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TOWARD A LEXICAL PROCESSING MODEL FOR THE STUDY OF SECOND LANGUAGE VOCABULARY ACQUISITION

Evidence from ESL Reading

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A major requirement for theory development in L2 vocabulary acquisition is an adequate model of L2 lexical organization and processing. At present, there is no widely accepted model of this kind, but recent research has demonstrated the potential usefulness of Levelt's (1989, 1993) L1 speech processing model (de Bot & Schreuder, 1993; Green, 1993; Poulisse, 1993). This paper explores the relevance of the model as adapted for L2 lexical processing of written texts, with particular attention to its mental lexicon components (concepts, lemmas, and lexemes) and organization. The model is first discussed in terms of its relevance to L2 lexical access, retrieval, and acquisition processes. Findings of an introspective L2 vocabulary study follow, detailing how university ESL learners reported dealing with unfamiliar words while carrying out L2 reading tasks. The information provided on their lexical inferencing strategy and varied knowledge sources used in the process

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provide support for the lexical components and organization proposed by Levelt. It is argued in this paper that the process of inferring the features of unknown words in a reading passage can be described in terms of lemma construction, as defined in the model.

In the literature on second language vocabulary acquisition, various accounts have been given of what it means to know a word (e.g., Nation, 1990; Richards 1976). These generally emphasize knowledge of word forms, their meanings, and their linguistic features, and the ability to use words in different modalities and in sociolinguistically varied settings. Whereas descriptions of what it is to know a word remain vague, the way in which learners acquire such knowledge is even less well understood. More attention has been paid to conditions that apparently promote or impede the acquisition process than to the process itself. In this article, we take the view that understanding both the nature of vocabulary knowledge and the acquisition of this knowledge requires consideration of the organization of the mental lexicon and the mechanisms of language processing.

An empirically based processing model is needed, and we argue that the L1 production model developed by Levelt (1989) as revised to accommodate comprehension (Levelt, 1993) is an appropriate starting point for our discussion of lexical knowledge. We consider the Levelt model to be the most complete, empirically based language production model available; one that includes elements of other proposals such as those of Dell (1988) and Garrett (1988). The aim of this paper is not to show which language production model can best account for language production or, more specifically, bilingual production, but rather to show how lexical knowledge in incipient learners can be represented in terms of Levelt's model. In recent years, a number of researchers have shown that the Levelt model can be applied successfully to language use by bilingual speakers (de Bot & Schreuder, 1993; Green, 1993; Poulisse, 1993) and to grammatical aspects of second language acquisition (Towell, Hawkins, & Bazergui, 1996). In this paper, first we show that the conceptual and lexical components of this model are central to language processing and that an adapted version of the model may be used to represent both spoken and written language modes, in L2 as well as L1 processing. We then consider how the kinds of lexical knowledge represented in the model may be accessed by L2 speakers as they infer the meanings of new words, in particular through written input. In this context, we present some empirical findings from an introspective study of lexical inferencing in L2 reading. The data from this study consist of learners' think-aloud reports on their attempts to infer the meanings of unknown words from reading texts. In these, learners reveal some of the knowledge and contextual cues they draw on as they attempt to identify or construct the appropriate syntactic and semantic features of an unfamiliar word. These findings may be interpreted in accordance with the componential view of lexical knowledge presented in the adapted model.

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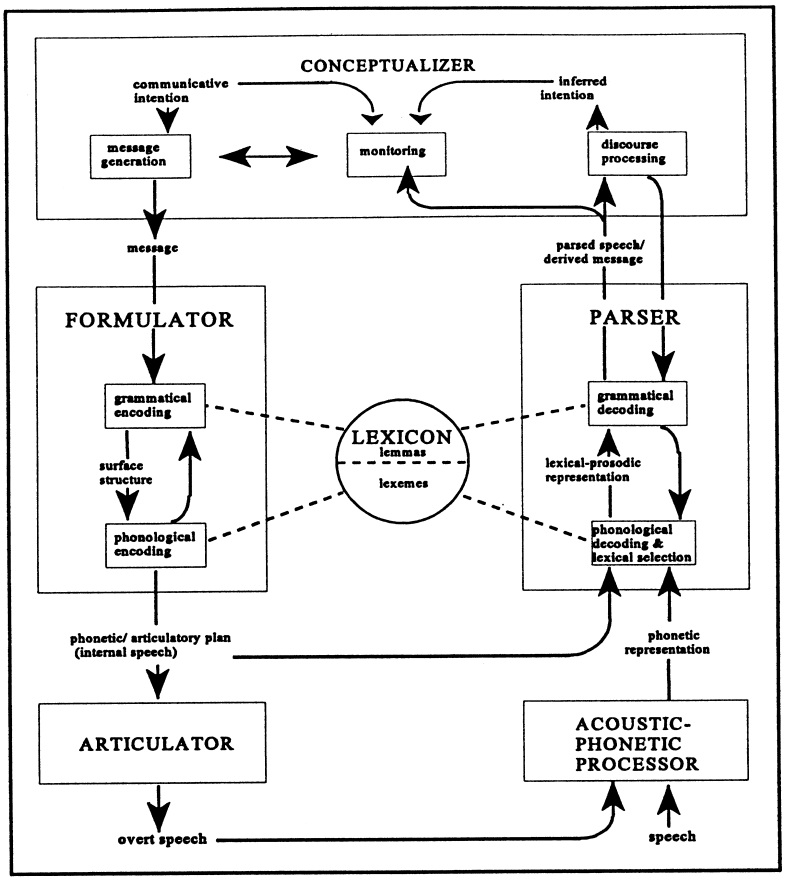


Figure 1. Schematic representation of the processing components involved in spoken language use. [Reproduced with permission from W. Levelt (1993), "Language use in normal speakers and its disorders." In G. Blanken et al. (Eds.), *Linguistic Disorders and Pathologies. An International Handbook*. Berlin: de Gruyter.]

THE LEVELT MODEL

Levelt's (1989, 1993) model of L1 speech processing provides a sound basis for development of a general language processing model, applicable across modalities and for bilingual processing. We propose that, at the representational level, the same organization and components apply to both comprehension and production, while recognizing the obvious differences between modalities in message realization, in particular with respect to time and memory constraints (see discussion later).

There are three distinct levels of representation in Levelt's production model: the *conceptual* level, the *lemma* level, and the word form (*lexeme*) level (Figure 1), each

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of which is central to the various forms of productive and receptive language use. In this model, the mental lexicon mediates between conceptualization and grammatical and phonological encoding. That is, resulting syntactic patterns are not determined by the message itself but, rather, by the mediating lexical items and their features (Levelt, 1989, p. 181). Levelt refers to this as the "lexical hypothesis." According to the model, a speaker's communicative intentions are formatted by the *conceptualizer,* the processing system that accomplishes the mental activities of conceiving an intention, selecting relevant information to be expressed, and ordering and monitoring the information (Levelt, 1989, p. 9). Its output is the "preverbal message," a message containing all the necessary information for converting meaning into language but that is not in itself linguistic. Such a message can be interpreted by the *formulator.* In the formulator, the preverbal message is converted into a speech plan (phonetic plan) through a process of selection of appropriate lexical entries and the application of grammatical and phonological rules. This process involves at least four kinds of lexical features: semantic, syntactic, morphological, and phonological (the latter including syllable and accent structure). In Levelt's model (1989, 1993), these specifications of a lexical entry are represented at two different levels, the lemma, which includes the semantic and syntactic information, and the lexeme, or its corresponding morphophonological form. According to Levelt (1989), a lexical entry may include more than one lexical item. For example, a verbal entry may have multiple items inflected for tense, number, case, and so on. These inflections are signaled by the entry's diacritic features. Derivations, however, represent distinct entries.

In production, lexical items are activated by matching the preverbal message with the meaning part of the lemma. The selection of appropriate lemmas and the relevant syntactic information (e.g., syntactic category, argument structure, and diacritic parameters) will then lead to formation of the surface structure of the message. How this matching of a preverbal concept and the appropriate lemma takes place and how a specific match is evaluated by the speaker are as yet not very clear (e.g., Is there enough overlap between the specification in the concept and the selected lemma?), although de Bot (1995) argues that preconceptual elements are differentially weighted depending on the demands of the conversational setting. The activation of syntactic procedures will have consequences for the eventual word form (e.g., genitives in English can be constructed by adding an *s* [*his sister's friends*] or by setting up a prepositional phrase [*the friends of his sister*]). As the surface structure is being formed, the morphophonological information corresponding to the lemma is activated and encoded. In the phonological encoding process, different parts of the word form are assembled. This phonological encoding provides the input for the *articulator* in the form of a phonetic plan, which is then realized in speech production.

The distinction between lemmas and lexemes is found in most theories of language production (cf. Butterworth, 1989). Evidence for this distinction comes from research on naturally occurring and elicited speech errors, aphasia, tip-of-the-tongue (TOT) phenomena, and various experimental paradigms, such as word and picture naming. There is no perfect one-to-one match between lemmas and lexemes. The activation of a lemma through matching on the basis of the conceptual specification

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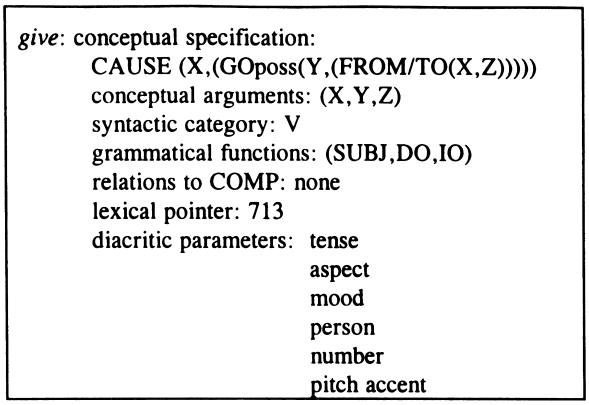


Figure 2. Lemma for *give*.

may not always lead to retrieval of the right lexeme, and the lexeme may, furthermore, not be retrieved as a whole. Evidence from speech errors (e.g., *heft-lemisphere* for *left hemisphere*) shows that the lexeme is not a ready-made template but that it consists of a frame into which phonological segments are inserted. The imperfect match between lemma and lexeme is obvious in TOT studies that indicate that subjects appear to know well above chance level the number of letters, the initial letter, the number of syllables, and the syllable that carries primary stress in the word(s) sought (Brown & McNeill, 1966; Jones & Langford, 1987). TOT phenomena are interesting for language acquisition researchers because they often occur when words are only partly known. The literature provides two explanations for TOT phenomena: They may result from related interlopers that block the intended lexemes or from insufficient activation of the lexemes. Experimental evidence (e.g., Meyer & Bock, 1992) supports the incomplete activation hypothesis. This means that if the information available in a lemma is not sufficient to activate the corresponding lexeme then this lexeme will not become available as a whole, although some partial activation may occur.

Because our evidence from the introspective study mainly relates to information represented at the lemma level, it is important to clarify what is known about this level. First, its semantic information "specifies what conceptual conditions have to be fulfilled in the message for the lemma to be activated" (Levelt, 1989, p. 188), whereas its syntactic information specifies the item's syntactic category, its assignment of "grammatical functions" (i.e., the grammatical components required by the syntactic environment of a given verb), and a set of diacritic parameters including tense, person, and number, that are used to select the specific form of a lexical item. The lemma's lexical pointer is an "address" in the lexeme inventory, pointing to the corresponding correct phonological frame or form. Figure 2 presents the information represented in the lemma for the verb *give* (Levelt, 1989, p. 191).

In Levelt's explanation of the lemma for *give* (1989, pp. 188–191), the *conceptual specification* involves three variables: *X,* a *person,* which is both an agent of the

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causative *event* and the source of the *path; Y,* a *thing*, which is the theme; and, *Z,* a *person,* which is the goal of the path. These three slots for *conceptual arguments* play an important role in the process of sentence formation because *grammatical functions* can be assigned to them.

This lemma's *syntactic category* is verb. Its *grammatical functions* means that it requires a subject, direct object, and indirect object (listed in the same sequence as the corresponding arguments). A lemma further specifies, under *relations to complement,*[1] how to map *conceptual arguments* onto *grammatical functions* if they do not have a one-to-one relationship, as with *give.* The *lexical pointer* provides the connection with the appropriate morphophonological form entry in the lexeme inventory (indicated by a number). This entry contains related inflections of *give* (e.g., *gave, giving*), which are distinguished from one another by *diacritic parameters* (e.g., tense, number), which must all be specified for an accurate lemma–lexeme connection to be made.

The lemma structure of other types of words is far less complex than that for verbs.[2] Nouns can have various types of complements: prepositional phrases (PPs) (the car *in the street*), noun phrases (NPs) (the *man's* car), or sentences (Ss) (the car *my brother likes*). Proper or common type is part of a noun's conceptual specification, and count or mass information is part of its syntactic information. For a count noun, it will have to be specified "obligatory determiner when singular" in the grammatical specification.

As noted earlier, one of the points to be addressed in modeling lexical knowledge is to what extent one model can account for representations and processes in different modalities. In other words, is it possible to develop a model that can account for speaking, listening, reading, and writing? The Levelt (1993) version of the model presented in Figure 1 is a recent update of the original model in Levelt (1989). The present model is in line with experimental evidence that suggests that on the *representational* level there are similarities between reading and listening, in particular with respect to visual and auditory word recognition (cf. Bradley & Forster, 1987) as well as between comprehension and production, in particular with respect to word form representations (cf. Zwitserlood, 1994). Although the proposal for shared representations is not without problems (see, e.g., Ferrand & Grainger, 1992, for a completely opposite view), we take the position that there is sufficient evidence to support the shared representation hypothesis.

A schematic representation of Levelt's (1993) model indicating adaptations to account for oral and written modalities is presented in Figure 3. The model represents concepts, lemmas, and lexemes as shared in comprehension and production but with different input and output processes.

Modeling L2 Vocabulary Processing

An important question for researchers who have studied vocabulary acquisition is how word knowledge can be acquired from contextualized language input, such as in a reading task, without explicit vocabulary instruction. Existing literature indicates that such learning is determined by complex interactions of contextual, word,

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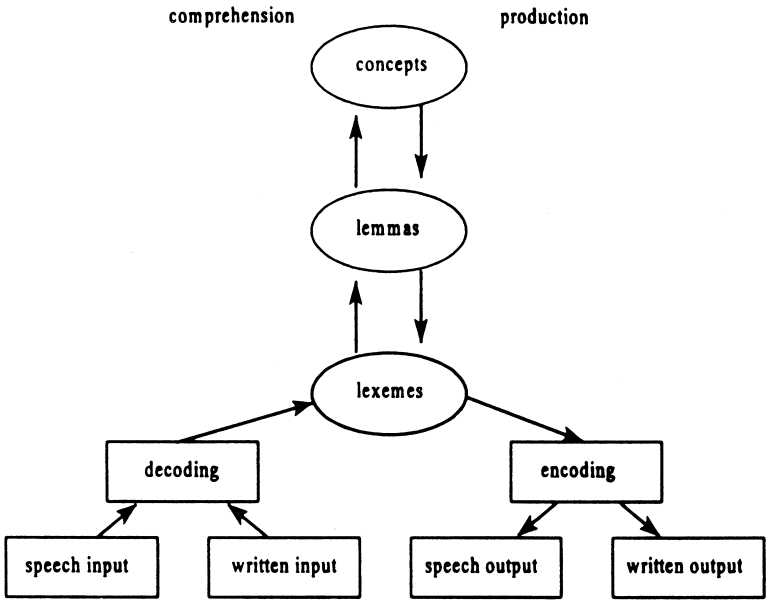


Figure 3. Lexical comprehension/production model for oral and written modalities.

textual, and learner factors. Whereas specific learning outcomes in a given instance are therefore unpredictable, research is gradually providing information on conditions that affect the likelihood of a new word being to some extent comprehended and learned, as well as recognition that in most cases internalization of more than rudimentary new lexical knowledge requires multiple, meaningful exposures in varied—especially written—discourse contexts. (For recent perspectives, see Haastrup, 1991; Haynes, 1993; Herman et al., 1987; Hulstijn, 1992; Li, 1988; Nation & Coady, 1988; Sternberg, 1987; Stoller & Grabe, 1993.) Sternberg and Powell (1983, as cited in Sternberg, 1987) suggest that learning from context involves three basic elements: *learner processes of knowledge acquisition* (selective encoding and selective combination of new information, and selective comparison in relating this to previous knowledge), *contextual cues* on which these processes operate (e.g., temporal, spatial, and functional description cues), and *moderating variables* (e.g., number of occurrences of the unknown word, importance of the unknown word to understanding the context in which it is embedded, and density of unknown words). A first condition in the development of further lexical knowledge appears to be that the word is judged by the learner to be of interest and learnable. Second, the context in which it is presented must provide adequate information for its comprehension. Third, it must be processed to a sufficient degree. Specific attention has to be allocated to both the context and the word itself. In the reading process, the comprehension system will try to match a word form and a meaning. In terms of our adaptation of Levelt's (1993) model, this means that a number of steps have to be taken. The

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string of letters that are read has to be matched with a lexeme. Assuming that a sufficient match is made, this form must then activate a lemma, which in turn must be matched with a concept if comprehension (at the word level) is to succeed. Whether such initial comprehension leads to internalization of some representation of the word form and its syntactic and semantic characteristics is far from assured (cf. Gass, 1988, and discussion in Paribakht & Wesche, 1996a, for a characterization of different levels of lexical intake processing).

The process of inferring the meaning of an unfamiliar word from a reading text may also be analyzed in terms of where the processing links between knowledge at different levels fail to be made. When an unknown word is encountered, the "not knowing" can be the result of a number of factors. The word form is given in the text, and the conceptual system contains the conceptual frames—but possibly not the specific content—needed to go from a lexeme to a lemma to a concept. One or more of these in-between steps can be the source of the "not knowing." A first possibility is that the written form and the internal word form representation (lexeme) cannot be matched, such as when a written word is primarily known in its spoken form, its written form is familiar but not its meaning, or it is not known at all. The next step is from lexeme to lemma. As mentioned earlier, there is no simple one-to-one relation between a lexeme and a lemma, and the basis on which a connection between the two is made is not entirely clear. A number of subprocesses are likely to play a role. In the target lexeme and surrounding language input, all relevant morphological information is represented. The language comprehension system has to parse this input into units that can be handled in the next stage of processing. Depending on the level of proficiency of the language user, various types of information can be used to connect the word form with its meaning: in particular, morphemes indicating word class or meaning components, syntactic information in the sentence that reveals the argument structure of the lexical items, and semantic information from the surrounding text as it interacts with the learner's knowledge. As in TOT phenomena, it is likely that all this information will be used to attempt activation of the appropriate lemma, but sometimes the information available will be insufficient to activate the lemma. If the lemma is activated, this activation will translate the syntactic information into conceptual information (e.g., "subject with nominative marking" into "agent"), and the complete set of conceptual specifications will serve to connect the lemma with one or more concepts. When this is achieved, the connection between input and comprehension has been made. In all the steps between levels, a certain amount of information is needed to activate the next level, and the process of inferring the meaning of unknown words is actually one of gathering more information to go from one level to the next.

At least one important aspect in which comprehension differs from production is relevant to this process: whereas in production all information is basically top-down, in comprehension there is an interaction between bottom-up information (letters or sounds, morphemes, etc.) and top-down information (knowledge of the world, the discourse setting, the text, the sentences, etc.). In the interpretation of text, both types of information are used, and the learner has the possibility of internalizing at least some features of the new lexeme.

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When a word's meaning and syntactic specifications are unknown, both semantic and syntactic information may be inferred from the context, and syntactic information may itself be used to infer meaning. Naigles, Gleitman, and Gleitman (1993) present evidence that children acquire the meaning of verbs on the basis of a supposedly stable correlation between word meaning and syntactic formats: "They use knowledge of syntactic structures derived from linguistic observation to make conjectures about word meanings" (p. 1). The process is referred to as *syntactic bootstrapping,* which supplements *semantic bootstrapping* (Pinker, 1984) (i.e., using knowledge of meanings to make conjectures about syntactic structures). Adult language learners are likely to use whatever information is available to them to interpret unknown words, and in that process both syntactic bootstrapping and semantic bootstrapping are options. With respect to the acquisition of verbs, Braine (1987) claims that children use general rules that generate "default" argument structures for novel verbs and verbs that have not been acquired fully in terms of argument structure. Starting from a canonical sentence schema, a default argument structure is set up. For example, a child may use SVO as a default structure in acquiring the meaning of verbs. A verb like *fall* will then first be interpreted as similar to *drop,* and only through repeated exposure will more detailed argument structures be developed in which *drop* and *fall* are distinguished. A logical problem in inferring the meanings of unfamiliar words through such *bootstrapping* from surrounding text is that whereas a rich context will provide cues to intended meaning that can aid in inferring the features of unknown words the reader may not find it necessary to attend to such words because global meaning has already been comprehended. However, if the learner attends sufficiently to a given new word, some additional information on its syntactic category and grammatical functions can generally be extracted based on the word form itself and its surrounding syntactic structure.

We can as yet only speculate about how the process of extracting meaning from context and adding information to a developing lemma actually takes place. We propose that initial attention to the form of an unknown word (Gass, 1988, "apperceived input") may lead to the setting up of an empty knowledge structure for a new lemma. The process of inferring meanings of unknown words can be viewed, within the framework proposed here, as an attempt to fill in an empty lemma structure. Syntactic information from surrounding text may be inferred with relative ease by experienced readers of the language, aided in languages such as English or French by their relatively restricted number of different word categories and argument structures. Semantic variability is evidently much greater. Semantic information in a lemma can only come from existing concepts in the learner's conceptual system: The lemma does not develop a conceptual specification on the basis of form characteristics. The process of learning the meaning of a lexical item must, then, involve the copying of semantic information from the conceptual system to the lemma. Once a lexical item has been added to the lexicon in a more or less primitive form (and sometimes containing inadequate or misleading semantic and/or syntactic specifications vis-à-vis the target language norm), its continued use will gradually specify additional information.

A recent study by Parry (1993) provides data that can be viewed as illustrating

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the process of extracting lemma information about new words through reading. In her longitudinal study of a Japanese university student's acquisition of English vocabulary, she gathered data on the learner's guesses of the meanings of unknown words in a long academic text, a course textbook for anthropology. The student made L1 glosses for words she did not know. Back translations of these glosses are highly informative as to the syntactic and meaning components the student inferred for unknown words. Even for incorrect guesses, she almost always guessed the correct word category (e.g., verbs were generally not interpreted as nouns). For "nearly correct" guesses, there were clear semantic relations between the original words and the guesses, in particular superordination (e.g., *gather* given as a gloss back translation for *forage,* the original word), hyponymy (e.g., *a cluster of plants* for *vegetation*), and part-whole relationships (*fertilizer* for *nutrient*). In addition, some glosses appeared to subtract meaning from the original words (e.g., *failure* for *demise*, sharing the original meaning component of *cessation* but not *death*) or to add meaning (e.g., *waste* for *depletion,* sharing the common component of *reduction* while adding *irresponsibility* as a new meaning component). These examples support a componential view of word meaning (cf. Jackendoff, 1993).

The data from a recent introspective study that examined L2 learners' use of inferencing in dealing with the unknown words they encountered in reading (Paribakht & Wesche, 1996b; Wesche & Paribakht, 1995) provide additional evidence that learners' attempts to infer the meanings of the target words and their reliance on multiple knowledge sources in the process can be viewed as an effort to construct corresponding lemma entries (i.e., to fill empty lemma structures). Only partial and relevant data from this study are reported here to substantiate the preceding claim. First, some general information about the introspective study is presented, followed by a description of the learners' use of an inferencing strategy and the various knowledge sources they appealed to in attempts to determine word meanings. Finally, several examples are analyzed from the perspective of the adapted model, which interprets learners' inferencing as a process of lemma construction.

THE INTROSPECTIVE READING STUDY

The main purpose of the introspective study (see also Paribakht & Wesche, 1996b; Wesche & Paribakht, 1995) was to gain a better understanding of the process of L2 vocabulary acquisition through reading by asking learners to introspect and think aloud[3] as they carried out reading comprehension activities. Of particular interest were the kinds of strategies they used in dealing with unfamiliar words they encountered in written texts and the types of knowledge sources and cues they used in attempts to infer their meanings.

An earlier classroom experiment (Paribakht & Wesche, 1977; Wesche & Paribakht, 1996) demonstrated incidental vocabulary acquisition of given words through the reading of thematically related texts. The follow-up introspective research used think-aloud procedures, learner performance data, and observation data to explore this process as learners read and demonstrated their understanding of texts from the previous study. It focused on the initial stages of the process by which new vocabu-

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lary knowledge might be gained. The introspective study provides rich data on the learners' reports of their attempts to infer meanings and other features of unknown words and on the knowledge sources and cues used in inferring lexical features. These data may be interpreted in terms of the adapted model, as illustrated by the following examples.

Subjects

Subjects were 10 students in an intermediate-level university ESL class in the 1993 fall semester. These students, from a variety of L1 backgrounds (e.g., French, Chinese, Persian, Spanish, Vietnamese, Arabic), volunteered for an individual out-of-class research session. All of these students used French as their official language of study at the bilingual University of Ottawa (Canada).

Procedures

Data collection and analysis included the following procedures. Several weeks before their individual research sessions and interviews, students were presented in class with a text on the subject of acid rain, and they were asked to read it and circle all the words they did not know. The texts were collected as an indication of the words unknown to each student in the target text. (See the Appendix for the text.)

Prior to the interview session, each subject was trained in think-aloud procedures. After an introductory explanation, each subject was presented with a colored picture and was asked to talk about what they were thinking while looking at the picture. Further practice involved a reading text on a topic similar to that of the target text and comprehension tasks identical to those in the experiment.

Following these training exercises, each student carried out two consecutive reading comprehension tasks based on the target text in the presence of an interviewer. The tasks were used to ensure that learners attended to meaning when reading the text. Half the students began with the summary task and half with the question task.[4] In both cases, think-aloud protocols were collected (a) as learners read the text, (b) upon completion of each step of the target task, and (c) following completion of each task. Thus, three kinds of self-report data were obtained: *introspective* protocols (what learners reported being aware of while carrying out the reading and comprehension activities), *immediate retrospective protocols* (recollections by learners of what they had done to fulfill the preceding step of the task), and *delayed retrospective* protocols (learners' reflections on the whole process after completion of the task) (Mann, 1982).

The summary task required the learner to read the text in segments, stopping at the end of each paragraph to give a summary of its content. Learners were also asked to verbalize their thoughts as they carried out the task. Immediately after summarizing each paragraph, learners were asked to indicate whether they had come across unknown words while doing the task and, if so, how they had dealt with each of them. The question task required learners to read the same text and answer comprehension questions. They were also asked to verbalize their thoughts

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while answering each question. Immediately after answering each question, they were also asked whether they had encountered any unknown words while doing the task and, if so, how they had dealt with each of them.

The verbal protocols thus obtained were transcribed, and together with other relevant documents they formed the data set for the larger study (Paribakht & Wesche, 1996b; Wesche & Paribakht, 1995). The examples quoted in this article came from the immediate retrospective protocols.

Data Analyses and Findings

Data analysis involved independent and collaborative readings and rereadings of the transcripts and related documents by the research team in order to identify, describe, and classify each learner's responses to each word he or she had indicated as unknown while carrying out the reading-based tasks. These analyses first of all revealed that learners identified a relatively small portion of textual words, mainly content words (nouns, verbs, and adjectives), as unknown and ignored approximately half of the unknown words.[5] Of the 299 different words (536 tokens) in the text, learners identified an average of 11 as unknown during the initial in-class reading, 15 when doing the summary task, and 9 when doing the question task. Although content words comprised 77% of the types, they accounted for over 97% of the unknown words identified in all three task conditions. Second, learners used a limited set of strategies and sources in their attempts to identify the meanings of those words they decided to deal with.[6] Third, they almost exclusively dealt with content words (nouns, verbs, and adjectives).

Strategies for Dealing with Words. Analysis of the data showed that learners used two minor and one main strategy types in their attempts to identify the meanings of unknown words. The first two were oral attempts at word retrieval[7] and appeals for assistance[8] directly to the researcher or through a dictionary. The most important strategy by far was inferencing, involving 80% of all strategies used. In the following section, data on the use of inferencing, including the types of knowledge learners used in the process, is presented to illustrate the relevance of Levelt's model for describing L2 lexical organization and processing.

Inferencing. When subjects actively tried to identify the meanings of unknown words, lexical inferencing (i.e., making an informed guess about the words' meaning using all available cues [see also Haastrup, 1991]) was the main strategy they used. Further data analysis revealed that learners drew on a variety of knowledge sources—sometimes helpful, sometimes misleading—in the inferencing process. These sources, linguistic (intra- and interlingual) and extralinguistic, represent their own knowledge interacting with cues from the words themselves and the surrounding text. In Table 1, the sources are listed in descending order of their frequency of occurrence. It is interesting to note that these learners relied heavily on morphosyntactic information in their inferencing attempts (50% of occurrences). Evidently, words embedded in written text readily yield this kind of information in addition to

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Table 1. Knowledge sources used in inferencing

Major linguistic sources	
Sentence-level grammatical knowledge	34.6%
Word morphology	15%
Punctuation	11.2%
Extralinguistic sources	
World knowledge	9.3%
Minor sources	
Discourse and text	3.7%
Homonymy	3.7%
Word associations	2.8%
Cognates	1.9%
Unknown sources	17.8%
Total	100%

the graphemes themselves, suggesting that reading may be particularly valuable as a vehicle for learning these aspects of word knowledge.

Uses of varied knowledge sources in inferencing are exemplified below. It should also be noted that learners sometimes used multiple sources of information while working on a given word.

Sentence-Level Grammatical Knowledge. Knowledge of relationships among speech parts in a sentence, often signaled by word order, was frequently used in dealing with unknown nouns and adjectives—for example ("I" refers to the interviewer and "S" to the student):

(1) I: *Okay. You've marked two words there, controversial and infancy, that you didn't know the meaning of. Did they give you any trouble in understanding the paragraph?*
S: *So, because the commercial controversial. This word . . .* [9] *could but be ??? most in the environmental issue so I can omit it. I . . . just put the most and ??? environmental and issue. So they talk about a issue. The issue. Another to describe the issue. So I omit this word.*

In this example, the learner deduces the syntactic category of the word (i.e., that it is a qualifier or an adjective) from his sentence-level analysis (i.e., of relationships among speech parts).

Knowledge of Word Morphology. Learners' knowledge of word L2 derivations (i.e., stems and affixes) and of grammatical inflections (e.g., *-tion, -ly, -ed, -s*) was sometimes used in inferring the meaning of an unknown word:

(2) S: *Outdistanced, distance. This is the same thing. Standing and outstanding.*
I: *What are you trying to do in order to try and understand that word?*

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S: *Just go the root of the word. Maybe is the same root because I have standing and outstanding. Distance and outdistanced.*

Punctuation. Learners sometimes used their knowledge of punctuation and capitalization rules to infer the meaning of the target word from a written text. In these data, applications were limited to proper nouns and the use of commas in series:

(3) S: *Oh, about ah . . . Oh, that is the name of the lake, no? Adirondack. Is not the name of the lake?*
I: *Not the name. Here's your lake.*
S: *Lake. Oh, Panther.*
I: *But Adirondacks—you can see it's a name also?*
S: *Because is capital letter A.*

World Knowledge. Learners frequently used their knowledge of the theme and topic of the reading text in inferring the meaning of an unknown word:

(4) I: *I should be doing this on video instead of on tape, because your hand is showing me . . . that . . .*
S: *Oh . . . when the liquification . . . liquide devient [liquid becomes][10] . . . the snow become liquid . . . and it go liquid . . . I think so, I think I see the meaning.*
I: *How did you figure out the meaning? Or how did you see the meaning?*
S: *You know when the snow comes and where sun and the snow become liquid . . .*
I: *Okay, but how did you decide that that's what this word meant? Melts. You're describing it to me, but how did you, how did you . . .*
S: *Oh, because I see enters lakes and rivers and because fall snow go to enter lakes and rivers.*

In this example, both world knowledge and discourse knowledge sources may have been activated in the inferencing process.

Discourse and Text. Learners occasionally used information from other parts of the text (i.e., beyond sentence boundaries) in guessing the meaning of the target word. In our data, this appeared limited to semantic information, but learners may have used their knowledge of cohesive devices in making discourse level semantic links:

(5) S: *Second is hard to answer. Because I don't know what is pH. The pH may be the measure of the pollution. I don't know. When this snow melts in the spring, will be go into the river and lake so is make pollution you know because when the snow have lots of acid. So when it run the pollution in the river and lake. The normal pH only 7, this when the spring runoff, the degrees to only have 5. Something like this, I don't know.*

Two learner knowledge sources, discourse knowledge (from the first clause of the previous sentence) and world knowledge, appear to interact here in extracting a meaning for the target word.

Homonymy. Several learners used their knowledge of sound relationships to guess the meaning of an unknown word. This is based on the phonetic similarity

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between the target word and another word in the learners' mental lexicon and, although sometimes useful, is often a source of confusion and misunderstanding:

(6) I: *Melts?*
S: *Uh hum.*
I: *So what did you do with these words?*
S: *Yes, this is . . . sentir [smell]. I know this word. No, no. I don't know melts. I smell, oh smell, no it's smell.*
I think smell . . . uh . . . I don't know this word.

Knowledge of Word Associations. Knowledge of word associations was sometimes used to infer the meaning of an unknown word:

(7) I: *Accommodated?*
S: *Yeah.*
I: *What did you do with that?*
S: *Accommodated I guess from accommodation. We have a . . . hotel reservation, maybe is called, that phrase is accommodation.*
I: *Okay, from a hotel reservation, accommodation. Okay. Good. And that's it?*
S: *Okay.*

In this task, two knowledge sources appear to have been used: word associations and word derivations.

Cognates. Knowledge of word cognates[11] (mainly English and French in this study) was sometimes used in inferencing:

(8) S: *The paragraph 4 say that perhaps the . . . acid rain is . . . is most controversial environment issue. But the study . . . has . . . make, has made . . . to here, is not . . . suffisant [sufficient], in French. For clear the effect of . . . effect of this . . . question means acid rain on the environment. But I don't understand very well controversial. I think it, it don't have the means of controverse [controversy] in French. Because the controverse in the French is . . . don't understand controversial. I can guess, but, but . . . so . . .*

In this example, although it is evident that the learner is drawing on his or her knowledge of English and French cognates to infer the meaning of the unknown word, this knowledge source seems to be more misleading than helpful in the process.

Interpreting Inferencing in Terms of the Model. Examples from the reading study can also be used to illustrate learners' attempts to identify the constituents of the missing lemma (e.g., its grammatical category, argument structure, conceptual elements); and in other words, to fill its "empty structure." The preceding examples can be analyzed not only for the knowledge sources drawn upon but also in terms of the new lemma-level knowledge that is generated. Example 3, used to illustrate the use of punctuation information, also reveals that the learner inferred at least the following lemma components for Adirondacks:

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syntactic category: noun

conceptual specification: proper noun

syntactic specification: count

The following example illustrates this process for the verb *melts.*

(9) S: *No, no. I don't know melts. I smell, oh smell, not its smell. I think smell . . . uh . . . I don't know this word. When the snow . . . uhm . . . this is uh . . . you have snow, when the snow liquification . . . and. . . .*
I: *I should be doing this on video instead of on tape right, because your hand is showing me . . . that . . .*
S: *Oh . . . when the liquification . . . liquide devient [liquid becomes] . . . the snow become liquid . . . and it go liquid . . . I think so, I think I see the meaning.*
I: *How did you figure out the meaning? Or how did you see the meaning?*
S: *You know when the snow comes and where sun and the snow become liquid . . .*
I: *Okay, but how did you decide that that's what this word meant? Melts. You're describing it to me, but how did you, how did you . . .*
S: *Oh, because I see enters lakes and rivers and because fall snow go to enter lakes and rivers.*

In this example, the learner first attempts word retrieval and comes up with a similar-sounding word. He then realizes that *melts* is not related to *smell.* He proceeds to infer the meaning. He first notices that it is something that snow *does* and indicates in this way that he perceives its *syntactic category* as that of verb and that one of its *grammatical functions* is subject (*snow*). He then considers what its conceptual specification might be, going from the parallel construction in which *snow* appears with a verb he knows, *enters: The snow enters lakes and rivers.* Its doing this implies a change of state ("becoming liquid," as he expresses in his L1). He has, thus, identified the core meaning of *melts,* as well as the following *diacritic parameters:* tense, person, and number.

Lemma features of the noun phrase *Clean Air Act* are inferred in the following example:

(10) S: *Yeah. I want to see . . . Can I . . . if I can't take the hold . . . if I understand this the federal Clean Air Act . . . I don't understand what is that Clean Air . . . this is a federal Clean Air, oh this is department of . . . I don't know what is exactly . . . this is part of law. I have exam I can give answer, but uhm . . . this is I can see . . . this law is outdistanced by the evenement [event] . . . by the knowledge . . . This law, the federal Clean Air is outdistanced by new knowledge. Their mandat [mandate] . . . oh comment [how] say that . . . they have to . . . now . . . this is what I see.*
I: *Okay. Good. Well we do know there was a word, drawback, that made it difficult for you to answer the question, but you've tried to look at it, at the paragraph, and figure out what it means.*
S: *Yeah, because I just read this, I see the federal Clean, and this is law, this is amended in 70s around. Expired in . . . all this writing continues on extensions outdistanced by the growing connaissance [knowledge] et [and] knowledge about air pollution. They say they have some progress and this law is outdistanced. But when they say what is the main drawback of the Clean Air Act, I see . . . I see this Air Act is outdistanced of the relative now.*

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In this example, the learner is able to infer some lemma elements of *Clean Air Act.* He identifies *Act* as a noun, which heads a noun phrase as a complement to the verb *is,* and it is probable but not clear that he has inferred that it is a proper noun. He refers to it once with the indefinite determiner *a,* so he appears to know that *Act* is a count noun. He infers its semantic domain from *federal* and sees that it is *part of law.* Therefore:

conceptual specification: count
syntactic specification: noun
relations to complement: NP
diacritic parameters: number (*-s*)
determiners: *this, the, a*

As the preceding examples illustrate, the kinds of knowledge and contextual information that learners use in inferring the meanings of unknown word forms (lexemes) and the syntactic and semantic (lemma) features they identify when reading conform to the mental lexicon components in the adapted model.

CONCLUSION

In this paper we have discussed the importance of a language processing model as a basis for further theory development in second language vocabulary acquisition and considered an adapted version of Levelt's (1993) lexically based model of L1 speech processing as a useful model for this purpose. Of particular interest is the model's *lemma* component of the mental lexicon that mediates between preverbal concepts and word forms. We propose that this model provides a useful theoretical framework for further study of the process by which L2 learners gain lexical knowledge from L2 input. Learner data from an introspective study of L2 lexical inferencing has been used to illustrate the potential of the model to account for the kinds of knowledge and cues sought by learners inferring new word meanings for reading comprehension and how learners' attempts to infer the meanings of unknown words in written texts can be understood as an initial stage in lemma construction in the mental lexicon. Further theoretical specification of this lexical level will be needed as research in second language vocabulary acquisition progresses—for example, to clarify possible relationships between L1 and L2 lexical knowledge and to specify how successful inferencing of lemma features during L2 input processing may lead to lexical acquisition. As it stands, the lexical component of the model provides a useful organizational framework for research, which has proven relevant to our analysis of word inferencing from written texts. Similar evidence from other kinds of language input and other kinds of learners, and, eventually, from typologically different languages, should further clarify the strengths and shortcomings of the conceptualization of the mental lexicon presented by the model for L2 vocabulary acquisition research.

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NOTES

1. Relations to COMP has to do with the syntactic setting of a verb. In a formal style, verbs like *doubt* have to be followed by a *that* clause, which is the complement of that verb. In some languages the relation to COMP is stricter than in others. For example, in Dutch, verbs like *denken* ("think") and *hopen* ("hope") have to be followed by a *dat* ("that") complement.

2. In the present version of the model, it is not always clear how word formation takes place. There is evidence that word stress can have an impact on the word formation process in a very late stage, that is, when the phonological elements are inserted in the lexical frames. How newly formed words such as *holiday-wise* are constructed is still an open question. One solution could be that the conceptual meaning of *-wise* in the preverbal message leads to the activation of a morphological procedure that combines the stem of the related lemma with the *-wise* morpheme.

3. Introspective and think-aloud methods of data collection, which attempt to gain insights into the workings of the learners' minds as they try to perform certain tasks, have gained increasing prominence in SLA research as a complement to so-called objective data. These methods have both merits and shortcomings (Faerch & Kasper, 1987; Mann, 1982). The indisputable merit of introspective data is that there is no other way to access learners' thoughts and perceptions, leaving researchers to only speculate about learners' mental activities. However, introspective data may be unreliable, as learners vary in their ability both to introspect and to report their thoughts. The latter problem is compounded by learners' limited communicative abilities in the L2. Reliability can, on the other hand, be improved by training subjects in think-aloud procedures and, when possible, conducting the introspection in the learners' language of choice.

4. The purpose of using two comprehension tasks in the study was to examine the influence of task on learner strategy use and to investigate whether the tasks differentially made words salient to the learners and engaged them in lexical processing. Although the nature of the task influenced the number of words identified as unknown and the particular words learners chose to deal with, the inferencing strategy was of similar importance for both tasks.

5. Further analysis demonstrated that learners ignored unknown words for a variety of reasons (e.g., because they were not considered relevant to doing a given task, because they perceived them as unimportant or too difficult, and because they could do the task without knowing the exact meanings of those words).

6. As would be expected, learners differed in both strategy preference and reliance on different knowledge sources. However, the use of inferencing and major knowledge sources reported here were representative, with the notable exception of a student for whom the text was much too difficult. See Paribakht and Wesche (1996b) for further details.

7. The retrieval strategy is the strategy of repeating the target word out loud or rereading it several times. The purpose appears to be "buying time" while making the phonetic or graphic form of the word more salient in an attempt to retrieve it—for instance:

I: *Okay, and I noticed that you . . . when you were reading the first sentence, you stopped at the word "bleak," and you repeated it, and then you kind of paused. Can you tell me what you were thinking when you did that?*

S: *"Bleak." No I just eh . . . because I was . . . what do I want to say . . . I was repeating because I wasn't sure the meaning of the word "bleak," so I kept repeating, repeating, to see if, to see if it sounded familiar because it's a word that sound familiar. So I kept repeating.*

8. The strategy of appeal for assistance was used in the form of directly asking for assistance or verifying the meaning of the target word in a dictionary when in doubt. For instance:

S: *Fossil fuel. What's that mean? Can you pronounce this?*
I: *Fossil.*

In this example (direct appeal), by asking for the pronunciation of the target word, the subject seems to try to tap a different input mode that may help him to infer the meaning of the target word. Learners sometimes use both input modalities in trying to get the meaning. This is particularly pertinent when a learner recognizes a word in spoken form but not in written form, especially in a language with complex phoneme or grapheme correspondence such as English. This may often be the case in a second, as opposed to foreign, language learning context where the spoken forms of many words are more familiar than the written forms.

9. Periods (. . .) indicate a pause, and question marks (???) indicate an inaudible word.

10. English translations of French words are provided in brackets.

11. It can be argued that lemmas from different languages may be connected to the same lexeme. There

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is some evidence that word forms are shared by different languages. Clyne (1987) provides examples of trigger words, that is, words that are similar in form between two languages and that appear to act as switching points between those languages. It is very likely that what "counts" as a cognate may be dependent on level of proficiency and whether the language is spoken or written. Words like Dutch *bank* and English *bank* may be cognates in the visual mode and for incipient Dutch learners of English in the auditory mode, but with the elaboration of the phonological differences between the two languages the sounds that are treated as similar become differentiated, and thus the lexemes become independent of each other.

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APPENDIX

ACID SHOCK

For almost half the year, most of northeastern North America is covered in a thick layer of snow. Hibernating among the snowflakes, awaiting the bears of springtime, is a potent dose of sulfuric acid that, when released in the spring runoff, packs the knockout wallop of a heavyweight prizefighter.

As the snow melts and enters lakes and rivers, parts of these bodies of water can become as much as 100 times more acidic in a very short time. "While this acid bath usually only lasts for a few days to a few weeks, the pH values are often acutely lethal even in lakes that otherwise do not appear to be in danger," Dr. David Schindler of the Freshwater Institute in Winnipeg—a pioneer researcher into effects of acid rain on fish—told an Ontario government committee investigating acid rain. As an example, Dr. Schindler pointed out that Panther Lake in the Adirondacks normally has a pH of 7. But in the spring runoff it drops to a pH of 5.

Yet the air pollution picture is not totally bleak. Continuing research offers some hope of improvement. In late 1986 two scientists reported a chemical process capable of eliminating nitrogen oxides from diesel exhaust gases and coal-fired boilers. The hot gases, passed over a nontoxic chemical called cyanuric acid, break down into harmless nitrogen and water. If later research supports the findings, a giant step could be taken toward eliminating a major contributor to acid rain and man-made ozone.

Perhaps the most controversial environmental issue of the decade is acid rain, but that too is clouded in mystery. "We are in the infancy of understanding the full effects of an atmosphere acidified by burning fossil fuels," Dr. Chris Bernabo, an air-quality expert, told me. "In order to really understand it, we must conduct years of research."

The federal Clean Air Act of 1970, amended in 1977, expired in 1981. As of this writing it continues on extensions, outdistanced by the growing knowledge about air pollution.

We live on a forgiving planet, with mechanisms to deal with natural pollutants. Decay, sea spray, and volcanic eruptions annually release more sulfur than all the power plants, smelters, and other industries in the world. Lightning bolts create nitrogen oxides just as automobiles and industrial furnaces do, and trees emit hydrocarbons called terpenes. Their release triggers a bluish haze that gave the Blue Ridge its name.

For millions of years the ingredients of such substances have been cycling through the ecosystem, constantly changing form. They pass through plant and animal tissues, to sink into the sea, return to the earth, and are vaulted aloft in some geologic event to begin the cycle again. An atom of oxygen completes the cycle approximately once every 2,000 years. A portion of the next breath you take could have last been breathed by Jesus.

Can the earth assimilate the additional 70 million tons of sulfur that we release each year? What happens to plants that absorb the additional nitrogen oxides (NO_x) we create with our miniature lightning bolts inside car cylinders? Can the atmosphere take on the extra load of carbon dioxide (CO_2), methane, man-made ozone, and chlorofluorocarbon refrigerants that scientists say could raise global temperatures by the greenhouse effect?

Such chemical increases can be accommodated somehow, over time. Earth has plenty of that, but do we?

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