Language Learning 43:4, December 1993, pp. 559–617

Psycholinguistic Determinants of Foreign Language Vocabulary Learning

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This paper reviews the psycholinguistic factors that affect ease of learning of foreign language (FL) vocabulary and investigates their role in 47 students' learning of German under Repetition, Keyword or "Own" strategy conditions. Native-to-foreign learning is shown to be easier the more the FL words conform to the phonological ($0.40<r<0.63$; $p<.01$) and orthographic ($0.28<r<0.45$; $.05<p<.01$) patterns of the native language. However, these relationships are less pronounced (not significant) in foreign-to-native learning. The part of speech ($0.44<r<0.64$; $p<.01$) and the imageability ($0.37<r<0.53$; $.05<p<.01$) of the concept are strong determinants of learnability, suggesting an important influence of meaningfulness. Keyword effectiveness, particularly in the case of receptive learning, is influenced by the part of speech and imageability of the keyword. But keywords must also share considerable acoustic similarity with their foreign words to be effective reminders in productive learning ($r=0.61$; $p<.01$). Otherwise learners must practice these novel phonotactic and orthographic patterns to consolidate them.

We thank Sue Sinclair for gathering the pronunciation latency data.
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INTRODUCTION

Why are some foreign language (FL) vocabulary items so much easier to learn than others? Why is it easy to learn that the German word *Friseur* means *hairdresser* yet much harder to learn that *Zahlen* means *to pay*? Why is it easy to remember that the German for trousers is *Hose*, and to forget that *to rent* is *Mieten*?

Many factors might affect the ease of FL vocabulary acquisition (see Higa, 1965 for an early review). In essence, the process of learning a FL word is to map a novel sound pattern (which will be variable across speakers, dialects, emphases, etc.) to a particular semantic field that may (or may not) have an exact equivalent in the native language. Even this rudimentary description implicates a range of relevant variables: pronounceableness, familiarity with semantic content, and clear labeling of that meaning in the native language. We will briefly review established findings concerning such psycholinguistic variables before describing a study that assesses their effects on vocabulary learning.

PHONOLOGICAL FACTORS

FAMILIARITY OF FEATURES

Clearly, novice language learners are bound up in the orthographic and phonological aspects of vocabulary. While native speakers' lexical entries are clustered semantically (as evidenced by free associations of the type *top—>snow—>hill—>valley*, etc., learners often make associations driven by orthographic or phonological confusion, for example, *béton—>stupide* (confusion with *bête*) or *orchestre* (confusion with *bâton*) or *téléphoner* (confusion with *jeton*) or *Normandie* (confusion with *breton*), etc. (Meara, 1984). Similarly, Henning (1974) demonstrated that in a vocabulary recognition task, more-advanced learners and native speakers made errors indicating semantic clustering of lexical items whereas less-advanced learners showed evidence of a predominance of acoustic rather than semantic clustering.

Three or four dozen different independent gestures of the articulatory apparatus play distinctive roles in human speech (Wang, 1971). Different languages make use of different ranges of articulatory features. Thus difficulty arises when the FL learner is faced with features not exploited in the native language. For example, the contrast between /u/ and /y/ in French pronunciation differentiates between utterances of *au-dessous=below* and *au-dessus=above*. This contrast is not exploited in English and thus English learners of French must (a) learn to identify these unfamiliar features to perceive speech and (b) develop new motor patterns to accurately reproduce these in their own speech (Desrochers & Begg, 1987). This leads to predictions at both language and word levels:

1. The less the overlap between the feature set of the native and the foreign language, the harder it will be for the FL learner to learn to speak that language. This is exemplified by the great difficulty that native speakers of English have with the tonal differences that distinguish the meaning of Mandarin characters. The following five characters are all pronounced as *ma*, but with five distinctive tones. The tone marks over the vowel *a* visually capture the contour of each pitch pattern: "-" for the First, High and Level Tone, "´" for the Second or Rising Tone, "ˇ" for the Third or Low Tone, "`" for the Fourth or Falling Tone, and no marking for the Neutral Tone:

媽	麻	馬	罵	麼
mā	má	mǎ	mà	ma
mother	*hemp*	*horse*	*to scold*	*a participle*

2. The less the overlap between the feature set of the native and the foreign word, the harder it will be for the FL learner to learn that word. Thus, for example, a Chinese student of English has much more difficulty with the words *rice*, *regular*, and *eighth* (which exploit contrasts not found in Chinese) than with *pen*, *see*, and *sun* (Nation, 1987).

COMBINATIONS OF FEATURES: PHONOTACTIC REGULARITY

The pronounceableness of a word is determined not only by its phonemes and their articulatory features, but also by their position in a spoken word. Both absolute and relative position are important. An example of absolute position is /ŋ/ (the *ng* sound), which is common in English at the end of words but never occurs at the beginning. In many languages such as Hopi, Eskimo, or Samoan, *ng* is a common beginning for a word. "Our patterns set up a terrific resistance to articulation of these foreign words beginning with /ŋ/" (Whorf, cited in Carroll, 1956, p. 227). With regard to relative position, just as each language has its own set of phonemes so also does it have its characteristic sequential phoneme probabilities—the sequences that constitute phonotactic regularity. Rodgers (1969) demonstrated that Russian words that were more difficult for an English speaker to pronounce were learned more slowly than were those that were easier to pronounce, even if they did not have to be spoken. However, such pronounceableness effects can be countered if the learner has had practice with the sounds, sound combinations, and spelling used in these words (Faust & Anderson, 1967). Similarly, Seibert (1927) showed that for productive learning of French vocabulary, saying the words aloud led to faster learning with better retention than did silent rote repetition of vocabulary lists. She emphasized that learning the novel pronunciation of FL words is as much a matter of motor skill as of auditory perceptual memory, that "it is impossible to memorize speech material without articulating it in some form or another" (p. 309), and that this must be practiced "since the golden rule of sensori-motor learning is much repetition" (p. 309).

Recent work in cognitive psychology suggests that individual differences in ability to repeat novel phonological patterns (phonological short-term memory span) play a part in determining long-term vocabulary acquisition. Gathercole and Baddeley (1989) demonstrated in a longitudinal study that 5-year-old children's native receptive vocabulary acquisition was predicted by their short-term phonological memory ability (assessed by nonword repetition) one year earlier. In a recent reanalysis of the Gathercole and Baddeley (1989) corpus, Gathercole, Willis, Emslie, and Baddeley (1991) demonstrated that the "wordlikeness" of nonwords (e.g., *defermication* is high in English wordlikeness compared to *loddenapish*) predicted 11% of the variance in children's nonword repetitions even when word length was controlled. They concluded that not only word length but also phonological structure are important determinants of ease of repetition of novel words. This is a "linguistic hypothesis," whereby the familiarity of a novel word's phonological structure determines its repetition accuracy, with phonological frames constructed from similar vocabulary entries in the learner's lexicon being used to support the temporary phonological representation. Whereas these conclusions accord with our theoretical perspective, it is unfortunate that they go beyond their data—the method used by Gathercole et al. (1991) to assess phonological familiarity was to have undergraduates rate the wordlikeness of the nonwords on a dimension of *very like a word* to *not like a word at all*, a task that potentially confounds many dimensions of similarity, with the raters' judgments open to a variety of orthographic, phonological, and semantic factors. One purpose of the experiment that we will report will be to disentangle these aspects.

This review suggests that the overall similarity between sequential phoneme probabilities in the foreign and native languages will determine the ease of learning that foreign language. Specifically, the degree to which a particular FL word accords with the phonotactic patterns of the native language will affect the ease of learning that particular word.

SEMANTIC CONTENT

Items of experience are classified differently by different languages. The class corresponding to one word and one thought in Language A may be represented by Language B as two or more classes corresponding to two or more words and thoughts (Whorf, cited in Carroll, 1956). Thus, for example, Desrochers and Begg

(1987) refer to the French distinction between *balle*—a spherical object that can be caught with one hand, and *ballon*—that requiring both hands; the English translation *ball* is insufficient to represent and distinguish these meanings. Terms for color, temperature, divisions of the day, kinship, and parts of the body are all semantic fields that are divided up in different ways in different languages (Carter & McCarthy, 1988). Navajo has a fourth person singular and plural, which is used to address someone in the room or within earshot without naming him or her directly, and many African languages have inclusive and exclusive forms of the first person plural (we, including you to whom I am speaking vs. we, not including you to whom I am speaking). Hopi has one noun that covers every thing that flies, with the exception of birds—Hopi Indians call insect, plane, and aviator all by the same word and feel no difficulty about it. These few examples demonstrate the phenomenon of linguistic relativity (Whorf, cited in Carroll, 1956). Learning a new FL word is going to be easy if there is a 1:1 mapping of meanings represented by the native and foreign words. It is going to be harder if the same conceptual fields are covered by different lexical fields in different languages (Carter & McCarthy, 1988). Ijaz (1986) demonstrated that even advanced adult ESL learners differed substantially from native speakers in the semantic boundaries that they ascribed to English spatial prepositions, with word usage being heavily influenced by native language transfer. She concludes

> the second language learners essentially relied on a *semantic equivalence hypothesis*. This hypothesis facilitates the acquisition of lexical meanings in the L2 in that it reduces it to the relabelling of concepts already learned in the L1. It confounds and complicates vocabulary acquisition in the L2 by ignoring crosslingual differences in conceptual classification and differences in the semantic boundaries of seemingly corresponding words in the L1 and L2. (p. 443)

The implications for FL learners are clear: When the native language does not encourage the distinction between concepts, then students necessarily will have an additional conceptual chore in learning the FL that relies on these very distinctions. The greater the mismatch, the greater the problem: Two French balls present less difficulty than 22 (or however many it is—Whorf, cited in Carroll, 1956; Lakoff, 1987) forms of Eskimo's snow.

WORD CLASS

The part of speech of a word affects its learning: Nouns are the easiest to learn, adjectives next, whereas verbs and adverbs are the most difficult to learn in FL vocabulary list-learning experiments (Rodgers, 1969). These word-class effects are also found in other psycholinguistic performance measures; for example, Broca's aphasics have more difficulty in producing function words and inflections in their speech than they do substantives (agrammatism—Ellis & Young, 1988, Ch. 9); deep dyslexic patients also have greater difficulty reading function words, including auxiliary verbs, adverbs, and pronouns (Morton & Patterson, 1980; Patterson, 1981); meaningful nouns produce substantially more interference in Stroop tasks than do relatively meaningless function words (Ehri, 1977; Davelaar & Besner, 1988); children acquire nouns before they do other parts of speech (Gentner, 1982). These effects may directly reflect grammatical word-class or they may stem from imageability (in general, nouns are more imageable than verbs—Davelaar & Besner, 1988; Ellis & Beaton, in press) or meaningfulness (imageable items are more meaningful—Paivio, Yuille, & Madigan, 1968; Ellis, 1991).

IMAGEABILITY OF CONCEPT

When people are asked to learn lists of words, the greater the imageability of a word—that is the degree to which it arouses a mental image—the more likely it is to be recalled. This is a robust effect in free recall experiments (Paivio, 1971). It is even more reliable in paired-associate learning (PAL), a laboratory analog of vocabulary learning, in which the subject has to learn a novel association of a stimulus word experimentally paired with a response word (Paivio, 1971; Rubin, 1980). This effect has withstood many attempts to demonstrate that its association with recall is spurious and attributable to *tertium quid* psycholinguistic attributes such as meaningfulness (Dukes & Bastian, 1966; Paivio, Yuille, & Smythe, 1966; Christian, Bickley, Tarka, & Clayton, 1978; Rubin, 1983), concreteness (Christian et al., 1978), familiarity (Frincke, 1968; Paivio, 1968) or age-of-acquisition (Gilhooly & Gilhooly, 1979).

In the particular case of FL vocabulary learning, Carter (1987) notes that concrete FL words are generally learned earlier and more easily than are abstract words, but he cautions that this may be confounded by frequency, familiarity, and word class effects. We cannot find any reference to imageability effects when subjects are using their own strategies of FL vocabulary learning. However, many experimental studies (e.g., Wimer & Lambert, 1959; Kellog & Howe, 1971) have compared native language words with pictures or objects as stimuli for learning word responses in the FL. The results have consistently shown that FL vocabulary items are learned in fewer trials and with fewer errors if nonverbal referents rather than native language words serve as stimuli.

WORD FREQUENCY

Vocabulary learning may be affected by the frequency of the concept. This is certainly true in naturalistic learning situations because frequency determines exposure. It is less likely in controlled experimental situations that ensure equal exposure to all the vocabulary. However, in free recall experiments word frequency has a small but significant positive effect (Christian et al., 1978; Rubin, 1983). In PAL, a closer analog of vocabulary learning, there is in general a facilitative effect of the frequency of the response word (Postman, 1962; Shapiro, 1969; Paivio, 1971, pp. 262–266), a result which suggests that higher frequency responses are more available. The effects of stimulus frequency are more variable and may even be negative (Paivio, 1971).

WORD MEANINGFULNESS

In PAL experiments, speed of learning varies directly with the meaningfulness of both the stimulus and the response word, but this relationship is considerably more pronounced for the response word (Underwood & Schulz, 1960; Postman, 1962). The major determinant of success in PAL is the degree to which the stimulus and response words are strongly yet uniquely associated. When both stimulus and response are more meaningful, there is a greater chance of forging associations between them. However, the PAL of FL vocabulary is rather different in that the subject is essentially learning a nonsense sound—word association and thus extrapolation from these findings is questionable.

ORTHOGRAPHIC FACTORS

ORTHOGRAPHIC REGULARITY AND DIFFERENT ALPHABETS

A native speaker of a language using the Roman alphabet transfers more easily to another of the same script than to one that uses different orthographic units or frames such as the Cyrillic alphabet or the logographs of Kanji (Carroll & Sapon, 1955). Similarly transfer is easier if both scripts contain frames that move in the same way (e.g., in rows from left to right vs. the reverse, or vertically in columns. See Desrochers & Begg, 1987; Nation, 1987).

SEQUENTIAL LETTER PROBABILITIES

The argument concerning orthographic regularity parallels that of phonotactic regularity: Different languages have different sequential letter probabilities; for example, *ll* is common at the beginning of a Welsh word but never introduces an English word. Thus, the learning of the orthography of FL words may be determined by the degree to which the sequential letter probabilities match those of the native language. The same holds at the individual word level: The degree to which a particular FL word accords with the orthographic patterns of the native language may affect its ease of learning.

WORD LENGTH

The longer the FL word, the more to be remembered, the more scope for phonotactic and orthographic variation and thus the more room for error. This is also likely to be confounded and reinforced by frequency because Zipf's law (1935) holds that more frequent words evolve a shorter form.

FAMILIARITY OF GRAPHEME TO PHONEME MAPPINGS

FOR READING

In studies of the repetition and learning of nonwords, experimenters and participants alike assume that the spelling-sound correspondences operate just as in the L1. Unfortunately, different languages do not work in the same way in this respect. The L2 student has to learn how FL orthography maps onto FL pronunciation.

Scripts based on alphabetic writing systems reflect to a lesser (e.g., English) or greater (e.g., Korean, Serbo-Croatian, Welsh) degree the pronunciation of language units. There are rules of correspondence between graphemes and phonemes (e.g., see Venezky, 1970, for the English "rules"). If the FL is regular in this respect, then it is easier to learn to read. An English learner of Maori can read sentences in Maori aloud, without understanding them, after only a few minutes study because Maori uses the same letters as English and the relationship between spelling to sound is very regular (Nation, 1987). Yet these rules of correspondence can differ markedly between languages sharing the same script (*pace* the naïve English learner of Welsh who continues to pronounce *f* as /f/ rather than /v/. There are further difficulties of a different type if the script is logographic (e.g., Kanji) and contains no such cues for assembling phonology from script. It may be predicted for language and word levels that (a) the less the overlap between the grapheme-phoneme correspondence rules of the native and the foreign language, the harder it will be for the FL learner to learn to read or write that language; and (b) the less the overlap between the grapheme-phoneme correspondence rules for the graphemes of the native and the foreign word, the harder it will be for the FL learner to learn to read or write that word.

FOR SPELLING

Phoneme-grapheme correspondence rules are not invariably the simple reverse of grapheme-phoneme correspondences. For example, in English the phoneme /O/ is only rarely (p=.15) spelled *au* (as in *auction*), yet the graphemic option *au* is almost always (p=0.95) pronounced /O/ (Berndt, Reggia, & Mitchum, 1987). Yet the learner must acquire these correspondences to spell an alphabetic FL using a phonological strategy.

SIMILARITY OF FL AND NATIVE WORDS

Sometimes FL words just remind us of the native word, a factor that usually stems from the languages' common origins or from language borrowing. Thus the German *Hund* (dog) may be more easily retained than the French *chien* because of its etymological and sound similarity with the English *hound* (Nation, 1982). Such reminding, whether based on orthography, phonology, etymology, or "borrowing" (e.g., *le hot-dog*) typically facilitates the learning of that FL word (Anderson & Jordan, 1928) and students who are instructed to look for such inter- and intralingual mnemonic associations generally retain new words with greater efficacy (Cohen & Aphek, 1980). There can, of course, be interference when such reminding is inappropriate (For example, the Englishman mentally groping for a French hug might be happily surprised to get more than he bargained for if he lunged at *embrasser*.)

USING KEYWORD MEDIATION

Atkinson and Raugh (1975) reported an experiment in which they compared learning of FL vocabulary by means of mnemonics with a control condition in which participants used their own strategies. In the experimental condition, participants were presented with a Russian word and its English translation together with a word or phrase in English that sounded like the Russian word. For example, the Russian word for battleship is *linkór*. American students were asked to use the word *Lincoln*, called the keyword, to help them remember this. Atkinson and Raugh found that people who had used the keyword method learned substantially more English translations of Russian words than did the control group and that this advantage was maintained up to six weeks later.

Numerous subsequent studies have confirmed the effectiveness of the keyword method in FL and native language vocabulary learning (see Paivio & Desrochers, 1981; Pressley, Levin, & Delaney, 1982; Levin & Pressley, 1985; Cohen, 1987; Desrochers & Begg, 1987 for reviews). It has been shown that keyword mnemonic techniques are more effective than are other direct methods such as rote rehearsal or placing vocabulary in the context of a meaningful sentence (Pressley et al., 1982; Nation, 1982). Sternberg (1987) states "for learning specific vocabulary, the keyword method of vocabulary teaching and learning is faster and more efficient than learning from context. . . . As far as I can tell, it may be the most effective of the currently available methods" (pp. 94–95).

The common explanation for the success of these systems is that the keyword enables people to combine in a single associative image the referent of one native word with that of a second native word that sounds like the foreign word, that is, the meanings of the native word and the keyword are integrated in one image. There are two stages in recall using keywords. The first stage of recalling the meaning of a foreign word involves remembering the native keyword that sounds like the foreign word. The second stage involves accessing an interactive image containing the referent of the keyword and "seeing" the object with which it is associated. By naming this object the learner accesses the native translation.

The involvement of keyword mediators introduces a number of additional potential psycholinguistic determinants of success:

1. *Reminding power of foreign word for keyword.* The first of Raugh and Atkinson's (1975) criteria for a good keyword is that it "sounds as much as possible like a part (not necessarily all) of the foreign word" (p. 2). Whereas it may be relatively easy to find English keywords that sound like some foreign words (e.g., for the German words *Blech, Böttcher, Decke, Flitter*), others are considerably more problematical (e.g., the German nouns *Abhilfe, Bleiarbeiter, Durchschlag,* and *Geschluchze*). (See Desrochers & Begg, 1987). Raugh and Atkinson demonstrate a correlation of .53 between the probability of a keyword being remembered given a Russian word and the probability of the English translation being remembered by different subjects using the same keyword as a mnemonic.
2. *Reminding power of keyword for foreign word.* Raugh and Atkinson's (1975) criterion applies here, too, but with even more importance because the keyword has to cue the pronunciation of the foreign word. So it has to sound as close as possible to the foreign word. Word recall is likely to be best if the keyword or part of it overlaps with the initial part or cluster of the foreign word to be recalled (Horowitz, Chilian, & Dunnigan, 1969; Loess & Brown, 1969; Desrochers & Begg, 1987). But it remains to be determined whether the best overlap is in terms of pronunciation or orthography or both.
3. *Imageability of keyword.* Raugh and Atkinson's (1975) second criterion is that "it is easy to form a memorable imagery link connecting the keyword and the English translation" (p. 2). Thus "concrete nouns may be good as keywords because they are generally easy to image; abstract nouns for which symbolic imagery comes readily to mind also may be effective keywords" (p. 2).

4. *Imageability of mediational sentence.* Atkinson and Raugh (1975) reported that the probability of remembering the image-based link between keyword and native word in one set of subjects correlated .49 with the relative recall of the native words (given the foreign word) by other students learning FL vocabulary under keyword instructions.

The range of these possible psycholinguistic factors is summarized in Figure 1 for learning both without (Figure 1a) and with (Figure 1b) keyword mediators. Although many of these variables have been studied individually, their interrelationships remain to be determined. Furthermore, it is quite possible that each will make a different contribution depending on the learning strategy

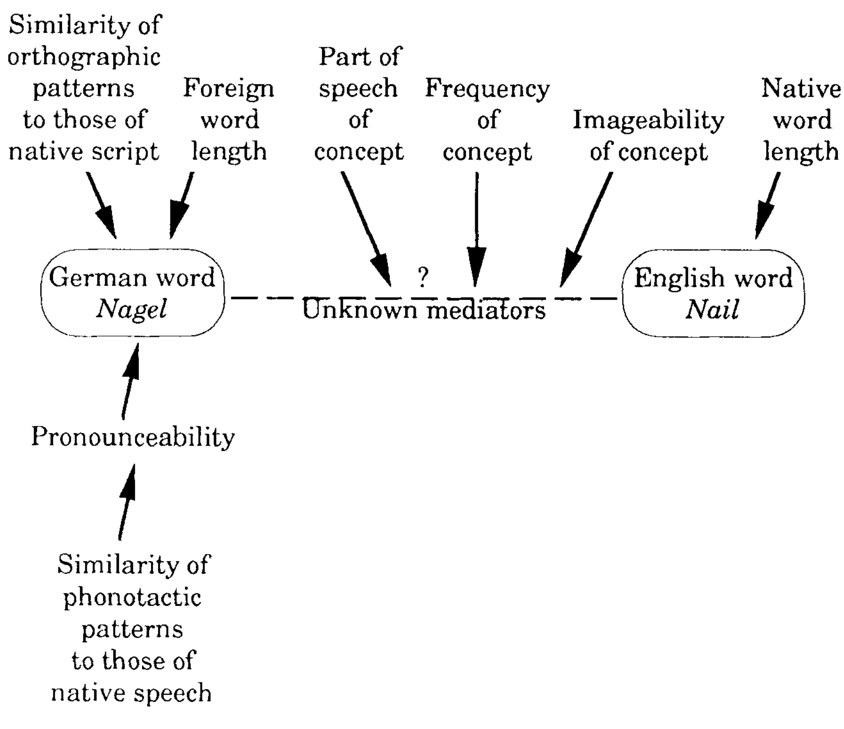

Figure 1a. Potential determinants of learnability of foreign language vocabulary without keyword mediation.

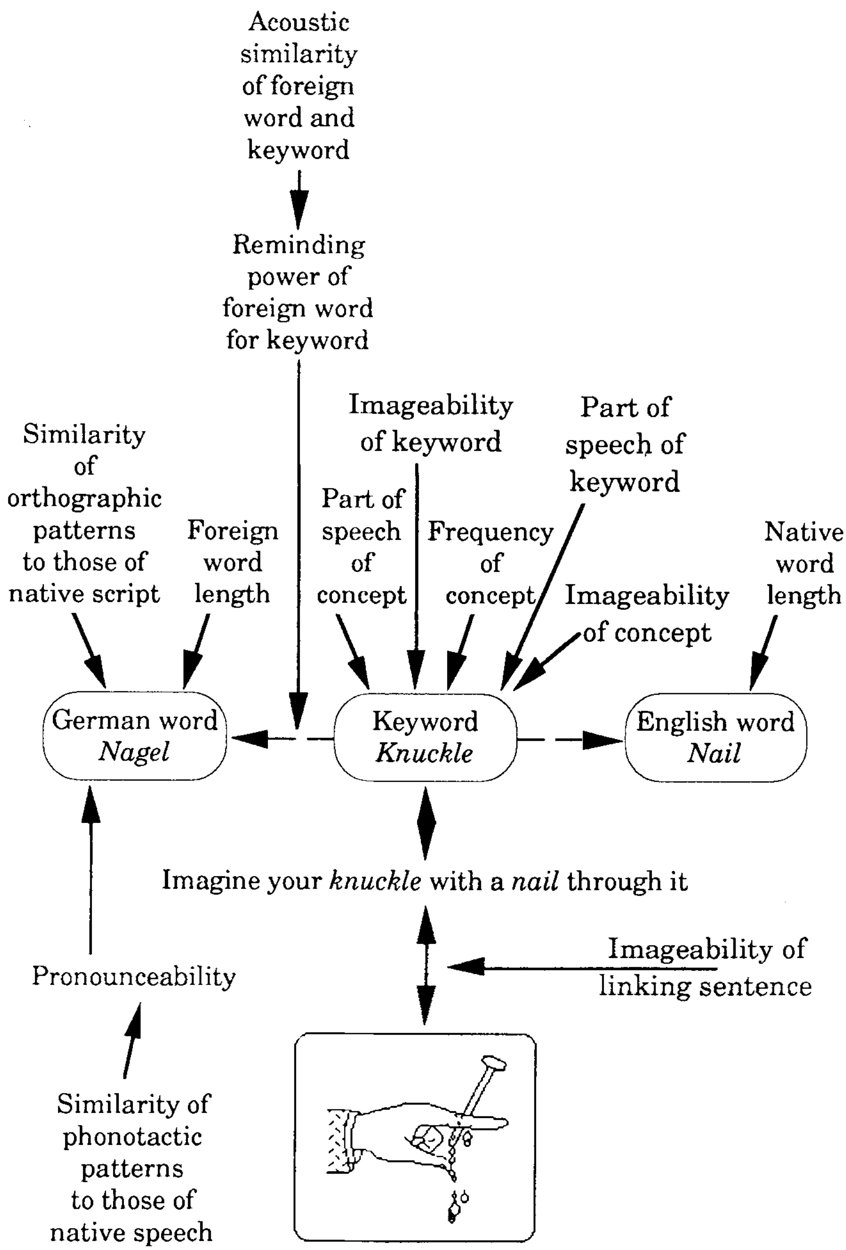

Figure 1b. Potential determinants of learnability of foreign language vocabulary with keyword mediation.

that students adopt—for example, repetition learners versus keyword learners.

The study reported below thus *concurrently* assessed the following effects and therefore *their interactions* on the "learnability" (Higa, 1965) of FL vocabulary:

1. Phonological content of the foreign word and the degree to which its phonotactic sequence accords with those found in the native language;
2. word class;
3. imageability of the concept;
4. foreign and native word lengths; and
5. orthographic content of the foreign word and the degree to which its phonotactic sequence accords with those found in the native language.

It further investigated whether, when subjects are instructed to use keyword mediation, the following factors play a determining role on FL learnability:

6. whether the keyword is a noun or a verb;
7. the imageability of the keyword;
8. the imageability of the whole mediational sentence;
9. the spoken overlap between the keyword and the foreign word;
10. the orthographic overlap between the keyword and the foreign word; and
11. the degree to which the keyword reminds people of the foreign word.

METHODS

VOCABULARY LEARNABILITY

PARTICIPANTS

Forty-seven L1 English-speaking undergraduates of psychology (13 males and 34 females) participated in this study. They were naïve as to the theoretical background to the research and spoke no German. The mean age was 24.2 (*SD* 6.2) years.

APPARATUS AND PROCEDURE

All testing was done individually by means of a Macintosh computer programmed in Hypercard.

In German Vocabulary Learning Stage I, students were randomly allocated to one of four groups that had had the same exposure to German vocabulary but under different instructions. Two of the groups had to use the keyword method, two did not. Of the two groups using the keyword method, one was provided with a keyword that was a noun, the other was given the keyword as a verb, in a sentence devised by the experimenters. The groups were instructed as follows:

Own Strategy Group. "Please now do your best to learn the German translation of the following English words."

Repetition Group. "In order to learn the English-German pairs of words please repeat aloud each pair of words continuously until presentation of the subsequent pair of words. Please now do your best to learn the German translation of the following English words."

Noun Keyword and Verb Keyword Groups (The Imagery groups). "To help you learn the words, the computer will display for each German word an instruction to IMAGINE a specific scene that links the sound of the English and German words together in some way. You must try to produce in your mind's eye as vivid an image as possible of the scene. You may find it helpful to close your eyes while you think about it, but remember to study the German word properly first, and to open your eyes in good time for the next word-pair. The linking of the sounds may only be approximate, but you will find that the process of imagining a visual scene will help you to recall the words subsequently. Please now do your best to learn the German translations of the following English words."

The computer randomly assigned subjects to groups. This resulted in there being 10 students in the Own Strategy group, 10 in Repetition, and 8 and 19, respectively (a late-discovered bug in the "random" number seed) in the Noun and Verb Keyword Groups.

The German words used in this experiment are shown in Table 1, along with their English translations and the noun and verb keywords for these respective conditions.

In the vocabulary learning session, the students were introduced to the procedure with 12 practice words (not used in the experiment itself) whose order of presentation was randomized for each participant.

The procedure for each learning trial was: The English word was presented in a box at the left-hand top of the screen with the German translation accompanying at the right-hand top. As the stimuli were presented the German word was spoken. The speech in this experiment was recorded by a native female German speaker and digitized for later use using MacRecorder. If the students were in either of the two imagery conditions, the appropriate imagery mediation sentence was presented in a field underneath the two stimuli. After 7 seconds the German word was spoken again. The trial finished after 10 seconds when the screen cleared for one second before the next trial.

After a block of 12 learning trials, the student was tested on the material just presented. The first test block was German to English. The 12 German words were reordered randomly and for each test trial the German word appeared at the top left of the screen, it was spoken at the same time, and the subject was invited to type in the English translation. After the 12 German-to-English test trials the identical procedure was repeated in the reverse direction (i.e., from English to German) with the exception that the English word was not spoken.

On completion of the practice phase of the experiment (12 trials learning, 12 trials German-to-English test, 12 trials English-to-German test) the students entered the main vocabulary learning phase. Here they carried out this procedure three times for the 12 word-pairs of Block A; they then did the same for Blocks B and C in turn. (See Table 1.)

The students completed a second experimental session (German Vocabulary Learning Stage II) approximately one month (M=31.4 days, SD=4.5) after the first session. The students were tested for recall of the 12 practice pairs with the same testing procedure used in Stage I—first they gave the English translations for the 12 German words presented in random order, and then the German translations when presented with the English words.

Once the students had been tested for their long-term retention of the translations in both directions for the 12 practice pairs, they completed one set of trials relearning the practice words under the same instructions and condition as in German Vocabulary Learning Stage I. Subsequently a German-to-English test was carried out, followed by an English-to-German test as in Stage I.

This procedure was then repeated for Blocks A, B and C.

The recall scores for each word were pooled over all testing sessions and expressed as percentage correct for each condition. It is these scores that constitute the FL learning and recall data to be analyzed across words in the present study.

PSYCHOLINGUISTIC DETERMINANTS

The above procedures demonstrated that the receptive vocabulary most easy and most difficult to learn were, respectively, *Friseur-hairdresser* and *Zahlen-pay*. The easiest productive (native to foreign) pair was *trousers-Hose* and the hardest was *to rent-Mieten*. To determine the psycholinguistic factors that determined these relative difficulties, the following additional variables were measured:

PHONOTACTIC REGULARITY OF FOREIGN WORD

Accuracy in saying and learning a foreign word may be affected by the degree to which its pronunciation follows the sound patterns of the native language, that is, whether its component phonemes are common in the native language and whether they follow typical sequential orderings. There is a need for an exhaustive corpus of position-sensitive transitional frequencies of

Table 1
The Stimulus Material Used in This Experiment

GW	EW	Noun Keyword Sentence
Block A		
Sperre	barrier	Imagine a *sparrow* on a station *barrier*
Hose	trousers	Imagine *trousers* wrapped round a garden *hose*
Nehmen	to take	Imagine you *take* a *name in* your address book
Haben	to have	Imagine *harbours have* many ships
Ecke	corner	Imagine an *echo* in a *corner*
Dohle	jackdaw	Imagine a *jackdaw* with a *dollar* in its beak
Kaufen	to buy	Imagine you *buy* a *coffin*
Fliegen	to fly	Imagine *fleas fly* quickly
Leiter	ladder	Imagine a *lighter* at the foot of a *ladder*
Friseur	hairdresser	Imagine your *hairdresser* inside a *freezer*
Stellen	to put	Imagine you *put steel* girders in your house
Brauchen	to need	Imagine *brokers need* much experience
Block B		
Teller	plate	Imagine a fortune-*teller* with a pile of silver *plates*
Küche	kitchen	Imagine your *kitchen* and a *cook* in it
Mieten	to rent	Imagine you *rent meat* to friends in your room
Zahlen	to pay	Imagine *sailors pay* for hot rum
Klippe	cliff	Imagine nail-*clippers* on a *cliff*
Fahne	flag	Imagine a *flag* on a *fan*
Rufen	to call	Imagine you *call* a friend to put a new *roof* on a cottage
Graben	to dig	Imagine *crabs dig* holes in the sand
Schere	scissors	Imagine *shears* besides a pair of *scissors*
Rasen	lawn	Imagine your *lawn* covered in *raisins*
Stossen	to push	Imagine you *push stores* in a cupboard
Streichen	to paint	Imagine *strikers paint* slogans on walls

GW=German Word; EW=English Word; PoS=Part of Speech of Word to be Learned; O=Order of Words in Mediation Sentence

Verb Keyword Sentence	PoS	O
Imagine you *spare* a penny at a station *barrier*	N	GE
Imagine dirty *trousers* and *hose* them down	N	EG
Imagine you *take* and *name* a puppy	V	EG
Imagine you *harbour* criminals and *have* doubts about it	V	GE
Imagine you *echo* the sentiments of the person in the *corner*	N	GE
Imagine a *jackdaw* and *dole* out some bread to it	N	EG
Imagine you *buy* sweets and *cough*	V	EG
Imagine you *flee* quickly and *fly* away	V	GE
Imagine you *light* a fire at the foot of a *ladder*	N	GE
Imagine your *hairdresser* and *freeze her*	N	EG
Imagine you *put* one book down and *steal* another	V	EG
Imagine you *broke* a pen and *need* it	V	GE
Imagine you *tell a* story about silver *plates*	N	GE
Imagine your *kitchen* and *cook* a meal there	N	EG
Imagine you *rent* a room and *meet* friends in it	V	EG
Imagine you *sail* and *pay* for hot rum	V	GE
Imagine you *clip* a rope to a *cliff*	N	GE
Imagine *a flag* and *fan* yourself with it	N	EG
Imagine you *call* a friend and *roof* your cottage	V	EG
Imagine you *grab* a spade and *dig* with it	V	GE
Imagine you *shear* off some hair with a pair of *scissors*	N	GE
Imagine your *lawn* and *raise* its level	N	EG
Imagine you *push* and *store* things in a cupboard	V	EG
Imagine you *strike* out old graffiti and *paint* new slogans	V	GE

Table 1 (continued)
The Stimulus Material Used in This Experiment

GW	EW	Noun Keyword Sentence
Block C		
Schalter	counter	Imagine a sea-side *shelter* with a candy-floss *counter*
Flasche	bottle	Imagine a *bottle* in a *flash* of lightning
Streiten	to quarrel	Imagine you *quarrel* about the Menai *straits*
Laufen	to run	Imagine bread *loaves run* down the street
Brücke	bridge	Imagine a small *brook* under a hump-backed *bridge*
Messer	knife	Imagine a *knife* in a *mess* of gravy
Treten	to step	Imagine you *step* on a stair *tread*
Tragen	to carry	Imagine *dragons carry* fire hoses
Nagel	nail	Imagine your *knuckle* with a *nail* through it
Birne	pear	Imagine a *pear* on a gas *burner*
Sagen	to tell	Imagine you *tell* someone *sago* is good for them
Reissen	to tear	Imagine *rice tears* a hole in a paper bag

GW=German Word; EW=English Word; PoS=Part of Speech of Word to be Learned; O=Order of Words in Mediation Sentence

phonemes in spoken English. Given the lack of same we made do with the tables produced by Hultzén, Allen, and Miron (1964) from a small running text of 20,000 phonemes (roughly one page each from 11 different plays contained in a collection of drama for young people) delivered in "normal, modern, standard-colloquial American English" (Hultzén et al., 1964, p. 5). These tables give first- to fourth-order sequences and frequencies of phonemes. We had a phonetician transcribe the German words as spoken in these experiments and then calculated the summed biphoneme frequencies for each word (irrespective of position). Thus, for example, the word *Birne* (biːrnə) has the frequencies: #b=197+bi=33+ir=7+rn=14+nə=25+ə#=325—>total=601. Because these totals are heavily influenced by word-length, the final measure of phonotactic regularity adopted was the average biphoneme frequency; thus for biːrnə the phonotactic regularity score was 601⁄6=105.7. If a

Verb Keyword Sentence	PoS	O
Imagine you *shelter* under a candy-floss *counter*	N	GE
Imagine a *bottle* and *flash* a light onto it	N	EG
Imagine you *quarrel* and *straighten* your tie	V	EG
Imagine you *loaf* about and then *run* off	V	GE
Imagine you *brook* no disagreement over the building of a hump-backed *bridge*	N	GE
Imagine a *knife* and *mess* it with gravy	N	EG
Imagine you *step* quietly as you *tread* on the stair	V	EG
Imagine you *drag* and *carry* fire-hoses	V	GE
Imagine you *knuckle* down to fixing a *nail*	N	GE
Imagine a *pear* and *burn* it	N	EG
Imagine you *tell* someone to *say go* when you are ready	V	EG
Imagine you *rise* up and *tear* a paper bag in half	V	GE

phoneme does not appear in American English, for example the /ç/ in *Küche*, the word was given a proportionately low regularity score with zero for both biphoneme combinations, /yç/ and /çə/. Of course these measures are mere approximations as they depend on the pronunciation of the speakers both in this experiment and in Hultzén et al. (1964), the ear and categorization pattern of the various transcribers, coarticulation effects, speech sampling, and so forth. However noisy a measure, in general the higher the resultant score, the more the pronunciation of the foreign word conforms to frequent sequential phoneme combinations in English.

PRONOUNCEABLENESS OF THE FOREIGN WORD

To check the pronounceableness of the German words, we had

7 English undergraduates (4 males and 3 females, age range 18–27 years), who had never learned any German, attempt to pronounce them after a single hearing. The German vocabulary, spoken as in the vocabulary learning experiments, was presented in a random order under Hypercard control. At the initiation of each trial, a word was spoken and the subject repeated this 10 times as quickly as possible. A German speaker listened to each repetition and judged it correct or incorrect, entering 1 or 0 into the computer. The final input stopped a clock. Thus, for each subject there was a score out of 10 for each word's correct repetition and a time (in 60ths of a second) for 10 repetitions.

The average accuracy score was 6.84 (*SD* 2.47) with high accuracy for *Leiter*, *Stossen*, *Streichen*, *Messer*, *Stellen*, and low accuracy for *Nehmen*, *Zahlen*, *Rufen*, and *Rasen*. The reliability was acceptable with a Cronbach's alpha across subjects of 0.71. The average time taken to say each word 10 times was 6.32 (*SD* 0.36) seconds. Pronunciation time varied as a function of written word length ($\rho=0.46$, $p<.01$). Cronbach's alpha across the 7 students was 0.83. There was the expected inverse relationship between pronunciation speed and accuracy ($\rho=-0.37$, $p<.05$).

PART OF SPEECH OF CONCEPT

The part of speech of the word to-be-learned was classified as a binary variable with 0 for verbs and 1 for nouns.

CONCEPT IMAGEABILITY

The imageability of the concept was assessed using the procedure of Paivio, Yuille, and Madigan (1968) (whose norms themselves only address nouns and so fail to suffice for present purposes). Twenty-three first-year psychology students (5 males and 18 females, M=27.3 years, SD=9.6 years) rated the 36 English words for imageability on a 7-point scale. The full instructions are available from the authors. In summary these were: "Any word which, in your estimation, arouses a mental image (i.e., a mental picture or sound, or other sensory experience) very quickly and easily should be given a high imagery rating; any word that arouses a mental image with difficulty or not at all should be given a low imagery rating. Think of the nouns *apple* or *fact* and the verbs *to run* or *to know*. *Apple* or *to run* would probably arouse an image relatively easily and would be rated as high imagery; *fact* or *to know* would probably do so with difficulty and would be rated as low imagery. Your ratings will be made on a 7-point scale, on which 1 is the low imagery end of the scale and 7 is the high imagery end of the scale." The interrater reliability of this procedure was high (Cronbach's alpha across raters was 0.98). Unfortunately, only five of these words appeared in the Paivio et al. (1968) norms and, thus, it was impossible to triangulate to assess concurrent validity. The mean imageability ratings across subjects for each word were then used in later analyses. These ranged from 2.09 (*to need*) to 6.91 (*scissors*) (M=5.23, SD=1.52).

CONCEPT FREQUENCY

The best available index of concept frequency is word frequency in the native language. The Francis & Kucera (1982) norms that count the number of written occurrences in roughly the million words of the Brown Corpus were used to measure this factor. This has the advantage over other corpora in that it tags words for their syntactic class, thus distinguishing between different parts of speech or meanings of polysemous words or homonyms (cf. Thorndike & Lorge, 1944, analyses in which the count for *tear* includes its use as a verb and as nouns reflecting either sartorial or emotional raggedness). It should be noted, however, that the Brown Corpus reflects American rather than Northern-Welsh English usage, and thus this operationalization, although the best available, is only an approximation to our target of concept frequency. The frequency counts for our words ranged from 1 (*jackdaw*) to 12,458 (*to have*) and were heavily positively skewed. We therefore used log(10) of the Corpus frequencies in the analyses.

ORTHOGRAPHY

Accuracy in writing the foreign word may be affected by the degree to which the orthography of the foreign word follows the spelling patterns of the native language.

The positional bigram counts of Solso and Juel (1980) were used to assess the English orthographic regularity of the German words. Positional bigram counts provide a more accurate estimate of word orthography than do single letter positional counts as they reflect multiple letter-connecting regularities—the true frequencies of bigrams by position are preserved. For example, the sum of bigram frequencies (SOBIF) of the regular word *mother* is high (*mo*=1,721, *ot*=895, *th*=1,797, *he*=1,811, *er*=7,527; SOBIF=13,751), that of the irregular word *avoid* is low (*av*=65, *vo*=81, *oi*=81, *id*=345; SOBIF=1,248). Applying these procedures to the German words we discover, for example, that, even ignoring the dieresis, *Küche* has the lowest SOBIF at 99, whereas *Leiter* has the highest at 14,013. The SOBIF score thus assesses the conformity of the German words to regular English orthographic sequential dependencies, but it is affected by word length (Spearman's ρ=0.27 in our sample); the longer the word, the higher the SOBIF. We therefore computed two other indices of English sequential orthographic regularity. The first, AVBIF, is the word's SOBIF divided by its length in letters. The other, MINBIF, is the smallest bigram frequency of the bigrams constituting the word. MINBIF is thus particularly sensitive to words with very uncommon spelling patterns that might cause the learner considerable difficulty, for example, the *ck* in Positions 2 and 3 of *ecke* occurs in no English four-letter word counted in Solso and Juel (1980); similarly the *hm* in *nehmen* is a very unusual spelling by English standards; in contrast *rasen* is spelled thoroughly in accord with English spelling patterns with positional BIFs all in excess of 500.

The measures AVBIF and MINBIF were both used as indices of English sequential orthographic regularity in the statistical analyses.

WORD LENGTH OF FOREIGN AND ENGLISH WORDS

These were simple letter counts.

SIMILARITY OF FOREIGN WORD AND KEYWORD

Orthographic. Three different measures of orthographic similarity were computed and then summed as a total score. The first was the number of letters that the German word and keyword have in common until the first mismatch, expressed as a proportion of the German word length (e.g., the keyword *sparrow* for *sperre* scores 2 for *sp*—a 0.33 overlap). The second was total letter overlap regardless of position (*sparrow* and *sperre* share *s*, *p*, *r*, *r*—a 0.66 overlap). The third was absolute positional letter overlap (again in this case *s*,*p*, *r*, *r*=0.66). The first measure heavily reflects the degree of overlap of the initial segments of the words, which Desrochers and Begg (1987) hold to be important. The others reflect any letter overlap that might serve as a reminding cue. The final orthographic similarity measure is the simple sum of these three aspects and ranges from 0.33 (Verb keyword *cough* for *Kaufen*) to 3.00 (keyword *hose* for *Hose*).

Acoustic. This was similarly assessed by having a linguist phonetically transcribe the German words as they were spoken in the experiment, and the associated Noun and Verb keywords. The same three overlap measures (initial, total, and absolute overlap) were computed for these phonemic transcriptions, expressed as a proportion of German word-length, and summed to give a total score. These ranged from 0.2 (the keyword *sago* [seigo] for *sagen* [zagən]) to 3.0 (the Verb keyword *clip a* [klipə] for *Klippe* [klipɔ]).

REMINDING POWER OF FOREIGN WORD FOR KEYWORD

The experimental procedure for determining reminding power was heavily influenced by that used by Atkinson and Raugh (1975, p. 132). We tested only the unidirectional association from foreign word to keyword.

A Macintosh computer was programmed in Hypercard to say each German word as it was spoken in the learning experiments and to show the associated keyword at the same time. Each trial consisted of the keyword being presented midscreen. The German word was spoken at keyword onset and repeated 3 and 6 seconds later. The screen went blank after 9 seconds and there was a 1-second intertrial interval. The training trial sequence comprised 6 practice items from Table 1, followed by the 36 test items in randomized order, finishing with 6 more filler items to remove recency effects. The test trials followed the same trial order. Each trial comprised the computer saying the German word at the same time as the trial number appeared on the screen; the word was repeated after 3 seconds, and the screen went blank after another 5 seconds. There was a 1-second intertrial interval. These experimental sequences were recorded onto video for use in the two experimental sessions proper. In the first of these, 30 first-year psychology students (9 males and 21 females, M=24.7 years, SD=9.1 years) learned the Noun keywords. In the second, 33 different first-year psychology students (5 males and 28 females, M=24.1 years, SD=7.5 years) learned the Verb keywords. The procedure was the same on both occasions. The students were instructed that they were to observe the video-monitors and that they were to try to learn the English (Key)word that went with each German word. They then attended to the training trials.

After a 2-minute retention interval, filled with the havoc of the students talking to their neighbors, the test trials were presented and the subjects wrote down the (Key)word for each trial on a numbered answer sheet. These were later scored for correctness and the reminding power of each German word for its keyword calculated as the probability of the latter's correct recall over the group of subjects. The worst keyword in this respect was *sailors* for *Zahlen* (reminding probability=0.03), the best was *flash* for *Flasche* (1.0). The mean for the Noun keywords was 0.55 (0.27), that for the Verb keywords was 0.50 (0.27); this difference is not significant, $t(35)=1.53$, *ns*). The correlation between Verb and Noun keyword-reminding powers was significant ($\rho=0.67, p<.001$) demonstrating that, to a large degree, it is equally easy (or difficult) to find a useful keyword for a German word whether that keyword be a noun or a verb.

KEYWORD IMAGEABILITY

The same procedure and instructions were used to assess the imageability of the keywords. The 36 Noun keywords from the Noun Keyword Condition were combined with the 36 Verb keywords from the Verb Keyword Condition (in their infinitive form) and these were then randomly ordered. Twenty different first-year psychology students (3 males and 17 females, M=25.8 years, SD=8.6 years) rated these keywords for imageability on a 7-point scale. The interrater reliability was again high (Cronbach's alpha across raters was 0.94). The mean imageability ratings across subjects for each keyword were then used in later analyses. The most imageable keyword was *coffin* (6.95) and the least was *to broke* (1.6). The Noun keywords (M=5.79) were as a group more imageable than were the Verb keywords (M=4.55), $F(1,70)=20.72$, $p<.001$.

MEDIATING SENTENCE IMAGEABILITY

High imageability of both keyword and English word does not guarantee a highly imageable mediating sentence—these can still be integrated to a lesser or greater degree (see, e.g., Bower, 1970; Bower & Winzenz, 1970; Winograd & Lynn, 1979). A similar procedure to that described above was therefore used to separately assess the imageability of the mediating sentences. The 36 mediators from the Noun Keyword Condition were randomly mixed with those from the Verb Keyword Condition and 20 different first-year psychology students (4 males and 16 females, M=19.7 years, SD=2.5 years) rated these *sentences* for imageability on a 7-point scale. The instructions emphasized that it was the sentences as a whole that were to be assessed: "Any phrase which, in your estimation, arouses a mental image (i.e., a mental picture or sound, or other sensory experience) very quickly and easily should be given a high imagery rating; any phrase that arouses a mental image with difficulty or not at all should be given a low imagery rating. Think of the phrases "The dog chased the cat" or "The fact was known". "The dog chased the cat" would probably arouse an image relatively easily and would be rated as high imagery; "The fact was known" would probably do so with difficulty and would be rated as low imagery." The interrater reliability was lower than when keywords in isolation were rated but was still acceptable (Cronbach's alpha across raters was 0.88). The mean imageability ratings across subjects for each mediating sentence were then used in later analyses. The most imageable mediating sentence was "Imagine HARBOURS HAVE many ships" (6.45), the least imageable was "Imagine BROKERS NEED much experience" (1.95). There was no significant difference between the imageability of the mediating sentences constructed from Noun or Verb keywords—the mean imageability was 4.6 in both cases, $F(1,70)<1$.

RESULTS

CORRELATIONAL ANALYSES

The Pearson correlations between the psycholinguistic variables are shown in Table 2.

There is a negative correlation between native word frequency and native word length (r=–0.61), confirming Zipf's law, and the longer items also tend to be nouns (r=0.61) and more imageable (r=0.43). The longer the foreign word, the longer it takes to pronounce (r=0.52) and the greater its chance of not conforming to the phonotactic (r=–0.44) and orthographic (r=–0.30) patterns of the native language. In this sample of words, the nouns that were learned better than the verbs tend to be less frequent (r=–0.62), and the more frequent items tend to be less imageable (r=–0.59); thus any positive effects of word class or imageability cannot be a confound of word frequency. The nouns are much more imageable than are the verbs (r=0.80). The two measures (bigram frequency) of orthographic sequential regularity intercorrelate (r=0.54) and orthographic sequential regularity is associated with phonotactic regularity (r=0.63 and r=0.38) and both pronunciation accuracy (r=0.39) and time (r=–0.28). Phonotactic regularity (controlled for word length) determines pronunciation time (r=–0.55).

The patterns of intercorrelation within the Noun and Verb keyword conditions are similar, with spoken overlap between the foreign word and keyword predicting reminding power (r=0.66 and r=0.62) much more than did orthographic overlap (r=0.31 and r=0.25). When the data for both Noun and Verb keywords are analyzed together, reminding power correlates 0.64 (p<.001) with spoken overlap and 0.29 (p<.01) with orthographic overlap. The standardized multiple regression equation predicting reminding power from these two variables results in a beta of 0.60 (p<.001) for spoken overlap and 0.14 (*ns*) for orthographic overlap, suggesting that the degree to which the keyword sounds like the foreign word is much more important than the degree to which they are spelled similarly.

Within each condition, the more imageable the keyword, the more imageable the mediating sentence that associates the foreign word and the keyword (r=0.39 for the nouns and 0.36 for the verbs) even though these ratings for keywords and sentences were performed by different groups of judges. In the experiment measuring imageability of the mediating sentence, the keyword and native word appeared equally often early or late in the mediational sentence. When we pooled the data for Noun and Verb keywords, a standardized multiple regression analysis predicting mediation sentence imageability from the imageability of the keyword and the native word resulted in betas of 0.28 (p=0.02) for the keyword and 0.21 (p=0.07) for the native word (R^2=12%)—there is, unsurprisingly, little to choose between them. What *is* important is that, as far as is possible, *both* the native word and the keyword are imageable—if a compound imageability score is calculated as the multiple of the imageabilities of the keyword and

Table 2A

Pearson Correlations Between the Psycholinguistic Variables: Native and Foreign Word Factors

						GermanWord				
								Pronunciation		Phono
	EW Length	GW Length	EW Freq	PoS[a]	CI	AVBIF	MINBIF	Acc	Time	Reg
EW: Length	1.00									
GW: Length	0.03	1.00								
EW: Freq	–0.61**	0.02	1.00							
Part of Speech[a]	0.61**	–0.35*	–0.62**	1.00						
CI	0.43**	–0.19	–0.59**	0.80**	1.00					
GW: AVBIF	0.07	–0.09	–0.13	0.15	0.09	1.00				
GW: MINBIF	0.15	–0.30*	–0.20	0.18	0.19	0.54**	1.00			
GW: Pro Acc	0.02	0.14	–0.06	–0.11	–0.01	0.39**	0.14	1.00		
GW: Pro Time	0.30*	0.52**	–0.22	0.09	0.14	–0.28*	–0.01	–0.34*	1.00	
GW: Phono Reg	0.09	–0.44**	–0.01	0.33*	0.18	0.63**	0.38**	0.20	–0.55**	1.00

[a]Part of Speech, Noun=1, Verb=0.

*$p<.05$. **$p<01$, one-tailed.

EW=English Word; GW=German Word; Freq=Frequency; CI=Concept Imageability; AVBIF=Average Bigram Frequency; MINBIF=Minimum Bigram_Frequency; Pro Acc=Pronunciation Accuracy; Pro Time=Pronunciaiton Time; Phono Reg= Phonotactic Regularity

Table 2B

Pearson Correlations Between the Psycholinguistic Variables: Noun Keyword Factors

	NK	NK	NLS	G&NK Overlap	
	Rem Power	Imageability	Imageability	Orthographic	Spoken
NK: Reminding Power	1.00				
NK: Imageability	–0.04	1.00			
NLS: Imageability	0.00	0.39**	1.00		
G&NK: Orthographic Overlap	0.31*	–0.30*	0.05	1.00	
G&NK: Spoken Overlap	0.66**	–0.18	–0.08	0.24	1.00

Table 2C

Pearson Correlations Between the Psycholinguistic Variables: Verb Keyword Factors

	VK	VK	VLS	G&VK Overlap	
	Rem Power	Imageability	Imageability	Orthographic	Spoken
VK: Reminding Power	1.00				
VK: Imageability	–0.14	1.00			
VLS=Imageability	–0.03	0.36*	1.00		
G&VK: Orthographic Overlap	0.25	0.00	0.06	1.00	
G&VK: Spoken Overlap	0.62**	–0.23	–0.11	0.25	1.00

*$p<.05$. **$p<01$, one-tailed.

NK=Noun Keyword; NLS=Noun Linking Sentence; G&NK=German and Noun Keyword; Rem Power=Reminding Power; VK=Verb Keyword; VLS=Verb Linking Sentence; G&VK=German and Verb Keyword native words, this compound predicts the imageability of the mediating sentence with a beta of 0.44 (R^2=19%).

The Pearson correlations between the psycholinguistic variables and word recall in the two directions of translation and four conditions of the experiment are shown in Table 3.

Many of the correlations are significant. There is a strong negative correlation between recall and German word-length in all conditions of productive translation but less so in receptive translation. Nouns are easier to learn than are verbs in all conditions, as are highly imageable items, confirming Ellis and Beaton (in press). Further reassurance in the robustness of these effects is derived from the observation that the strongest correlation between concept imageability and recall (0.53) is found in the Noun Keyword condition in which participants were required to use imagery mediation and effective (imageable) keywords were provided.

The degree to which the foreign word conforms to the phonotactic patterns—and to a lesser degree the orthographic patterns—of the native language, strongly affects translating to the foreign language.

The degree to which the foreign word reminds subjects of the keyword in the present study predicts vocabulary recall in both Noun and Verb keyword conditions of our earlier study (Ellis & Beaton, in press). This is somewhat stronger for receptive than for productive translation, but interpretation of this is qualified by the fact that the measure of reminding power was from the foreign word to the keyword and not the reverse. These associations with reminding power are paralleled by those of orthographic and spoken overlap between the foreign word and the keyword. There are no effects of degree of either keyword imageability or mediating sentence imageability within either the Noun keyword or Verb keyword conditions, but one should note the restricted range of imageability within each of these conditions. Remember, too, that *as a whole* Noun keywords are much more effective (Ellis & Beaton, in press) and that the Noun keywords are significantly more imageable than are the Verb keywords (Methods section, above).

CAUSAL PATH ANALYSES

Some of these predictor variables are intercorrelated, and causal path analysis was therefore performed using LISREL (Jöreskog & Sörbom, 1984; Saris & Stronkhorst, 1984) to summarize the major effects while controlling for spurious relationships attributable to common causes. The data for the Noun and Verb keyword conditions were used making 72 observations in all. Two separate analyses were performed, one for FL learnability from native to foreign language and one for the reverse direction of translation. The paths permitted in the two models were the same, as shown in Figure 2. The exogenous variables were acoustic and orthographic similarities of foreign word and keyword, whether the keyword and native word was a Noun (1) or not (0), and two phonological variables: phonotactic regularity (reflecting the degree to which the foreign word conformed to the native pronunciation patterns) and pronunciation time. The intervening endogenous variables were (a) reminding power of foreign word for keyword and imageability of (b) keyword and (c) native word and (d) mediating sentence. The outcome endogenous variable was learnability. All shown paths were fitted in the models, but only the paths that were significant at least at the 5% level are drawn in solid lines with their accompanying path-weights.[1]

The path-weights in Figure 2 can be interpreted similarly to the betas that result from standardized regression analyses: Thus, for example, the 0.61 path-weight from Acoustic Similarity of Foreign Word and Keyword to Reminding Power of Foreign Word for Keyword implies that for each standard deviation unit increase in the former, one would expect a 0.61 standard deviation unit increase in the latter.

These analyses demonstrate:

1. In learning the foreign vocabulary for native words, the pronounceableness of the foreign word has a strong determining effect (0.37) depending on the degree to which it conforms to the phonotactic patterns of the native language. There is no such effect in the reverse direction.

Table 3

Pearson Product Moment Correlations Between Psycholinguistic Factors and Recall of Vocabulary Under the Different Training Regimes

Condition	Own Strategy		Repetition		Noun Keyword		Verb Keyword	
Direction of Translation	E>G	G>E	E>G	G>E	E>G	G>E	E>G	G>E
English Word – Length	0.26	0.39**	0.21	0.35*	0.21	0.44**	0.42**	0.48**
German Word – Length	–0.70**	–0.34*	–0.63**	–0.29*	–0.63**	–0.11	–0.52**	–0.31*
English Word – Frequency	–0.11	–0.32*	–0.12	–0.24	–0.34*	–0.35*	–0.12	–0.24
Part of Speech (Noun=1, Verb=0)	0.56**	0.52**	0.51**	0.45**	0.64**	0.44**	0.56**	0.53**
Concept Imageability	0.37*	0.50**	0.42**	0.41**	0.53**	0.42**	0.39**	0.41**
German Word – AVBIF	0.16	–0.01	0.21	–0.06	0.39**	0.01	0.04	0.01
German Word – MINBIF	0.30*	0.17	0.31*	0.13	0.45**	–0.02	0.28*	0.16
German Word – Pronun Accuracy	–0.07	0.15	–0.08	0.10	0.03	0.21	0.00	–0.01
German Word – Pronun Time	–0.36*	–0.19	–0.35*	–0.19	–0.40**	–0.09	–0.19	–0.03
German Word – Phono Regularity	0.51**	0.26	0.47**	0.26	0.63**	0.08	0.40**	0.24

Condition	Own Strategy		Repetition		Noun Keyword		Verb Keyword	
Direction of Translation	E>G	G>E	E>G	G>E	E>G	G>E	E>G	G>E
NK — Reminding Power of GW					0.36*	0.61**		
NK — Imageability					0.11	0.21		
NLS — Imageability					0.17	0.25		
G & NK — Orthographic Overlap					0.56**	0.07		
G & NK — Spoken Overlap					0.25	0.30*		
VK — Reminding Power of GW							0.38**	0.41**
VK — Imageability							–0.06	0.00
VLS — Imageability							–0.06	0.01
G & VK — Orthographic Overlap							0.36*	0.12
G & VK — Spoken Overlap							0.31*	0.35*
Mean Recall[a]	0.56	0.66	0.66	0.71	0.52	0.73	0.48	0.63

* $p<.05$. ** $p<.01$. one tailed.
[a]from Ellis and Beaton (in press).
E=English; G=German; AVBIF=Average Bigram Frequency; MINBIF=Minimum Bigram Frequency; Pronun Accuracy=Pronunication Accuracy; Pronun Time=Pronunciation Time; Phono Regularity=Phonotactic Regularity; NK=Noun Keyword; NLS=Noun Linking Sentence; GW=German Word; VK=Verb Keyword; VLS=Verb Linking Sentence.

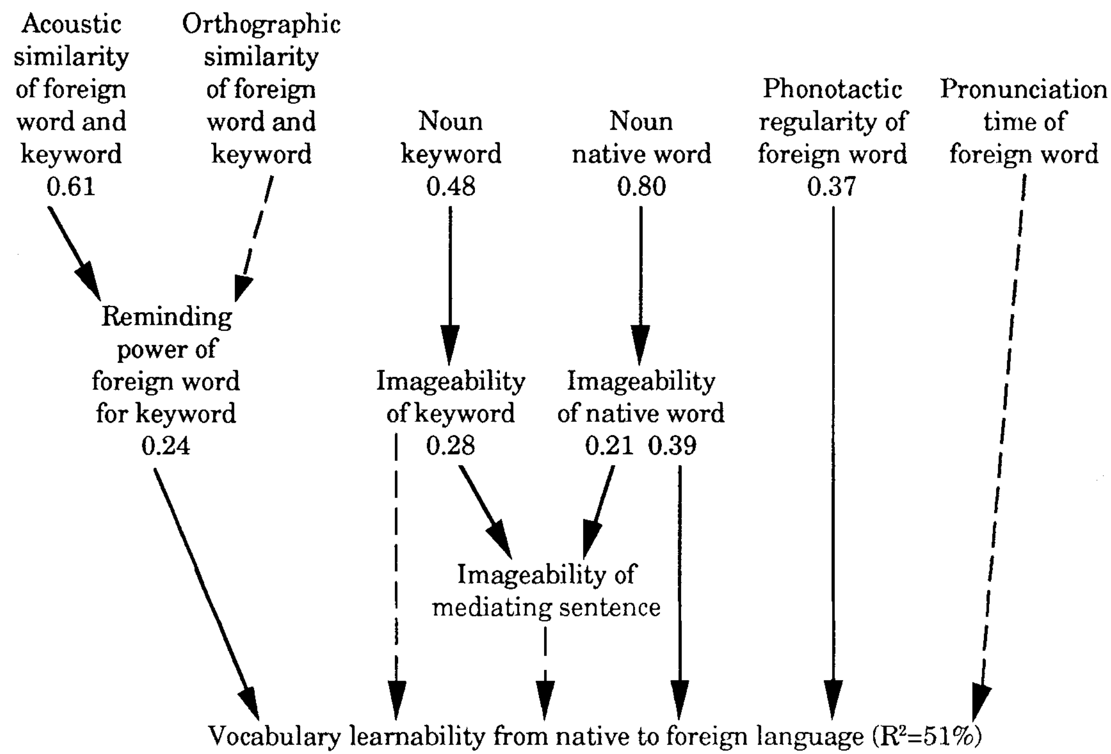

Figure 2a. LISREL causal path solutions predicting foreign language learnability (from native to foreign language). All permitted paths are shown, but the nonsignificant ones are shown as dashed lines.

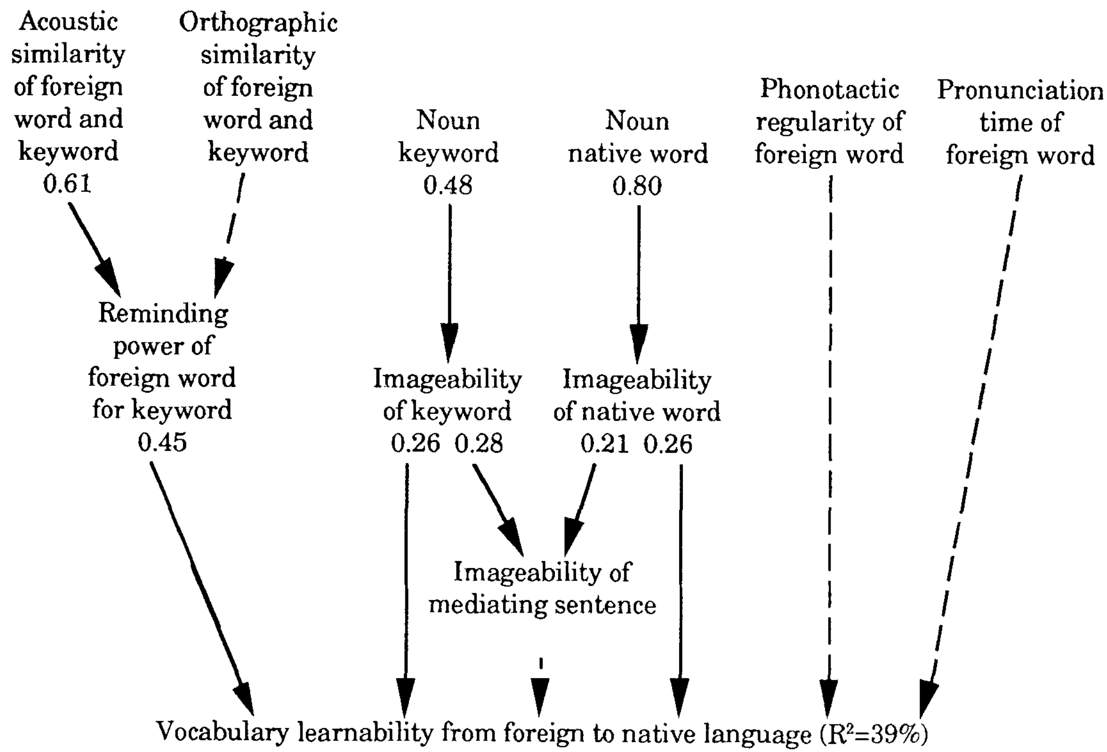

Figure 2b. LISREL causal path solutions predicting foreign language learnability (from foreign to native language). All permitted paths are shown, but the nonsignificant ones are shown as dashed lines.

2. Nouns are much more imageable than are verbs, very much so (0.80) for the native words but somewhat less for the keywords, when the designer was at pains to select keywords as nearly as possible the same, or similar, for noun and verb keyword conditions.
3. The imageability of both the keyword (0.28) and the native word (0.21) affect the imageability of the mediating sentence that relates the two.
4. However, the imageability of these component words directly determines the learnability of the FL vocabulary. In neither analysis does mediating sentence imageability per se predict learnability.
5. The imageability of the native word is all-important in translating from native to foreign language; the imageability of the keyword only becomes a significant factor when translating from foreign to native language. This parallels the general finding that in PAL, imageability effects are much stronger for the stimulus word than for the response word (Paivio, 1971; Rubin, 1980); in translating from native to foreign language, it is the native word that is the stimulus, whereas the keyword is the stimulus member of the to-be-associated pair in translating from foreign to native language.
6. Acoustic similarity between foreign word and keyword much more importantly determines reminding power than does orthographic similarity (even though responses were typed in this experiment).
7. The reminding power of the foreign word for the keyword is a significant determinant of FL learnability in both directions of translation, but more so in going from foreign to native language (0.45) than from native to foreign language (0.24). Note, however, that reminding power was only assessed in the former direction.

DISCUSSION

PHONOLOGICAL FACTORS

These "by-word" analyses demonstrate significant correlations between the ease of pronunciation of FL words and their learnability. Gathercole and Baddeley (1989) demonstrated that young children's phonological short-term memory span (their ability to repeat novel nonwords in order) predicted their L1 vocabulary one year later, even when prior vocabulary levels were taken into account. In their reanalysis, Gathercole et al. (1991) showed that both nonword length and the degree to which nonwords were "word like" predicted ease of repetition of the nonwords. In the present study we have gone further; first, by directly measuring phonotactic regularity; second, by showing that this predicts long-term memorability; and third, by showing that this effect is independent of (a) mediational aspects between the novel word and its L1 translation equivalent by means of imagery and/or semantic association, and (b) the orthographic regularity of the novel word.

The results therefore lend further, more specific, support to theories positing a role of phonological short-term memory (Gathercole & Baddeley, 1989, 1990) and phonological long-term memory in vocabulary acquisition, whereby representation of the novel sound sequence of a new word in phonological short-term memory promotes its longer-term consolidation both for later articulation and as an entity with which meaning can be associated. The easier a novel word is in this respect, either because of its short length or because it conforms to the learner's expectations of phonotactic sequences of language, the easier it is to learn. Phonotactic regularity might allow the novel word to better match the learner's settings of excitatory and inhibitory links between sequential phonological elements (Estes, 1972) for input processes such as phonological segmentation or for output as articulatory assembly (Snowling, Chiat, & Hulme, 1991), either per se or as expectations of phonological sequences as influenced by regularities in the learner's lexica (Gathercole et al., 1991).

A number of studies, using different methodologies, converge on this conclusion. The first is a training study (Gathercole & Baddeley, 1990) in which children poor on nonword repetition were found to be slower than children who were good on nonword repetition at learning new vocabulary (phonologically unfamiliar names such as *Pimas* for toys). They were not slower to learn a new mapping for familiar vocabulary (familiar names like *Thomas* for the toys). Thus, it appears that temporary phonological encoding and storage skills are involved in learning new words. As Gathercole and Baddeley (1990) point out,

> Acquiring a new vocabulary item . . . must minimally involve achieving a stable long-term representation of a sequence of sounds which is linked with other representations specifying the particular instance or class of instances. The locus of the contribution of phonological memory skills seems most likely to be in the process of establishing a stable phonological representation as, in order to do this, a temporary representation has presumably to be achieved first. Immediate phonological memory seems an appropriate medium for this temporary representation and, presumably, constructing the stable long-term memory representation of the novel event will interact with the adequacy of this temporary representation. By this analysis, the better the short-term representation, the faster the long-term learning.
> (pp. 451–452)

A second source of evidence for a relationship between phonological memory and vocabulary acquisition comes from the study by Baddeley, Papagno and Vallar (1988) of an adult neuropsychological patient, PV, who appeared to have a highly specific acquired deficit of immediate phonological memory. PV was completely unable to make associations between spoken word and nonword pairs, despite showing normal phonological processing of nonword material. She had no difficulty, however, in learning new associations between pairs of words. In other words, temporary phonological memory is particularly involved in the long-term learning of *unfamiliar* phonological material.

This relationship holds for new words whether they are of native or foreign sources. Thus, Service (1992) demonstrated that the ability to represent unfamiliar phonological material in working memory (as indexed by Finnish children's ability to repeat aloud pseudowords that sounded like English) predicted FL (English) acquisition two and a half years later.

However, theories of FL vocabulary learning and the role of phonological memory systems typically fail to make the important distinction concerning direction of translation. The present study's findings suggest that phonological factors are more implicated in productive learning when the student has a greater cognitive burden in terms of sensory and motor learning. Ellis and Beaton (in press) demonstrate from individual differences analyses that although keyword techniques are efficient means for receptive vocabulary learning, for productive learning they are less effective than repetition (at least for learners naïve to the pronunciation patterns of the foreign language). The present by-word analyses clarify this in that they demonstrate the strong effects of the foreign word's regularity of pronunciation (in terms of the phonotactic patterns of the native language) on the success of learning. Such an effect is absent in receptive learning.

These effects parallel those of Papagno, Valentine, and Baddeley (1991) who demonstrated, in a design comparable to ours in that it required productive vocabulary learning with written responses, that articulatory suppression (which presumably disrupts the articulatory loop component of STM) interfered with the learning of Russian vocabulary, but not of native language paired-associates, in Italian adults. English subjects, however, were not so disrupted in learning Russian, but were when learning Finnish words greatly dissimilar to English, a result that Papagno et al. attributed to the greater association value of Russian words for these subjects. Their results suggest that the articulatory loop is used in FL vocabulary acquisition when the material to be learned is phonologically unfamiliar and when semantic associations via native language cognates are not readily created, but it can be circumvented if the material readily allows semantic association. Taking together their results and ours, we would predict that (a) in such pairs of "different" languages, articulatory suppression will have a much greater effect on productive rather than receptive vocabulary learning; and (b) it will be much more detrimental for *ab initio* learners who are naïve to the pronunciation patterns of the foreign language. However, these experiments remain to be performed.

In conclusion, there is a considerable body of evidence that phonological factors are involved in (particularly productive) long-term vocabulary acquisition: (a) Individuals deficient in phonological STM have difficulty in acquiring the phonological representations of unfamiliar words. (b) Phonological STM span predicts vocabulary acquisition in both L1 and L2. (c) Interfering with phonological STM by means of articulatory suppression disrupts vocabulary learning when semantic associations between the native and foreign word are not readily available. (d) Nonword length and word likeness predict repeatability. (e) Foreign language word regularity in terms of L1 phonotactics determines learnability.

How then should we conceptualize the development of vocabulary from the very beginnings of entry into a new language to full proficiency? What are the causal relationships between phonological STM and the phonological aspects of LTM for vocabulary? Gathercole and Baddeley (1989, 1990) demonstrate quite clearly that phonological STM predicts long-term vocabulary acquisition. Yet at the same time there are robust demonstrations of a LTM component of STM span that is independent of speech rate, that is, STM span is greater for FL lexical items that have been encountered more often (Hulme, Maugham, & Brown, 1991; Brown & Hulme, 1992). The direction of causation is neither STM to LTM, nor LTM to STM, but rather it is reciprocal. Both directions apply because new skills or knowledge invariably initially build upon whatever relevant abilities or knowledge are already present; then, as they are used, they legitimate and make more relevant (Istomina, 1975) those prior skills and knowledge, and so in turn cause their further development. This is the *normal* developmental pattern. The case of reading development is a clear example. Thus Ellis (1990; Ellis & Cataldo, 1990) demonstrate reciprocal interactions between reading, phonological awareness, spelling, and STM whereby, for example, initial levels of implicit phonological awareness determine the child's entry into reading, but reading itself causes development of phonological awareness. Similarly, Stanovich (1986) has persuasively argued the case for reciprocal relationships and bootstrapping effects in reading more generally: "In short, many things that facilitate further growth in reading comprehension ability—general knowledge, vocabulary, syntactic knowledge—are developed by reading itself" (p. 364). He refers to these as "Matthew effects"—"unto those who have shall be given"—the more you know, the easier it is to learn more—such is growth and development.

Vocabulary acquisition is no exception to this rule:

> A further possibility is that nonword repetition ability and vocabulary knowledge develop in a highly interactive manner. Intrinsic phonological memory skills may influence the learning of new words by constraining the retention of unfamiliar phonological sequences, but in addition, extent of vocabulary will affect the ease of generating appropriate phonological frames to support the phonological representations. (Gathercole et al., 1991, pp. 364–365).

The novice FL learner comes to the task with a capacity for repetition of L1 words. This capacity is determined by (a) constitutional factors, (b) metacognitive factors (e.g., knowing that repetitive rehearsal is a useful strategy in STM tasks), and (c) cognitive factors (phonological segmentation, blending, articulatory assembly). Such cognitive language processing skills occur at an implicit level in input and output modules that are cognitively impenetrable (Fodor, 1983) *but whose functions are very much affected by experience*—hence, for example, frequency and regularity effects in reading (Morton, 1969; Baron & Strawson, 1976; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Brown, 1987; Paap, McDonald, Schvaneveldt, & Noel, 1987), spelling (Barron, 1980; Barry & Seymour, 1988), and spoken word recognition (Morton, 1969; Marslen-Wilson, 1987).

The degree to which such relevant skills and knowledge (pattern recognition systems for speech sounds, motor systems for speech production) are transferable and efficient for L2 word repetition is dependent on the degree to which the phonotactic patterns in the L2 approximate to those of the L1, hence the phonotactic regularity effects at both language and individual word levels. Here then we have long-term knowledge affecting phonological STM, that is, the linguistic hypothesis of Gathercole et al. (1991).

The "good language learner" (Naiman, Fröhlich, Stern, & Todesco, 1978) knows that repetition and practice of new vocabulary are useful strategies (O'Malley, Chamot, Stewner-Manzanares, Kupper, & Russo, 1985). In so doing, the good learner acquires long-term L2 vocabulary. Here we have phonological STM determining long-term vocabulary acquisition (Gathercole & Baddeley, 1989, 1990).

As their L2 vocabulary extends, as they practice hearing and producing L2 words, so good language learners automatically and implicitly acquire knowledge of the statistical frequencies and sequential probabilities of the phonotactics of the L2. Their input and output modules for L2 processing begin to abstract knowledge of L2 regularities, thus they become more proficient at short-term repetition of novel L2 words. And so L2 learning lifts itself up by its bootstraps.

MEDIATIONS AND ASSOCIATIONS —IMAGEABILITY AND MEANINGFULNESS

Nouns are far easier to learn as FL vocabulary than are verbs. This is of little surprise in the conditions in which subjects were encouraged to use keyword imagery mediation. Here the by-word analyses in large part parallel the individual differences analyses of Ellis and Beaton (in press) in that they demonstrate that the imageability of both the keyword and the native word determines the effectiveness of keyword methods of FL vocabulary learning. Greater effectiveness depends upon greater imageability, which in turn is best promoted by choosing nouns as keywords.

To our knowledge, ours is the first demonstration of the effects of keyword imageability and the directional interaction whereby keyword imageability is more important in translating from foreign to native language than from native to foreign language. However novel in the keyword literature, a comparable effect is standard in research concerning imagery effects in PAL, in which the imageability of the stimulus member of the pair has much more effect than does that of the response (Paivio, 1971; Rubin, 1980). These findings, taken together with the interactions between keyword effectiveness and individual differences in Gordon Imagery Control (Ellis & Beaton, in press), strongly confirm interpretation of the keyword technique in terms of theories of imagery.

However, nouns are also far easier to learn as FL vocabulary than are verbs even when subjects are *not* instructed to use imagery mediation. Within the literature on organization and memory, mediation is discussed predominantly in terms of semantic links. A relationship might be made between the stimulus and response words because it taps into preexisting semantic links; thus, at the extreme, highly associated pairs are easy to learn (Jenkins, Mink, & Russell, 1958). Otherwise subjects may choose from a wide variety of strategies: for example, to attempt to link the two items in a meaningful sentence (as in the sentence generation condition of Bower and Winzenz, 1970). The possibilities are endless—even with research on nonsense syllables, Baddeley (1976) writes:

> Anyone who has worked with nonsense syllables will know that, despite the effort put into scaling their association value, familiarity, pronounceableness, and so forth, the correlation between these measures and the learning of individual syllables is low. . . . The probable reason for this lack of consistency is that subjects will use any strategy they can devise to give meaning to an item or pair. . . . Given a flexible and ingenious subject, it is hardly surprising that no measure based on a single coding dimension has proved to be an accurate or reliable predictor of learning. Indeed, the best way of predicting the difficulty of a nonsense syllable pair is

> still to ask subjects (Prytulak, 1971), presumably because subjects can base their judgements on the whole range of possible coding strategies, whereas most measures are based on a single coding dimension. (p. 273)

With meaningful material we give the fertile mind even more scope, and with imageable material yet more again.

There are diverse psychological theories of meaning, but many posit that the element representing a word in semantic memory is associated with a number of features or, more fully, predicates. This assumption has been used to analyze work in sentence verification (e.g., Anderson, 1976), category prototypes (e.g., Rosch, 1975), concepts (e.g., Schank & Abelson, 1977), basic categories (e.g., Rosch, 1976), similarity (e.g., Tversky, 1977), metaphor (e.g., Ortony, 1979), episodic memory (e.g., Tulving, 1983), semantic priming (e.g., Meyer & Schvaneveldt, 1971), and deep dyslexia (Jones, 1985). All of these models are concerned to represent meanings, and propositional representations are well suited to this end—knowledge is represented as a set of discrete symbols that are linked by associational relationships to form propositions; concepts of the world are thus represented by formal statements, with the meaning of a concept given by the pattern of relationships among which it participates. (See Rumelhart & Norman, 1985, for a review.) Meaningful concepts have many relationships; less meaningful ones have few. When Rubin (1980) factor-analyzed 51 psycholinguistic variables measured for 125 words and Paivio, Yuille, & Madigan (1968) imageability, (a) meaningfulness (m, associative frequency, and categorizability), and (b) concreteness loaded on the *same* factor, suggesting that these measures have much in common. Another way of operationalizing this definition of meaning is to measure the "ease of predication" of the word, that is, the ease with which what the word refers to "can be described by simple factual statements" (Jones, 1985, p. 6; e.g., a *dog* is a type of animal, a *dog* barks when angry, a *dog* has four legs, a *dog* wags its tail when pleased, a *dog* often lives in a kennel, etc., vs. an idea . . .). When Jones (1985) had participants rate 125 nouns for ease of predication, there was a very high correlation (r=.88) between this measure and Pavio et al. imageability. When he chose a measure of predication time (the mean number of seconds taken to produce two predicates for each word) there was a correlation of r=–0.72 with Pavio et al. imageability (Jones, 1988). These are high correlations; it seems that imageability and predictability go hand in hand. Schwanenflugel, Harnishfeger & Stowe (1988) and Schwanenflugel (1991) argued that the greater meaningfulness of imageable words arises from their greater "context availability" (Schwanenflugel, 1991, p. 242), a concept very similar to predictability. In this view imageable concepts, as a result of their experientially based cores, more easily allow access of relevant world knowledge, or "inner provided contexts" (Harnishfeger & Stowe, 1988, p. 501) that add meaning relationships to the word. The common feature of all of these theories is that things experienced and analyzed visually are imageable things are meaningful things about which we have coordinate and subordinate semantic information.

Gentner (1982) emphasized the parallelism of vision that allows for ready associations: Good concrete objects are cohesive collections of precepts because objecthood is created by spatial relationships among perceptual elements. Perceptual elements packaged into noun referents are highly cohesive (i.e., have many internal relationships to one another), whereas perceptual elements packaged into verb referents are distributed more sparsely through the perceptual field and have fewer internal relationships with one another. Thus, noun concepts are richer and nouns are more easily mapped onto discrete perceptual experiences. Hence, they are more meaningful and more easily acquired in either first or second languages. Similarly Ellis (1993) proposed that imageability effects in verbal learning reflect the fact that visual imageability confers meaning, or, as Lakoff & Johnson (1980) and Barsalou (1991) suggested, symbols are grounded in our perceptual experience, that is, imageable items are meaningful items are memorable items.

KEYWORD MEDIATION

Finally, the present results confirm the two-stage view of keyword mediation proposed by Raugh and Atkinson (1975) that a useful keyword must be (a) highly imageable *and* (b) an effective reminder of the foreign word; that is, imageability is needed for the link between native word and keyword, but the keyword and the foreign word must also be similar enough to effect their mutual reminding. The beta of 0.44 between the compound of native and keyword imageabilities and FL vocabulary learnability confirms the imagery mediation stage of the process. That the reminding power of the foreign word for keyword (as measured above) is a separate stage is demonstrated by its separate and significant effects in the causal path analyses (Figure 2). These analyses also demonstrate that effective reminding is achieved by having the keyword as acoustically similar to the foreign word as possible; orthographic similarity is of less concern.

INDIVIDUAL DIFFERENCES AND INSTRUCTIONAL TECHNIQUES

These analyses have concentrated on the factors that make *words* easier or harder to acquire. Allied questions concern (a) which *people* are better at learning FL vocabulary, that is *individual differences*, and (b) *effective methods* of learning, that is, *instructional techniques*. Our companion paper (Ellis & Beaton, in press) addresses these issues. It demonstrates that keyword techniques are more effective for receptive learning, but that repetition is superior for production. (This is the individual differences replication of the word pronounceableness effects discussed here.) Performance is optimal when learners combine both strategies. The nature of the keyword is crucial; whereas imageable noun keywords promote learning, verb keywords may actually impede it. Students left to their own devices report using imagery mediation 33% of the time, and in turn, noting similarity between the foreign and native words 19%, sentence mediation between a keyword and the native word 4%, sound similarity 4%, and rote repetition 2% of the time. Students high in Imagery Control naturally adopt imagery mediation strategies and perform better as a result. However, people can be encouraged to use this technique effectively; and when this is done, Imagery Control no longer predicts performance.

PROVISOS

Before reaching our general conclusions we must emphasize the limitations of this research. The study focused on the very beginning stages of vocabulary learning, and one cannot assume that learning occurs in similar ways at different stages of proficiency (Meara, 1984). Our operationalization of vocabulary learning treats it simply of the learning of word pairs, and we have in no sense addressed the implicit learning of vocabulary (Ellis, in press-a, in press-b). The testing procedures involved typed responses, and furthermore they revealed nothing about the extent to which students can manipulate the foreign language words that they have "learned"; for example, we have not assessed whether students can use these lexical items in a sentence demonstrating that they understand their meaning, nor have we ascertained whether the students know in which contexts these lexical items can be used. Further research is needed to answer these and related questions.

PRACTICAL COROLLARIES

The second-language learner must acquire the pronunciation elements and their compounds in the foreign tongue as well as the graphemes and their patterns of orthographic combination in the foreign script—all this on top of the mappings of word meanings between the two languages. Keyword techniques can be very effective in promoting the semantic mappings, but they can do little for the phonological and orthographic aspects unless the learner is fortunate enough to be studying an FL that is sufficiently related to the mother tongue that there exists therein a host of cognates that will serve as effective keywords in that they closely share acoustic and orthographic similarity to the FL lexicon. Here, particularly, it is not as important that the keyword sound like the foreign word, but rather that the foreign word sound just like the keyword—a subtle but important distinction. If this is not the case, and it is often very difficult to find suitable keywords in this respect (see Nation, 1987; Hall, 1988), then the learner must also be encouraged to practice the pronunciations and writings of the FL to develop phonological and graphemic pattern-recognition and motor programs by some other means, such as repetition.

Revised version accepted on 31 March 1993

NOTE

[1]We could have tested other theoretically motivated models. For example, there are good reasons to expect that there are independent effects of part of speech on learnability that are not mediated by imageability (Gentner, 1982; Schwanenflugel et al. 1988; Schwanenflugel, 1991). Indeed, this is certainly the case from the data: In Table 3 in each of the eight cases, part of speech is a numerically better predictor of learnability than is concept imageability. Furthermore, in each of these cases, hierarchical regression analyses in which imageability is forced in at the first stage invariably demonstrate that word class makes a further significant contribution to the explained variance. Notwithstanding this, we chose to limit the analysis to the current model in which effects of word class are mediated by imagery for both theoretical and practical reasons: (a) much of the advantage of nouns over verbs is due to the fact that words are grounded in our imagery memories of perceptual experiences (thus Gentner, 1982, arguing that object concepts are given to us by the world whereas predicate concepts form a system that the child must discover, demonstrates that even as far as nouns are concerned, those that appear in the child's first words are all either concrete or proper nouns; they center on concrete precepts not abstract vagaries); (b) we are investigating the effects of imagery keyword mediation in which it is clear that there is an advantage of imagery over semantic association (Bower & Winzenz, 1970) and it is precisely the nature of these imagery effects that we wish to explore; (c) in our experiment, imagery and word class are so confounded (r=0.80) that if both native and keyword word class were entered as direct effects of learnability, extending the models in Figure 2, then there would be little variance left for imagery to explain. A factorial experiment in which part of speech is crossed with imagery in its full range for both nouns and verbs is needed to properly disentangle effects of word class and imageability.

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