially when long-term artificial breathing is required.

Appendix C

Experiment 1: Stimuli Used in Form-Priming for the Pseudoword Set (Word Targets Only)

Form-related stimuli (related nonword prime–related pseudoword prime–unrelated word prime–TARGET): brafelet-bracenet-stagnate-BRACELET, briefins-briening-sedative-BRIEFING, dustody-custony-acclaim-CUSTODY, desugnate-desiglate-timetable-DESIGNATE, dimcreet-discrent-refinery-DISCREET, elevapor-elenator-wardrobe-ELEVATOR, ludickous-ludierous-continent-LUDICROUS, maximide-maxidise-ligament-MAXIMISE, mewcury-mercusy-profile-MERCURY, redunvant-recundant-foreigner-REDUNDANT, refruin-regrain-dictate-REFRAIN, bincerity-sinterity-resultant-SINCERITY, smothey-scother-romance-SMOTHER, substribe-sunscribe-anonymous-SUBSCRIBE, tropley-prolley-obscene-TROLLEY, ukilise-utilisk-awfully-UTILISE, abutain-abstair-gazette-ABSTAIN, ampucate-imputate-flooring-AMPUTATE, analymic-anasytic-swinging-ANALYTIC, angidote-antidoth-sublease-ANTIDOTE, epostle-aportle-camping-APOSTLE, autobraph-altograph-steepness-AUTOGRAPH, consolate-confulate-obscurely-CONSULATE, divergest-diveagent-ventilate-DIVERGENT, euratic-erramic-harshly-ERRATIC, forweit-forfert-aerosol-FORFEIT, umitate-imigate-callous-IMITATE, indewent-infecent-fixation-INDECENT, liquirate-piquidate-racketeer-LIQUIDATE, sardastic-sircastic-medicinal-SARCASTIC, matirical-sapirical-violinist-SATIRICAL, stectral-speetral-bruising-SPECTRAL, affloct-auflict-outdoor-AFFLICT, animage-animate-transit-ANIMATE, sankrupt-bankrust-leafless-BANKRUPT, efnicacy-officacy-shrewdly-EFFICACY, engrive-entrave-flaming-ENGRAVE, gatsway-gateway-compass-GATEWAY, geobetry-teometry-abdicate-GEOMETRY, hysocrisy-lypocrisy-youngster-HYPOCRISY, irduction-induption-sedentary-INDUCTION, insictent-insustent-communion-INSISTENT, oksolete-obsolate-mythical-OBSOLETE, preather-preachet-adhesive-PREACHER, prospet-proster-honesty-PROSPER, roctangle-reatangle-dishonest-RECTANGLE, stringens-shringent-hideously-STRINGENT, toleract-telerant-immobile-TOLERANT.

Appendix D

Experiment 2: Stimuli Used in Repetition Priming

Word Targets: GENERIC, GODLESS, SCANNER, SALIENT, TOPICAL, BALDNESS, OVERTURN, POPULATE, ROOTLESS, HEADACHE, MORALIST, INTERSECT, MILESTONE, BLUEBERRY, PRETENDER, COLLISION, CRUMBLE, MYSTERY, COMMENT, CONGEST, ETHICAL, CHAMBERS, MOBILITY, DELEGATE, TIRELESS, CLIPPING, RETAILER, OVERSIGHT, VIABILITY, PUBLICISE, REWARDING, RETENTION.

Unrelated word primes used with the word targets: recover, turning, liberal, linkage, circuit, taxation, laughter, pressing, illusion, presence, hopeless, expensive, interface, blindness, inspector, passively, crumble, mystery, comment, congest, ethical, chambers, mobility, delegate, tireless, clipping, retailer, oversight, viability, publicise, rewarding, retention.

Unrelated word primes used with the pseudoword targets: acclaim, awfully, dictate, romance, profile, foreigner, resultant, timetable, continent, anonymous, sedative, ligament, refinery, wardrobe, stagnate, obscene, steepness, racketeer, obscurely, ventilate, violinist, flooring, sublease, bruising, fixation, swinging, harshly, aerosol, camping, gazette, callous, medicinal, shrewdly, leafless, adhesive, abdicate, mythical, immobile, flaming, compass, outdoor, transit, honesty, hideously, sedentary, casserole, dishonest, youngster.

Appendix E

Experiment 3: Stimuli Used in Semantic Priming

Semantically-related stimuli (word prime–pseudoword prime–target): stairway-abstair-stepladder, basin-forfert-bucket, mortar-infecent-cement, sawmill-sircastic-plywood, transformer-altograph-electrician, glazing-confulate-windowpane, carpenter-bankrust-bricklayer, blueprint-shringent-architect, veranda-reatangle-balcony, beam-prolley-pillar, install-imigate-plumber, contractor-sunscribe-renovation, fresco-custony-mural, excavate-desiglate-digger, bulldozer-piquidate-demolish, paintbrush-aportle-ceiling, spanner-scother-screwdriver, carpet-discrent-matting, heating-officacy-insulation, gravel-erramic-footpath, cable-animote-wiring, threshold-briening-doorway, crane-auflict-lifting, chalet-gatebay-bungalow, dispense-imputate-pharmacist, antibiotic-anasytic-pneumonia, soothing-ludierous-painful, smallpox-speetral-scarred, saliva-mercusy-secretion, operate-obsolate-tumour, syringe-elenator-vaccine, exhausted-diveagent-fatigued, paranoia-lypocrisy-insanity, fillings-induption-dentist, inject-entrave-morphine, coronary-regrain-artery, paramedic-preachet-physician, ointment-insustent-infection, scalpel-utilisk-incision, diagnose-maxidise-symptom, compress-antidoth-bandage, dislocation-bracenet-fracture, allergy-sinterity-sneezing, abdomen-proster-pelvis, midwife-telerant-newborn, respirator-sapirical-inhalation, anatomy-teometry-physiology, spectacles-recundant-eyesight.