SYNTACTIC PRIMING OF NOUNS AND VERBS IN CHINESE

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Language and Speech, 2001, 44(4), 437-471

Abstract

Syntactic priming of Chinese nouns and verbs was investigated, in word recognition (cued shadowing of auditory targets) and production (picture naming). Disyllabic compound words were presented after syntactically congruent, incongruent or neutral auditory contexts, with a zero delay between offset of the context and onset of the target. Significant priming was observed in both tasks, including facilitation as well as inhibition. Post hoc analyses showed that reaction times were also affected by sublexical variables that are especially relevant for Chinese, including syllable density (number of word types and tokens in the language with the same first or second syllable) and semantic transparency (whether the meaning of the whole word is predictable from the separate meanings of the two syllables within the compound). These patterns suggest competitive effects at the sublexical level. Implications for interactive models of lexical access are discussed.

1 Introduction

The grammatical and lexical features of Chinese differ in many important respects from the Indo-European languages that have been studied extensively in psycholinguistic research (Chen & Zhou, 1999; Li, 1998; Zhou & Marslen-Wilson, 1995). These include the near-absence of inflectional morphology, complemented by a rich and productive system of lexical compounding. In the present study, we exploit these differences to study the interplay between syntactic context and lexical access. Two different techniques are used in a single within-subjects design, to compare the recognition and retrieval of nouns and verbs following a syntactically congruent, incongruent or neutral lead-in phrase. In Part I, we compare syntactic priming of nouns and verbs, in a word production task (picture naming) and a word recognition task (cued shadowing, in which participants repeat an auditory target word signaled by a voice shift—Bates & Liu, 1996). In Part II, the same data are reanalyzed post hoc, to explore some of the variables (in addition to syntactic priming) that influence lexical access of nouns and verbs in this language, in both experimental tasks. In the end, we integrate Parts I and II by investigating the contributions of the same lexical variables to priming scores. Before describing the experiments and our results, we offer a brief review of current controversies regarding the existence and nature of syntactic priming effects (which motivated our selection of priming tasks), followed by a short description of the relevant properties of Chinese for an inquiry of this kind.

1.2 *On syntactic priming and task parameters*

The existence of syntactic priming is now well established (e.g., Balota, Paul, & Spieler, 1999; Goodman, McClelland, & Gibbs, 1981), but its interpretation is still a matter of debate. Two unpublished studies from our laboratories have shown that the time required to name or repeat an English noun or verb can be faclitated or inhibited by simple syntactic contexts such as "I like the ___" or "I want to ___", relative to neutral contexts such as "Now please say ___" (Federmeier & Bates, 1997; Liu, 1996). Recent studies of Italian (Bates, Devescovi, Hernandez, & Pizzamiglio, 1996; Bentrovato, Devescovi, D'Amico, & Bates, 1999), French (Grosjean, Dommergues, Cornu, Guillelmon, & Besson, 1994), German (Hillert & Bates, 1996; Jacobsen, 1999), Spanish (Wicha, Bates, Hernandez, Reyes, & Gavaldón de Barreto, 1997) and Russian (Akhutina, Kurgansky, Polinsky, & Bates, 1999) have shown that prenominal modifiers embedded in a short auditory phrase or a longer sentence context can prime the nouns they modify. Specifically, modifiers matching in grammatical gender can *facilitate* lexical access (decreasing reaction time relative to a neutral baseline) while modifiers with mismatching gender can *inhibit*, *suppress* or *interfere* with lexical access (increasing reaction times relative to the same baseline). These findings for gender complement and extend earlier studies showing that case and gender marking on prenominal adjectives can prime word access in Serbo-Croatian (Gurjanov, Lukatela, Lukatela, Savic, & Turvey, 1985; Gurjanov, Lukatela, Moskovljevic, & Turvey, 1985; Lukatela, Kostic, Feldman, & Turvey, 1983).

Although these effects are robust across structurally distinct languages, their interpretation is controversial. Wright and Garrett (1984) were among the first to show that lexical decisions to target words are easier to make when those words are compatible with the grammatical context. Friederici and Schriefers have shown that reaction times to content words are slowed following a syntactic violation (Friederici & Schriefers, 1994; Schriefers, 1993). However, because their effects were largely inhibitory in nature, these authors concluded that grammatical priming only operates after lexical access is complete, affecting the time required to integrate that word into a phrase or sentence context (for a discussion, see Friederici & Jacobsen, 1999). If this interpretation is correct, then terms like "sentence priming", "phrasal priming", "syntactic priming," "grammatical priming"or "structural priming" are all misnomers, because they do not involve a change in the process by which words are accessed in the first place (O'Seaghdha, 1997; but see Balota et al., 1999, for a different view).

Table 1 summarizes several diagnostics that have been offered to distinguish empirically between "true priming" (i.e., which affects activation within the lexicon) and "pseudopriming" (including prelexical "guessing" and postlexical integration) (Bates et al. 1996; Bentrovato et al., 1999; Hernandez, Bates, & Avila, 1996; Hernandez, Fennema-Notestine, Udell, & Bates, 2001; Neely, 1991). For example, lexical priming effects are regarded as automatic if they elicit a rapid response, in very short time windows (< 250 ms between prime and target), demonstrating facilitation relative to neutral baseline, in tasks that do not require metalinguistic judgments (which are assumed to involve postlexical steps that mask or obscure automatic priming). Most of the grammatical priming studies cited above meet these criteria, with one exception: grammatical priming cannot (by definition) use low ratios of semantically related material. In word-word-priming studies, low relatedness ratios are used to keep subjects from noticing the relatedness manipulation. This is done because of concerns that awareness of the manipulation will set off conscious, expectancy-based strategies that are peculiar to word-word priming tasks, and do not generalize to real-life language use. In connected discourse, the situation is very different. Because normal listeners always expect the upcoming word to fit the context, sentential or phrasal priming tasks that encourage this kind of integration may reflect a mix of automatic and expectancy-based priming that resembles the processes used in informal discourse, generalizing well to sentence-word interactions in real life.

With this exception (which, in our view, increases the ecological validity of sentence-level priming techniques), the two syntactic priming tasks used below were designed to meet all the criteria in Table 1 for distinguishing between automatic and strategic effects. Both tasks require rapid response to targets. In both tasks, there is also a minimal delay (0 ms) between offset of the auditory syntactic context and onset of the word or picture target (although, as in all auditory phrase- and sentence-priming tasks, processing of the lead-in phrase may begin well before its offset). The two tasks employ response modalities (i.e., auditory word repetition and picture naming) that do not require metalinguistic judgments or any other postlexical operation other than the motor processes required to articulate the target word (which the two tasks share). In the cued shadowing task, participants are asked to repeat auditory target words embedded in an auditory carrier phrase; they know which word to repeat because the target is signaled in some fashion (in our case, by a switch in the sex of the speaker's voice, spliced into the carrier phrase). The task is very easy for participants to understand, yielding significant priming even in very young children as well as brain-injured adults (Bates & Liu, 1996). We view cued shadowing as the auditory (intramodal) analogue to the oft-used cross-modal word-naming task, in which participants hear a lead-in word, phrase or sentence and read target words off the computer screen (at various intervals from the end of the auditory prime). Although word naming also requires a motor response (pronouncing the word), it is widely regarded as a technique for the assessment of word recognition rather than word production. By the same logic, we view cued shadowing as a technique for assessing word recognition despite the requirement of a vocal response, because it does not require the additional step of word retrieval that must be carried out in the picture-naming task. In fact, it is a significant advantage that cued shadowing and picture naming share the same output modality, because the contrast between these tasks permits us to distinguish more precisely between word recognition and word retrieval.

If facilitative or anticipatory effects of grammatical information on lexical access can be found in Chinese for these two tasks, then the case is strengthened for interactive-activation models in which different sources of information are combined, quickly and in parallel, to predict the identity of an upcoming word (see also Allopenna, Magnuson, & Tanenhaus, 1998; Balota et al., 1999; Elman, 1990; MacDonald, Pearlmutter, & Seidenberg, 1994; MacWhinney & Bates, 1989; Marslen-Wilson & Tyler, 1987; van Petten, Coulson, Rubin, Plante, & Parks, 1999). However, we acknowledge alternative explanations for such facilitative effects, including a cascading system of parallel modules that feed each other partial products, and/or architectures that permit "pre-integration" (context effects that prepare the way for extremely rapid postlexical integration (Altmann & Steedman, 1994; O'Seaghdha, 1997). Our main goal is not to distinguish between these alternatives (which, as Altmann and Steedman note, may be impossible to differentiate on strictly empirical grounds), but to explore the syntactic priming of Chinese words in tasks that should, because of their demand characteristics, generalize well to real-life language use.

Before proceeding to the experiments, a brief review of the relevant lexical and grammatical properties of the

Chinese language is in order, to explain why the study of syntactic priming may be especially illuminating in this language.

1.3 Design features of Chinese: Implications for lexical access

The language under study here is Mandarin Chinese, the official language in both Taiwan and Mainland China. For the sake of economy, we will use the single term "Chinese" to refer to the Mandarin dialect, although we note that the design features manipulated in the present study are shared with other dialects of Chinese.

There is a growing body of new research on lexical access in Chinese. However, most of this work has been carried out in the visual modality, exploiting the interesting difference between alphabetic and logographic codes (Chen & Tzeng, 1992; Perfetti & Tan, 1998). Studies of spoken word processing in Chinese are much less common, including studies of the role of lexical tone in lexical access (e.g., Cutler & Chen, 1997) and studies focusing on the high degree of homophony that exists in Chinese for individual syllables and for some compound words (Li & Yip, 1998). The present study will focus on lexical access of nouns and verbs in an auditory context, for auditory word recognition (assessed with a cued shadowing technique) and for word production (assessed with picture naming). Hence the logographic features of Chinese that have been studied to date will play a less important role than the grammatical and lexical features of the auditory language, which we will now describe.

Chinese has no conjugation paradigms (i.e., no inflections for tense, aspect, person or number on verbs) and no declension paradigms (i.e., no inflections for gender or number on nouns and/or their modifiers). Instead, grammatical relations are conveyed through a combination of word order regularities (see below), free-standing grammatical function words, and a small set of particles (e.g., aspect markers on verbs). The latter can be viewed as bound morphemes (based on standard tests for interposition), but they are fixed in form and meaning and do not undergo the kind of variation that characterizes inflectional paradigms in other languages. Furthermore, they are obligatory only in highly constrained semantic and syntactic contexts. The near-absence of inflectional morphology in Chinese means that nouns and verbs cannot be distinguished reliably on the basis of inflectional form alone. This is often true for English as well (e.g. "the comb" vs. "to comb"), though to a lesser extent. In fact, natural languages can be arrayed along a continuum of form-class ambiguity, with Chinese at one extreme, richly inflected languages like Italian at another, with English falling closer to the Chinese end of the spectrum.

The canonical or pragmatically neutral word order in Chinese is Subject-Verb-Object (SVO), similar to many Indo-European languages. However, Chinese permits several pragmatically conditioned word order variations that would be illegal in English, including SOV, OSV and VOS (Li & Thompson, 1981; Li, Bates, & MacWhinney, 1993; Lu, 1980). Complicating matters further, Chinese also permits omission of both the subject and the object in free-standing declarative sentences. Thus, it is not uncommon to encounter a sentence fragment in the order VN, which may be interpreted either as Verb-Object (canonical order) or as Verb-Subject (noncanonical order); conversely, one may encounter a sentence fragment in the order NV, which may also be interpreted either as Subject-Verb (canonical order) or Object-Verb (noncanonical order). In everyday language use, the choice between canonical and noncanonical interpretations rests on a complex interplay of lexical, semantic, pragmatic and/or prosodic factors. Taken out of context, many different orders are possible, and even though some combinations may be judged as "odd" when Chinese listeners are asked to judge their well-formedness (Liu, Bates, & Li, 1992), almost any combination can be interpreted reliably by native speakers (Li, 1996, 1998). This extensive word order variation means that verbs and nouns cannot be distinguished reliably based on sentence position alone.

Although Chinese has virtually no inflectional morphology, it does rely heavily on compounding to create complex words (for an extensive discussion, see Bates, Chen, Li, Opie, & Tzeng, 1993; Zhou, Ostrin, & Tyler, 1993). In fact, approximately 80% of all word types in Modern Chinese are compounds comprising two or more components (single-syllable morphemes) (Chao, 1968; Li & Thompson, 1981). In most cases, each component has its own meaning, expressed as a single syllable in the spoken language and a single character in the written language. However, the separate meanings of the sublexical elements are often modified when they are combined in a compound, sometimes to the point where the meaning of the whole word bears no transparent relationship at all to the meanings of the syllables that comprise it. This potentially important dimension of "semantic transparency" will be taken into account in the studies presented below.

Across the language as a whole, two-morpheme compounds are by far the most common word type. Indeed, it has been argued that Chinese is rapidly evolving toward a situation in which all (or almost all) open-class words contain at least two morphemes, including some with "dummy" elements like the affix *zi* added to maintain a bisyllabic rhythmic pattern (Chao, 1968; Li & Thompson, 1981; Wang, 1947). Some implications of the effect of word type are discussed by Chen, Andersen, Kempler, and Bates (1992), who have shown that differences in word type frequency affect performance by aphasic patients in word production tasks. Both fluent and nonfluent patients tend to give their best performance on disyllabic words; they both tend to omit one of the elements in trisyllabic words, and both sometimes add an extra element on monosyllabic word targets. Because it is unusual for nonfluent patients to add extra morphemes (i.e., omission is a more common error for these patients), this finding testifies to the strong pull of disyllabic structures for speakers of this language. In the present study, all lexical targets will be disyllabic compounds.

Complicating matters further, there are many cases in Chinese in which the compound itself and the open-class morphemes that it contains belong to different grammatical categories. This includes VN nouns like *la-lian* (literally PULL-CHAIN), which means "zipper", and VN verbs like *da-tie* (literally STRIKE-IRON), which means "to forge". Hence category membership can be assigned at two levels: the whole-word level, and the level of word components. Although Chinese permits many different compound types, the most common word structure for nouns is NN or Noun-Noun, while the most common word structure for verbs is VN or Verb-Noun (Huang, 1991; Dictionary of Frequency of Modern Chinese Words, Beijing Language Institute, 1985). In the present study, it will be necessary to vary the sublexical structure of our disyllabic targets, but these variations will be taken into account in post hoc analyses in Part II of the paper.

All of these facts about Chinese pose an interesting challenge to research on lexical access, in and out of context (Li & Yip, 1998; Zhou & Marslen-Wilson, 1995; see also papers in Chen & Zhou, 1999). Specifically, lexical access in Chinese (both comprehension and production) may be more context dependent and less form dependent than the corresponding processes in many Indo-European languages.

2 Method

2.1 *Participants*

Sixty native speakers of Mandarin Chinese (17 males, 43 females) participated in both tasks, in counterbalanced orders (30 with picture naming first; 30 with cued shadowing first). An additional 31 native speakers participated in word and picture familiarity ratings (20 participated in word rating, 20 in picture rating, including nine who participated in both). All participants were undergraduate students in one of two universities in Taiwan, who volunteered for course credit or were paid a small sum (100 Taiwanese dollars, approximately 3 U.S. dollars) for their participation. The average age for participants in the main experiment was 20 years, 8 months (range = 18-26 years).

2.2 *Materials*

2.2.1 *Auditory sentence contexts*

Because of the design features described above, it is no trivial matter to find phrase or sentence contexts that reliably distinguish between nouns and verbs. The two word classes are rarely distinguishable based on their surface form, and care must be taken to find syntactic contexts that unambiguously call for a noun or a verb, distinguishable from each other and from full phrases with similar form (Chen & Shi, 1992; Zhu, 1981). For the syntactic priming manipulation, nine sentence contexts were prepared (3 neutral, 3 noun contexts, 3 verb contexts—see *Appendix*); all were semantically neutral, providing information only about form class (in the respective noun and verb contexts), with no other syntactic or semantic information of any kind. Within the lists described above, assignment of items to one of the three lead-ins for each condition was random.

2.2.2 *Picture/word targets*

A total of 144 pictures designed to elicit specific names were chosen for the two experimental tasks, including 72 target object pictures, 72 target action pictures (and corresponding verbs), and another 18 practice items (9 objects and 9 actions). All pictures were black-and-white line drawings of common objects and actions (Abbate & La Chappelle, 1984a, 1984b; Dunn & Dunn, 1981; Goodglass, Kaplan, & Weintraub, 1983; Snodgrass & Vanderwart, 1980; various other sources, including drawings commissioned for the purpose of the study). The word stimuli reflect the most probable names for the picture items, and were selected to fit the following constraints: All target words were two syllables long, and within the respective noun and verb categories, half were selected to be "semantically transparent" (the meaning of the whole word is systematically related to the independent meanings of each of the two syllables within the word) and the other half were judged to be "semantically opaque" (the meaning of the whole word is not predictable from the separate meanings of the two syllables within that word; indeed, in some cases one or both of the participating syllables has no independent meaning in Chinese). A complete list of the expected word stimuli is provided in the *Appendix*. All but two words selected for this study were unambiguous in form class, that is, we avoided words that could be used (without any change in form) as both a noun and a verb. One word that could be used as both a noun and a verb was *tiao-sheng* (literally JUMP-ROPE), which means 'rope jumping' if used as a verb and 'jump rope' if used as a noun. The other word was *zhi-hui* (literally GUIDE-WAVE), which means 'conducting' if used as a verb and 'conductor' if used as a noun. Each of these items was used twice, once as a verb and again as a noun (in counterbalanced orders). These two items were included because we were unable to find enough unambiguous and picturable noun and verb items to complete the design without this compromise. As noted in more detail below, we eliminated any item eliciting accuracy or reaction time scores more than two standard deviations from the overall mean. Hence, if these two items proved to be outliers, they would be excluded prior to further analysis. This did not prove to be the case.

The 72 nouns and 72 verbs were randomly divided into three sets of 24. These subsets were used to construct three lists, so that each item had an opportunity to be represented in the congruent condition on one list, the incongruent condition on another list, and the neutral condition on a third list. Hence each participant (randomly assigned to a list) heard or saw each item only once within a given task, but items had an equal opportunity to be represented across conditions, and participants received an equal number of congruent, incongruent and neutral items. For each participant, the same list was used in both cued shadowing and picture naming; the two tasks were presented in counterbalanced orders (half received picture naming first; half received cued shadowing first).

Auditory stimuli (both target words and auditory contexts) were read by native speakers and digitally recorded in a soundproof chamber, and transferred onto a Macintosh computer as individual SoundEdit 1.0 files. Sentences were recorded in a male voice and target words were recorded in a female voice (see Bates & Liu, 1996, for a discussion of voice shifting in the cued shadowing task). For the sentence contexts, a normal rise-fall declarative sentence intonation was employed. For the auditory targets, recordings were made in an intonation intended to sound maximally natural at the end of any of the auditory contexts (within the constraints imposed by lexical tone in Chinese).

The words and sentences were cleaned (blank spaces before and after the utterance removed) and sound labels were placed at the beginning and end of each sentence, and at the beginning and end of each word. Reaction times were calculated from the end of each phrase, which coincided as closely as possible to the onset of the target (SOA = 0 ms). Once this process was completed, they were converted into individual PsyScope files (Cohen, MacWhinney, Flatt, & Provost, 1993) for experimental presentation. The length of the auditory contexts (excluding the interval in which pictures were presented) averaged 1135 ms (with a range from 1064 to 1258). Broken down by type, this corresponds to means of 1100 ms for the verb contexts, 1132 ms for the noun context, and 1173 ms for the neutral contexts.

We had restricted our selection to disyllabic nouns and verbs in part to insure that the two word classes did not differ in length (which could have provided an unintended cue to form class). However, to ensure that the two classes did indeed match, we also conducted an analysis of variance over items comparing noun and verb stimuli for length in milliseconds of the digitized words. There were no significant differences in length ($p > .24$). Overall, auditory words averaged 693 ms from onset to offset (s.d. = 60). The mean for nouns was 699 ms ($SD = 61$) and the mean for verbs was 687 ms ($SD = 60$).

Kelly and colleagues (Cassidy & Kelly, 1991; Kelly, 1992) have shown that English nouns and verbs differ systematically (though imperfectly) in prosodic features, including lexical stress. For example, disyllabic verbs tend to be stress final (e.g. 'to record'), while disyllabic nouns are more likely to carry initial stress (e.g. 'the record'). In contrast with English, disyllabic Chinese nouns and verbs do not differ systematically in tone or those subphonetic correlates of tone that overlap with lexical stress in English (e.g. amplitude). Informal inspection of the materials in the *Appendix* shows that there are no salient tone pattern differences between our noun and verb stimuli.

The picture targets were digitized images set in black outline on a white background. Individual files were created for each image, so that they could be called into the appropriate sentence during on-line presentation. The time between offset of the auditory context and onset of the picture was placed at zero.

2.2.3
Predictor variables

In addition to the matches for form class, length and semantic transparency that went into the design of the two experiments, we obtained a series of additional measures for all our target words, for use in the post hoc analyses described in Part II of the results. These include some that are quite familiar in research on Western languages, such as log frequency (estimated from written corpora) and ratings of both word and picture familiarity. In addition, we included predictors that reflect some of the special features controlling word formation in Chinese.

For all word targets, we derived measures of written word frequency at the whole-word level (Chinese Knowledge Information Processing Group [CKIP], 1993). In addition, all pictures and their associated target words were rated for familiarity. These ratings were provided by a separate set of 20 undergraduates, who rated the items for (1) familiarity of the word (on a 5-point scale, from 1 for low to 5 for high familiarity), and (2) familiarity of the object or action illustrated by each picture (also on a scale from 1-5).

Measures of neighborhood density (type and token, calculated separately for the first and second syllable) were also computed from CKIP, 1993 (see Zhou & Marslen-Wilson, 1995, for some interesting differences between first- and second-syllable effects.) These calculations of syllable density bear some explanation, because they reflect a peculiarity of Chinese that is not encountered in Western research on lexical access. Because written Chinese is not alphabetic, there is no direct equivalent of orthographic neighborhood density, and it is difficult to estimate phonological density from written corpora. In the written language, there is typically a direct mapping between single syllables at the spoken level and single characters at the written level (although many syllables are homophones that map onto more than one character). Most of these syllables occur over and over again across the language, within many different compound words. Hence, whether we are talking about spoken or written word access, the syllable is a natural unit in Chinese for the assessment of competitor effects. This rich sublexical structure (between sublexical syllables and their meanings) permits assessment of the separate and conjoint effects of density (at the level of word form) and transparency (at the level of semantic combinations). Density was measured separately for the first and the second syllable, and is defined as the number of words in the CKIP corpus that contain that syllable (regardless of its position within those words, i.e., first position, last position, or somewhere in between). Type density refers to the *number of different words* in the corpus that contain that target syllable; token density refers to the *absolute number of words* in the corpus that contain that target syllable. Finally, because the CKIP corpus is based on written material, all density calculations are based on logographic characters, rather than the spoken syllables that those characters represent. This is an important limitation, because Chinese syllables are often homophonic, and may be represented with different characters depending on the meaning that is intended. Hence written estimates of syllable density are likely to underestimate the number of neighbors that are active during auditory word comprehension.

Stimuli were coded 0 or 1 along a number of binary dimensions that might affect the time required to retrieve and produce an object or action name. One of these variables was semantic transparency (and its obverse, opacity). In semantically transparent words, the meaning of the whole is directly related to the meanings of the two sublexical components; in semantically opaque words the meaning of the whole is quite distinct from the meanings of the individual syllables considered separately. We did not treat semantic transparency as a factor in the priming experiment itself, because we knew in advance (based on previous studies by our research group) that it is likely to be associated with a host of other confounding variables. However, we made a point of balancing for semantic transparency across our noun and verb targets (36 transparent and 36 opaque within each noun and verb group), so that transparency effects could be explored together with other factors in the post hoc analyses described in Part II.

Another potentially interesting variable for Chinese is word structure typicality, reflecting the fact that Verb-Noun or VN structures are the most common verb form in the language, while Noun-Noun or NN structures are the most common word form for nouns. Verbs were categorized “1” for typical word structure if they took the VN form; nouns were categorized “1” for typicality if they took the NN form. If they did not fit the typical structure for their class, items were scored as “0”.

We also coded words for their compound status, which only applies to nouns in the present study. All of our verbs were true compounds, but a small proportion of the nouns were “monomorphemic disyllables”, typically foreign loan words, made up of syllables that are not found independently outside that word). Verbs were also coded independently for transitivity (coded “1” if they can take two or more arguments). Finally, we coded 1 or 0 for the presence/absence of an element in the target picture that corresponds to one of the sublexical elements in the compound (e.g., the presence of a wave in the picture intended to elicit *chong-lang*, the Chinese word for ‘surf’ that literally means DASH-WAVE).

2.3 *Procedure*

Participants were tested one at a time in a quiet cubicle. Stimuli were presented on a Macintosh Performa 6214 CD, using PsyScope presentation software (Cohen et al., 1993). Participants wore headphones with adjustable volume that were connected to the sound amplifier port of the Performa. The headset had a sensitive, built-in microphone that was connected to the Carnegie Mellon Button Box, a measuring device with 1-ms resolution designed for use with Macintosh computers. Response times were collected in milliseconds using the CMU button box, which was connected to the Performa modem port. The experimenter was present in the room, and hand-recorded all naming errors on a score sheet during testing. However, the participants were unable to see what the experimenter wrote or when entries were made. Because the experimenter did not wear earphones and could not hear the lead-in contexts, scoring was not influenced by syntactic context in which that item was presented for an individual subject).

At the beginning of each session, instructions were presented orally to the participants. The experiment began when the participants indicated that they understood the instructions. The sentences were randomly presented in a continuous sequence, in one of three random orders.

During the cued shadowing task (auditory presentation), a fixation point (+) appeared in the center of the screen. The lead-in sentence began, and was followed immediately (0 ms from offset of the lead-in phrase) by the auditory target word in a different voice. Participants were instructed to repeat the target word (signaled by the voice shift) as quickly as possible without making a mistake. In the picture-naming task, a picture appeared on the screen in place of the fixation point immediately after the end of the lead-in sentence. Participants were instructed to name the object or action as quickly as possible without making a mistake. The image remained on the screen for five seconds, or until the participants responded, whichever came first. An "NR" for no response was marked in the data file if the image disappeared prior to the participant's response. The trial ended when the experimenter pressed one of two buttons to indicate “correct” or “incorrect” response (nonresponses were scored as incorrect); this button press advanced the experiment to the next trial. Participants sometimes indicated that they knew they had made an inappropriate response, but the experimenter gave no feedback.

Prior to each of the two versions of the experiment, participants were given a brief practice session with the 18 practice stimuli (which were not used in the main experiment). They were instructed to speak directly into the microphone, as clearly as possible, to name the picture with a single word (if possible), and not to emit any other sounds (no clearing of the throat, no preparatory sounds like “Uhmmm”, etc.). Participants were allowed to continue when ready, by pressing any button on the keyboard. The entire experimental session lasted approximately 45 minutes for each task. The two tasks were administered in separate sessions, separated by at least one week. Most participants completed their second task within one to two weeks. One participant had a three-week span between tasks.

2.3.1
Scoring

For each participant, trials were coded to indicate invalid reaction times, due to extraneous noises, false starts, failures to trigger the voice key, or failures to respond within the time window. Then, based on hand scoring during the session (with audio-taped responses for review), we also noted any trials in which the subject produced an erroneous response. In the cued shadowing task, an error would constitute production of any word other than the auditory target. In the picture-naming task, responses were scored as correct if participants produced the expected target, a correct synonym, or a correct superordinate (hypernym) or subordinate (hyponym) description of that target. A name was scored as incorrect if participants produced a semantically incorrect response, or any response that changed the form class of the target (e.g., a nominal variant of a verb, or a verb variant of an intended noun target). For reaction time analyses, all invalid RTs and all trials with errors were eliminated. In addition, based on the overall mean for items, we eliminated any item with a mean RT more than two standard deviations from the mean on at least one task. This procedure for eliminating outliers (which is standard in on-line studies of lexical access) resulted in the exclusion of seven items (one noun and three verbs from picture naming—cowgirl, money-winning, paper-cutting, waking-up; two nouns and one verb from cued shadowing—magnet, hose, face-washing). Because task is treated as a within-participants and a within-items variable on analyses reported below, these seven items were eliminated from analyses of both tasks, and RTs for each condition were based on means for the remain-ing items.

In the same vein, we checked to see whether the mean for any participant produced RTs more than two standard deviations from the overall mean on either of the tasks. No participants had to be eliminated by this criterion. However, because of scheduling problems, two participants were unable to complete the second session (which involved the cued shadowing task in both cases). Hence analyses of the cued shadowing task are based on data for 58 participants. Data for all 60 were used in analyses of the picture-naming data, over both participants and items. The omnibus analysis only considers data for the 58 who participated in both tasks.

3 Results

3.1
Part I: Syntactic priming

3.1.1
Cued shadowing

*Errors***.** On the cued shadowing task, 1.6% of trials were eliminated for reaction time artifacts; there were no cases in which a participant failed to respond. With these trials removed, accuracy was very high, averaging more than 99%. Hence no further analyses were conducted on accuracy scores.

Response times. In the cued shadowing task, mean reaction times averaged around 760 ms (see Table 2 for details), with a standard error of 5.9 ms in the analysis over participants and 3.3 ms in the analysis over items. These averages are in the range that has been reported in previous cued shadowing tasks in other languages (e.g., Bates et al., 1996; Herron & Bates, 1997). Because the average duration of these disyllabic auditory words was 693 ms, this means that word repetitions typically began only 67 ms after word offset. Hence it is likely that many of the auditory targets were recognized before the word was over (see Part II for factors contributing to recognition latencies).

Response times were subjected to a 3 (syntactic context) by 2 (noun vs. verb) analysis of variance, over participants (F_1) and items (F_2). Comparisons with the neutral-control condition were reserved for post hoc analyses (simple F tests). Cell means for the significant effects are presented in Table 2.

There was a significant main effect of syntactic context in both analyses ($F_1(2, 114) = 28.24$, $p < 0.0001$; $F_2(2, 270) = 9.17$, $p < 0.0002$), reflecting faster RTs in the congruent condition, slower RTs in the incongruent condition, with neutrals falling in between. The main effect of form class was not significant, nor was the interaction between form class and context, indicating that the syntactic priming effect is equivalent for nouns and verbs in this task.

Post hoc analyses (simple effects) comparing the congruent and neutral conditions indicate that the facilitative component of this syntactic priming effect was significant ($F_1(1, 57) = 18.5$, $p < .001$; $F_2(1, 135) = 5.72$, $p < .02$). Analyses comparing the incongruent and neutral conditions indicate that the inhibitory component was significant as well ($F_1(1, 57) = 10.19$, $p < .01$; $F_2(1, 135) = 3.90$, $p < .05$). Although these effects are small (see Table 2), reflecting less than 20 ms of overall syntactic priming with between 8-10 ms each of facilitation and inhibition, they appear to be quite consistent over both participants and items (with very small standard errors in each condition).

3.1.2
Picture naming

Errors. On the picture-naming task, 3.2% percent of all responses were eliminated because of false starts or other reaction time artifacts, and another 15.3% were excluded from reaction time analyses because of errors (including 1.6% failures to respond, 1.5% responses after the reaction time window, and 12.2% frank naming errors). This proportion may seem high by the standards of most word recognition studies, but it is typical (indeed, comparatively good) for studies using picture naming as the dependent variable. For error analyses only, we included "time-out" trials (responses after the RT window) and trials with RT artifacts if a classifiable name was produced; all these responses together with those that had a usable RT were classified as correct or incorrect. The mean accuracy rate for the picture-naming task was 83%.

Because errors in picture naming were substantial, we conducted a 3 (syntactic context) × 2 (noun vs. verb) analysis of variance on percent accuracy, over participants and items. Cell means for these analyses are summarized in Table 3. Results revealed a significant main effect of context ($F_1(2, 118) = 41.62$, $p < .0001$; $F_2(2, 284) = 49.06$, $p < .0001$), reflecting higher accuracy on congruent trials, lower accuracy on incongruent trials, with neutrals falling in between. There was also a significant main effect of form class ($F_1(1, 59) = 97.6$, $p < .0001$; $F_2(1, 142) = 6.50$, $p < .02$), reflecting higher accuracy for object naming. The interaction between form class and priming was significant in both analyses ($F_1(2, 118) = 5.70$, $p < .01$; $F_2(2, 284) = 4.28$, $p < .02$). Table 3 shows that this interaction is due primarily to the interfering effects of an incongruent syntactic context, which appear to be greater for action names.

Response times. Mean reaction times on the picture-naming task averaged 1044 ms in the analysis over participants, and 1088 ms in the analysis over items, collapsed over form class and priming conditions in both cases (means are not identical because the impact of removing outlying items and items with errors is different in these two analyses). These RTs are substantially longer than the RTs observed with the same items in the cued shadowing task, indicating that picture naming is a much harder task. However, these naming times are comparable to object- and action-naming results in other picture-naming studies, particularly in languages in which the majority of items have two or more syllables (Bentrovato et al., 1999; Federmeier & Bates, 1997; Wicha et al., 1997).

Naming times were subjected to 3 (context) by 2 (noun vs. verb) analyses of variance, over participants and items. Comparisons with the neutral-control condition were reserved for post hoc analyses (simple F tests). Cell means for all significant effects are summarized in Table 4.

The two analyses revealed significant main effects of syntactic context ($F_1(2, 118) = 15.09$, $p < .0001$; $F_2(2, 270) = 18.06$, $p < .0001$), reflecting faster RTs in the congruent condition, slower RTs in the incongruent condition, with neutrals falling in between. Post hoc analyses (simple effects) indicate that the facilitative component was significant (neutral vs. congruent: $F_1(1, 59) = 10.18$, $p < .003$; $F_2(1, 135) = 12.49$, $p < .001$) as was the inhibitory component (neutral vs. incongruent: $F_1(1, 59) = 7.50$, $p < .01$; $F_2(1, 135) = 8.39$, $p < .005$). A comparison of Tables 2 and 4 indicates that syntactic priming effects are larger for picture naming than cued shadowing, although this may simply reflect the large difference between tasks in mean RT.

In contrast with results for cued shadowing, picture naming elicited large and significant main effects of form class ($F_1(1, 59) = 122.289$, $p < .0001$; $F_2(1, 135) = 15.18$, $p < 0.0002$), reflecting substantially slower RTs for action naming. There was, however, no significant interaction between form class and priming in either analysis. Hence the magnitude and direction of syntactic priming was the same for nouns and verbs, despite the large RT disadvantage associated with action naming (see Table 4).

3.1.3
Comparison of cued shadowing and picture naming

The separate analyses of cued shadowing and picture naming indicate that significant priming effects (both facilitation and inhibition) are observed with both procedures, though priming is larger in picture naming. Furthermore, there were large form class effects in picture naming but not in cued shadowing. To determine whether these task differences are significant, omnibus 2 × 3 × 2 analyses of variance were conducted over items and participants, with task as an experimental variable. Restricting our attention only to main effects and interactions with task, there was a very large main effect of task ($F_1(1, 57) = 174.59$, $p < .0001$; $F_2(1, 270) = 236.61$, $p < .0001$), reflecting a huge RT disadvantage for picture naming (which we attribute to the processes of picture decoding and word retrieval). There was also a significant interaction between task and form class ($F_1(1, 57) = 125.58$, $p < .0001$; $F_2(1, 270) = 15.50$, $p < .0002$), reflecting the absence of noun-verb differences in cued shadowing compared with a large disadvantage for verbs in picture naming. We attribute this to the well-known problems involved in depiction of familiar actions with static 2-dimensional drawings. Finally, there was a significant two-way interaction between task and priming ($F_1(1, 114) = 7.11$, $p < .002$; $F_2(2, 270) = 8.98$, $p < .0002$), reflecting larger priming in picture naming. The most conservative interpretation would be that priming increases in the picture-naming task because that task is slower and more difficult. The three-way interaction was not significant.

To summarize results for Part I, both of these experimental procedures yielded robust effects of syntactic context, including significant facilitation as well as inhibition relative to a syntactically neutral baseline (evidence compatible with theories in which context has a predictive effect). However, picture naming was more difficult than cued shadowing, and action naming was much harder than object naming, task differences that are evident in both accuracy and reaction time.

3.2
Part II: Post hoc analyses of factors contributing to word access in Chinese

In Part II, we will take advantage of the specific properties of word structure in Chinese to explore additional factors (other than syntactic context) that affect lexical access times in this language. All of these analyses were conducted over the full set of 144 experimental items (including the seven outliers that were trimmed from the priming analyses described above). However, we changed our definition of "accurate" to include averages across participants on any given item only for those participants who produced the intended target word (i.e., the same word that we used to obtain predictor variables like log word frequency, picture and word familiarity ratings, syllable density, and various other measures of word structure). With this more stringent definition of accuracy, we still had close to 100% accuracy in cued shadowing. However, percent correct in picture naming dropped to a mean of 62% (*SE* = 2.4%); 70.6% for nouns, *SD* = 3.2%, and 53.3% for verbs, *SE* = 3.4%). This means that the picture-naming reaction times used in the analyses below are based on performance by an average of 62% of the subjects (approximately 40 participants) for any given item.

3.2.1
Correlations among predictor variables

We began by examining intercorrelations among the predictors themselves, summarized in Table 5 (which only includes those predictor variables that pertain to both nouns and verbs). Although there are some significant correlations among these predictors, there is also substantial independence, which means that they could contribute in very different ways to variations in lexical access.

The word familiarity and picture familiarity ratings were positively correlated ($r = +.55$, $p < .001$), but clearly they are not measuring the same thing (sharing less than 30% of their variance). Log word frequency was only weakly correlated with word familiarity ($r = +.26$, $p < .01$) and was completely independent of the picture ratings.

A potentially important observation for Chinese regards the independence of first- vs. second-syllable density in Table 5, measured either by types or tokens. This means that we might expect to find quite distinct patterns of contribution to lexical access for first- vs. second-syllable density, a very important issue in a language dominated by disyllabic compounds. Table 5 also shows that the various density measures were relatively independent of both word frequency and word familiarity, the only exception being a small but significant correlation of +.20 ($p < .05$) between log frequency and type density for the first syllable.

Our measure of semantic transparency did not correlate with ratings of familiarity (for pictures or words), but it did correlate with word frequency ($r = +.33$, $p < .001$), indicating that semantically transparent words tend to be less frequent (and that semantically opaque words tend to be more frequent). Semantic transparency was correlated with only one of the four density measures: a small but significant correlation of –.23 ($p < .01$) with type density for the second syllable, which means that semantically transparent words are more likely to share their second syllable with other compounds in this language. The independence of transparency and density is important for our understanding of lexical processing in Chinese, where each syllable of a compound usually has an independent life outside of that word, overlapping with other words in the language at both the semantic level (relevant to the transparency variable) and at the form level (relevant to the separate density scores for each syllable). Because these variables are virtually uncorrelated, it should be possible to disentangle the effects of potential word competitors at two levels: competition (or facilitation) from words that overlap in form (density) and competition (or facilitation) from words that overlap in meaning (transparency).

Word structure typicality is another variable in Table 5 that seems to be surprisingly independent of the other lexical predictors. Recall that the noun and verb targets in our experiment reflect several different word types, for nouns and verbs respectively. However, in our stimuli and in the language as a whole, VN word types are the most common form for verbs while NN word types are the most common form for nouns. For this reason, we were surprised to find virtually no significant correlations between word structure typicality and variables like frequency, familiarity and density. The one exception was a modest positive correlation with second-syllable type density ($r = +.24$, $p < .01$), which means that VN verbs and NN nouns are also more likely than other word types to share their second syllable with other words in the language (testimony to the productivity of these two patterns). In addition, word structure typicality was significantly and negatively correlated with semantic transparency ($r = –.30$, $p < .001$), which means that the most common word types (VN verbs and NN nouns) also tend to be semantically transparent. This latter finding has interesting theoretical implications, because it reflects the productive use of preferred word types as “templates" (Chen et al., 1992) to create a wide range of compounds that preserve the meaning of their sublexical components.

Finally, Table 5 displays the correlations of each of these predictors with form class (0 = nouns; 1 = verbs).

Briefly summarized, our verb stimuli are lower in picture familiarity and semantic transparency than our noun stimuli, but verbs are higher than nouns in second-syllable density (both types and tokens) and word structure typicality (that is, there are more VN verbs than NN nouns). In other words, the grammatical distinction between these nouns and verbs is confounded (albeit modestly) with other word formation variables, justifying the kinds of post hoc analyses that we are conducting here.

To provide a better understanding of the patterns of collinearity among our predictor variables, we also conducted two factor analyses: one excluding the picture familiarity ratings (for use in analyses of cued shadowing, where no picture was present) and another including those ratings (for use in analyses of picture naming). Results of both factor analyses are summarized in Table 6.

The first factor analysis (excluding picture ratings) yielded four factors with eigenvalues greater than 1.0, accounting (respectively) for 21.5%, 19%, 14% and 12.7% of the variance. Factor 1 was defined primarily by density of the second syllable (with a weaker positive contribution from word structure typicality), while Factor 2 was defined primarily by density of the first syllable (with a weaker positive contribution from word frequency). Because frequency and typicality load in opposite directions on these two factors, there is a sense in which these factors reflect a Chinese variant of the frequency /regularity trade-off at the level of word form. That is, words high in first-syllable density tend to be more frequent but less typical in structure (i.e. "irregular"), while words high in second-syllable density tend to be less frequent but more typical in structure (i.e. "regular"). The third factor loaded primarily on frequency and familiarity, and it was also associated with semantically opaque words, indicating a different kind of frequency/regularity trade-off for Chinese words, this time at the semantic level. The fourth factor was defined primarily by word structure typicality and form class, which means that it is dominated by VN verbs.

The second factor analysis (which included picture ratings) yielded five factors with eigenvalues greater than 1.0, accounting (respectively) for 19.8%, 17.3%, 15.1%, 12.5% and 10.4% of the variance. The first two are essentially the same as the ones that we obtained excluding picture familiarity ratings, defined primarily by first- and second-syllable density, respectively. Factor 3 in this analysis was defined by a combination of word and picture familiarity ratings, so that it could be said to comprise a general "familiarity factor". Factor 4 was fairly heterogeneous, and seemed to be characterized by semantically opaque but high-frequency verbs. Factor 5 was also heterogeneous, defined primarily by high-typicality VN verbs with low second-syllable density.

These factor structures are complex and difficult to interpret. However, they correspond roughly to separate factors for first- and second-syllable density, followed by a series of trade-offs and oppositions among frequency, familiarity, density, semantic transparency and word structure typicality. Hence some of these factors may be viewed as lexical variants in Chinese of the distinction between regular and irregular words that has been studied extensively in English at the levels of orthography (Seidenberg & McClelland, 1989) and grammatical morphology (Pinker, 1991; Seidenberg, 1997). In the next section, we will first conduct separate correlation and regression analyses of the dependent variables in our study using the individual predictor variables, and then describe the correlations and regressions that are obtained with the factor scores.

3.2.2

Relations between predictor and outcome variables.

Table 7 summarizes the raw correlations between our predictor variables and reaction times for noun and verb items, considered separately and together. In addition to the 10 predictors described above, Table 7 also includes two predictors that only apply to the analysis of verbs (transitivity, depiction of a sublexical element) and one that only applies to the analysis of nouns (compound status).

Cued shadowing. Starting with results for cued shadowing, it is clear from Table 7 that all these contributions are relatively modest, but there were some significant effects (of the sort that might influence results in studies of lexical access), and they suggest some potential differences in the variables that influence access to nouns versus verbs. Word frequency and word familiarity had no apparent impact on overall RTs or on RTs for nouns, but there was a modest correlation between word familiarity and reaction times for verbs (+.26, $p < .05$). Note that this familiarity effect actually reflects *slower* RTs for words that are rated as more familiar, a surprising result which may reflect some of the familiarity/regularity confounds discussed above. Picture familiarity is of course not relevant to cued shadowing (since no pictures were used in that task), but at the very least the absence of a correlation means that picture familiarity ratings are not confounded with other factors that influence cued shadowing times. Note that we have found effects of frequency and familiarity on cued shadowing times in other studies (Liu, 1996), so the absence of effects for these Chinese words does not reflect a general characteristic of the cued shadowing task.

In contrast with the noneffects of familiarity and frequency, there were a number of significant correlations involving syllable density: First-syllable type density is associated with slower overall RTs and slower RTs on nouns, while first-syllable token density is associated with slower RTs but only for verbs; second-syllable type and token densities are both associated with slower RTs, but only for nouns. In general, these density effects are compatible with the idea that reaction times are slowed by competition from overlapping word candidates. The fact that we obtain partially separable effects of both first- and second-syllable density suggests that sublexical structure is playing an important role in word recognition, and that these effects are not restricted to the initial part of the word.

The strongest correlations in the cued shadowing data were with semantic transparency, reflecting faster RTs for words that are semantically opaque (across the board, for nouns, verbs and total scores). One might have expected results in the opposite direction, with faster RTs when the meaning of the whole word is predictable from the meanings of its parts. However, we have suggested that these transparency ratings may reflect another kind of competitor effect, a semantic analogue to the competition from overlapping word forms that may be responsible for negative effects of syllable density. The correlations in Table 7 are compatible with this interpretation. None of the other correlations in Table 7 reached significance for cued shadowing.

The last of the exploratory analyses that we undertook here were regressions using factor scores as predictors, to determine whether any of these latent variables had robust and independent effects on performance which might be masked when individual lexical predictors are evaluated one at a time. This did prove to be the case (summarized in Table 8).

Using the four factors that were appropriate for cued shadowing, we found significant unique contributions of Factor 1, which is defined primarily by second-syllable density. This factor is associated with a slowing of reaction times for both nouns and verbs, considered separately and together. Factor 2, which is defined primarily by density of the first syllable, was also associated with slower reaction times, although it only reached significance for verbs. Both of these results can be interpreted to reflect competition at the sublexical level in compound words. Factor 3 is defined primarily by words that are frequent, familiar and semantically opaque—the Chinese equivalent of high-frequency irregulars at the level of semantic combinations. This "semantic irregularity" factor was associated with faster reaction times when the other factor scores were controlled, but this effect only reached significance for nouns. Factor 4 made no significant unique contribution to cued shadowing.

Picture naming. In the picture-naming data, the contributions of predictor variables were again rather modest, but some systematic patterns did emerge, and they suggest once again that profiles of lexical access may differ for nouns and verbs. Word familiarity and picture familiarity were both associated with faster naming times (especially for verbs). In contrast with the cued shadowing data (where frequency had no effect at all), we did find a significant effect of frequency on naming times, but only for nouns. Also in contrast with cued shadowing, semantic transparency had little effect on picture naming, with one small exception: lower accuracy for semantically opaque verbs. It seems that the semantic-competitor effects that we observed for word recognition (assessed with cued shadowing) are not accounting for much of the variance in word retrieval (assessed with picture naming). The only other significant effects in Table 7 involved form class, reflecting an overall processing disadvantage for verbs in the picture-naming task (in line with results of the analyses of variance in Part 1).

Using the five factors that were appropriate for picture naming (including ratings of picture familiarity), we found further evidence for unique contributions to lexical access in Chinese. Factor 1 (which is defined primarily by second-syllable density) was associated with slower overall reaction times, although this effect failed to reach significance when nouns and verbs were considered separately. Factor 2 (which is defined primarily by first-syllable density) was also associated with lower accuracy and slower reaction times, although this effect holds primarily for verbs. Once again, these syllable density effects can be interpreted to reflect some form of competition at the sublexical level. Factor 3 reflects the combined effects of word familiarity and picture familiarity, and was associated with faster picture naming for both nouns and verbs, an unsurprising finding. Factor 4 has a very complex structure, but seems to be defined primarily by high-frequency words (especially verbs) that are semantically opaque, which might be viewed as "lexical-semantic irregulars". This factor was associated with slower word retrieval, in the opposite direction from the small but facilitative effect of lexical-semantic irregularity on cued shadowing of nouns (see above). To understand this difference, we considered a possible confound: some semantically transparent verbs contain a sublexical element that is depicted clearly within the target picture (e.g., the presence of a wave in the DASH-WAVE ('surf') example cited earlier), which might result in faster naming times. To test for this possibility, we had included presence/absence of a sublexical component in the picture as a separate lexical predictor in these exploratory analyses. As should be clear from the correlations reported earlier (Table 7), this confounding variable had no effect whatsoever on naming times, and it also failed to load on any of the latent factors. Hence we may tentatively conclude that lexically irregular Chinese words (especially verbs) are harder to retrieve in the picture-naming task, while lexically irregular Chinese nouns are easier to recognize in the cued shadowing task. Factor 5 made no independent contribution to picture naming in these regression analyses.

We must underscore that all of the results in Part II are small, and are based on post hoc analyses. Because so little is known about spoken word access in Chinese (compared with the voluminous literature on lexical access in English and other Indo-European languages), we present them here for their heuristic value, as factors to consider in future work on syntactic priming and lexical access in Chinese. At the very least, these findings suggest that sublexical factors (e.g., semantic transparency and syllable density) play a significant role in the recognition and/or retrieval of Chinese words. Furthermore, the contribution of these factors can vary over task (cued shadowing vs. picture naming) and form class (nouns vs. verbs).

3.3 *Unifying Parts I and II: Effects of lexical predictors on priming*

A final set of analyses was conducted to determine whether the lexical factors described above also influence the magnitude or direction of syntactic priming. This was an important analysis, because it had proven impossible to orthogonalize items on all possible dimensions for the priming task. Hence we need to know whether (and to what extent) our syntactic priming results were affected by all these lexical variables. Regressions were conducted using the respective facilitation and inhibition scores for each target item as dependent variables.

For cued shadowing, the four factors together made a small but significant contribution to the magnitude of syntactic facilitation (accounting for 7.3% of the variance), but not to inhibition. None of the individual factors contributed significant variance to facilitation or inhibition when it was added on the last step.

For picture naming, there was a small but significant 4.2% increase in facilitation for the first-syllable density factor, and a small but significant 3.0% decrease in facilitation for the factor associated with high word and picture familiarity. The factor scores did not affect inhibition. Because density seems to be a variable that slows down word retrieval (due perhaps to word form competition), the increase in facilitation associated with this density factor may mean that syntactic context helps to reduce the magnitude of competitor effects. Because familiarity is a variable that usually speeds up word retrieval, the decrease in facilitation associated with word and picture familiarity may mean that syntactic facilitation is smaller for items that are easy to retrieve outside of context.

In short, our various lexical variables do have some influence on the magnitude of priming, in theoretically coherent directions. Specifically, a congruent syntactic context seems to be especially helpful for items that are more difficult to access out of context. However, these effects are small. Furthermore, because of the counterbalanced design, and because priming results were significant over items as well as subjects, these findings complement but do not in any way contradict the significant priming effects observed in Part I.

4 Summary and Conclusion

In the first part of this study, we demonstrated syntactic priming of lexical retrieval in Chinese, in word recognition (assessed with cued shadowing) and word retrieval (assessed with picture naming). Following the diagnostics described in the introduction, we suggest that these priming effects are ecologically valid, reflecting a mix of automatic and expectancy-based priming similar to the effects of context in real-life situations. RTs were relatively fast (keeping in mind that these are all two-syllable words), following a minimal (zero millisecond) interval between context offset and target onset, in two tasks that require no postlexical decisions of any kind. Although the most efficient strategy in this experiment would be to ignore contexts that pay off on only 33% of trials, and are frankly misleading another 33% of the time, it seems that participants were unable to suppress syntactic information. This is just what we would expect if syntactic priming effects are largely automatic. Finally, priming effects included significant facilitation relative to neutral baseline, on both tasks. This last result adds to a growing body of evidence for anticipatory, predictive effects of context on word and sentence processing, in both comprehension and production (e.g., Allopenna et al., 1998; Altmann, van Nice, Garnham, & Henstra, 1998; Gaskell & Marslen-Wilson, 1997; Grosjean, 1980; MacDonald et al., 1994; MacWhinney & Bates, 1989; Marslen-Wilson & Tyler, 1981, 1987; van Petten et al., 1999). As we noted in the introduction, it is not clear at this point whether any empirical test could distinguish anticipatory priming models from theories that permit parallel modularity, rapid feeding of partial products from one module to another, and/or "pre-integration". That is, context may be used to set up a situation that facilitates integration after the word arrives, without changing the time course of word recognition itself (analogous to making up the guest room for an expected visitor, without influencing the train schedule in any way). For our purposes here, the point is simple: syntactic context can be used to enhance rapid and efficient lexical processing—in this language, in these tasks.

The Chinese language has some properties that are relevant to broader issues of lexical retrieval, in and out of context. As we noted earlier, there is great potential for semantic and syntactic ambiguity in Chinese, due to the near-absence of inflectional morphology, and to the prevalence of omission and word order variation at the sentence level. Our results for syntactic priming suggest that this grammatical context is one aspect of context that Chinese speakers can use as an aid to word recognition and production, to avoid ambiguity. The second half of this study was devoted to post hoc exploration of additional factors that also contribute to lexical access times in Chinese, in both of these tasks, for nouns and verbs considered separately and together.

The predictors that we chose included lexical variables that are commonly used in research on Western languages (e.g., log frequency, ratings of word and picture familiarity), as well as some aspects of word structure that permit us to exploit the special opportunities offered by Chinese for the study of lexical access. The latter included word structure typicality (i.e., whether the noun or verb items correspond to the most common "compound template" for that form class, VN for verbs and NN for nouns), compound status, the presence/absence of an item in the picture corresponding to a sublexical element in the word, semantic transparency (whether or not the meanings of the sublexical elements in a disyllabic word correspond to the meaning of the word as a whole), and syllable density (calculated separately for the first and second syllable, in types and tokens).

The most consistent effects that emerged from Part II involved syllable density. In both tasks (albeit to a different degree), both first- and second-syllable density were associated with slower reaction times. These results can be interpreted as competitor effects at the sublexical level, similar to neighborhood density effects that have been found repeatedly in English-language studies where density counts are based on overlapping letters or phonemes (Goldinger, Pisoni, Marcario, & Luce, 1992; Slowiaczek & Hamburger, 1992; Vitevich & Luce, 1999). Furthermore, the inhibitory effect of second-syllable density suggests that this competition is not restricted to neighbors that are active at word onset. We note, however, that the work by Luce and colleagues on density effects involves complex interactions between frequency and density that we have not tested here, so this remains an important issue for future research on "syllable density" in Chinese. In addition, we want to underscore that our syllable density counts were based on written corpora (calculated in characters), which are less ambiguous than auditory syllables. Hence these density effects probably underestimate the magnitude of the competition that we would observe with counts based on spoken rather than written syllables. One of us (C-H T) is now constructing a spoken-syllable database that can be used to test this hypothesis.

In the cued shadowing task, we also found robust evidence that semantic transparency slows reaction times. This result may seem surprising, since we might expect facilitation of word access when the meanings of the parts converge on the meaning of the whole. However, because of the rich and productive use of compounding in the Chinese language, high semantic transparency also means that there is competition with other word candidates at the semantic level (because each meaning unit also appears in many other words). At least within the cued shadowing task, it seems that some kind of semantic competitor effect is operating in Chinese, at the level of the meanings associated with the separate elements of a disyllabic word. These results for auditory word recognition and retrieval are compatible with results by Zhou and Marslen-Wilson (1995), demonstrating that sublexical and lexical effects operate together during lexical access in Chinese, requiring a model that acknowledges and incorporates effects at multiple levels. This would include the multistratal model that Zhou and Marslen-Wilson propose to account for their findings, but it might also include interactive-activation models that attempt a more direct mapping between phonetic and semantic representations, with the separate contributions of lexical and sublexical components emerging from the highly distributed nature of the representations incorporated by such models (Elman, 1990; Gaskell & Marslen-Wilson, 1997; see Chen & Bates, 1998, for a discussion of such models applied to noun vs. verb access in Chinese-speaking aphasics).

The other individual lexical variables that we included in our analyses had relatively small and inconsistent effects, including smaller effects of whole-word frequency and/or familiarity than are often reported for other languages (especially for tasks that require reading). There was some hint in the analyses using factor scores of complex trade-offs among frequency, density and semantic transparency and regularity for these compound words, reminiscent of the frequency by regularity interactions observed in studies of word reading in English. The possibility of frequency/regularity trade-offs at the level of word structure is one that deserves further study, particularly insofar as our results suggest that some kind of frequency/regularity interaction may be operating at two levels in Chinese: at the level of word form and at the level of semantic combinations in a language in which the vast majority of words are compounds.

Finally, our results using priming scores (facilitation and inhibition) as dependent variables suggested that syntactic context may interact with word structure variables in Chinese, increasing or decreasing the likelihood of a good fit between sentence context and the words that must be recognized or produced within that context. This is a useful finding, opening new avenues of inquiry regarding the interplay between context and lexical access. We must underscore, however, that the effects of these lexical variables on priming were relatively small as they played out here, and do not in any way contradict the primary result in Part I, regarding the existence of syntactic priming effects on lexical access for both nouns and verbs. Rather, they tell us which items are most vulnerable to syntactic priming. In particular (since the contributions of these factors affected syntactic facilitation but not syntactic inhibition), they tell us which items profit most from syntactic context.

We conclude that the investigation of syntactic priming is a fruitful enterprise, and that the Chinese language offers some special opportunities for the investigation of the interplay between grammatical and lexical processing that are not available in English. We are now conducting further studies of lexical access in Chinese, with larger and more varied word types, exploring the rich sublexical structure of this language as it interacts with semantic and grammatical context.

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Acknowledgements: This research was supported by Bates, “Cross-linguistic studies in aphasia" (NIH/ NIDCD RO1-DC00216). We are grateful for lengthy conversations about grammatical priming with Simona D’Amico, Simone Bentrovato, Antonella Devescovi, Victor Ferreira, Kara Federmeier, Arturo Hernandez, Thomas Jacobsen, William Levelt, Luigi Pizzamiglio, Bernadette Schmitt and Nicole Wicha, and to Ping Li for discussions of lexical access in Chinese. Of course these colleagues cannot be held responsible for our interpretations, or any errors that we may have made.

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Appendix

Lead-in Contexts (n = 9)

(1) neutral contexts (n = 3)

1a.	Ni	yinggaiyao	shuo	
	you	should	say	
	You should say ____.			
1b.	Shuoshuo	zhege	tu	
	say	this	picture	
	Try to name this picture: ____.			
1c.	Xianzai	qing	ni	shuo
	now	please	you	say
	Now please say: ___.			

(2) noun contexts (n = 3)

2a.	Nali	you	hendou	
	there	have	many	
	There are many ___ over there.			
2b.	Ta	zaizhao	nazhong	
	he	is looking for	that kind	
	He is looking for that kind of ___.			
2c.	Wo	kandao	yixie	
	I	see	some	
	I saw some ____.			

(3) verb contexts (n = 3)

3a.	Ta	jiao	wo	buyao
	he	call	me	don't
	He asked me not to ____.			
3b.	Zhegeren	zhengzai		
	this person	is ___ing		
	This person is ____.			
3c.	Wo	jiao	ta	zemo
	I	teach	him	how
	I taught him how to ___.			

Practice Items
(n = 18):

No.	Pinyin	morpheme translation	English
1	tuiche	push-car	to tow
2	ganbei	dry-cup	cheers
3	kafei	coffee	coffee
4	fengche	wind-car	windmill
5	bingxiang	ice-box	refrigerator
6	zhangyu	chapter-fish	octopus
7	sizhi	tear-paper	to tear
8	huojian	fire-arrow	rocketship
9	weiji	feed-chicken	to feed the chickens
10	caihong	color-rainbow	rainbow
11	watu	dig-dust	to dig
12	xianglian	neck-chain	necklace
13	modao	rub-knife	to sharpen
14	shamo	sand-land	desert
15	dangong	bullet-bow	slingshot
16	hejiu	drink-wine	to drink at a bar
17	xiuche	fix-car	to repair car
18	tiaolan	jump-fence	to hurdle

Experimental targets (n = 144)
(A single English word is given when the 2-character Chinese word has a mono-morphemic meaning, i.e., is not a compound)

No.	pin-yin	morpheme translation	English
1	naozhong	disturb-clock	alarm clock
2	mayi	ants	ants
3	guzhang	bulge-palm	to applaud
4	futou	ax-head	ax
5	beibao	bear-wrap	backpack
6	bianfu	bat	bat
7	xizao	wash-bath	to bathe
8	huxu	beard	beard
9	woshi	lie-room	bedroom
10	fengwo	bee-cave	beehive
11	qiche	ride-car	to ride a bike
12	jugong	bend-body	to bow
13	zheduan	fold-break	to break
14	douniu	fight-ox	to fight bulls
15	hudie	butterfly	butterfly
16	niukou	button	button
17	jiaoren	call-people	to call
18	luotuo	camel	camel
19	luying	expose-camp	to camp
20	wanpai	play-card	to play cards
21	jieqiu	catch-ball	to catch
22	liaotian	chat-sky	to chat
23	jitui	chicken-leg	chicken
24	jiake	jacket	coat
25	zhihui	point-wave	to conduct
26	zhufan	cook-rice	to cook
27	kesou	cough-cough	to cough
28	niuzai	ox-calf	cowgirl
29	tiaowu	jump-dance	to dance
30	xiwan	wash-bowl	to wash dishes
31	tiaoshui	jump-water	to dive
32	liugou	walk-dog	to walk the dog
33	heshui	drink-water	to drink
34	bendou	pan-funnel	dustpan
35	chifan	eat-rice	to eat
36	yanjing	eye	eye
37	xilian	wash-face	to wash face
38	zhalan	fence-fence	fence

39	dajia	strike-erect	to fight
40	diaoyu	fish (v.)-fish(n.)	(to) fish
41	tuoxie	drag-shoe	flipflops
42	chahua	insert-flower	to arrange flowers
43	datie	strike-iron	to forge
44	lese	garbage	garbage
45	chilun	tooth-wheel	gears
46	putao	grapes	grapes
47	jita	guitar	guitar
48	hanbao	hamburger	hamburger
49	shoukao	hand-handcuff (v.)	handcuffs
50	jushou	raise-hand	to raise hand
51	yijia	clothes-rack	clotheshanger
52	tiaogao	jump-high	to highjump
53	muma	wood-horse	hobby horse
54	qima	ride-horse	to ride a horse
55	shuiguan	water-pipe	hose
56	pintu	put-picture	jigsaw puzzle
57	tiaosheng	jump-rope	jump rope
58	yaoshi	key-spoon	keys
59	guowang	nation-king	king
60	guixia	kneel-down	to kneel
61	qiaomen	knock-door	to knock
62	xiuxi	rest (v.)-rest (v.)	to lean
63	xiexin	write-letter	to write a letter
64	dengta	light-tower	lighthouse
65	xitie	suck-iron	magnet
66	cunqian	deposit-money	to save money
67	facai	prosper-wealth	to win money
68	tuoba	drag-handle	mop
69	dengshan	climb-mountain	to climb a mountain
70	kaidao	open-knife	to operate
71	baoguo	wrap-wrap	to package
72	huatu	paint-picture	to paint
73	jianzhi	cut-paper	to cut paper
74	yingwu	parrot	parrot
75	kongque	hole-sparrow	peacock
76	qianbi	lead-pen	pencil
77	puman	pounce-fill	piggybank
78	fengli	phoenix-pear	pineapples
79	haidao	sea-steal	pirate
80	chatou	insert-head	plug
81	daogao	pray-tell	to pray
82	fazhan	punish-stand	to punish
83	tiqiu	kick-ball	to punt
84	pibao	leather-wrap	purse

85	saipao	race-run	to finish a race
86	kanshu	see-book	reading
87	qiangjie	rob-rob	to rob
88	liubing	glide-ice	to rollerskate
89	gongji	male-chicken	rooster
90	tiaosheng	jump-rope	to jump rope
91	meigui	rose	rose
92	huachuan	row-boat	to row
93	paobu	run-step	to run
94	fanchuan	sail-boat	sailboat
95	jingli	respect-courtesy	to salute
96	weijin	surround-towel	scarf
97	jiandao	cut-knife	scissors
98	chaojia	quarrel-erect	to scream
99	qianshui	submerge-water	to scuba dive
100	diaoke	carve-carve	to sculpt
101	shengbing	produce-sick	sick
102	changge	sing-song	to sing
103	huaban	glide-board	skateboard
104	huaxue	glide-snow	to ski
105	xueqiao	snow-sleigh	sled
106	shuijiao	sleep (v.)-sleep(n.)	(to) sleep
107	diedao	tumble-fall	to slip
108	weixiao	small-laugh	to smile
109	chouyan	draw-smoke	to smoke
110	guaniu	snail-ox	snail
111	xueren	snow-people	snowman
112	shafa	sofa	sofa
113	chaomian	saute-noodles	spaghetti
114	zhizhu	spider	spider
115	diaoxiang	carve-image	statue
116	aoye	decoct-night	to study
117	chonglang	dash-wave	to surf
118	beixin	back-heart	sweater
119	saodi	sweep-ground	to sweep
120	youyong	swim (v.)-swim (n.)	to swim
121	qiuqian	swing	swingset
122	shangke	ascend-course	to teach
123	chahu	tea-pot	teakettle
124	shuaya	brush-teeth	to brush teeth
125	zhangpeng	curtain-covering	tent
126	huangguan	emperor-hat	tiara
127	matong	horse-tub	toilet
128	tuoluo	cragginess-spiral	top
129	pashu	climb-tree	to climb a tree
130	kaiche	open-car	to drive a truck

131	laba	trumpet	trumpet
132	wugui	black-turtle	turtle
133	dazi	strike-word	to type
134	huoshan	fire-mountain	volcano
135	qichuang	rise-bed	to wake up
136	zoulu	walk-road	to walk
137	jiaoshui	spray-water	to water
138	juzhong	raise-weight	to lift weights
139	lunyi	wheel-chair	wheelchair
140	jiafa	fake-hair	wig
141	wupo	sorcery-woman	witch
142	huli	fox-beaver	wolf
143	qiuyin	earthworm	worm
144	lalian	pull-chain	zipper

Table 1: Diagnostics for Distinguished Automatic vs. Controlled Priming	
Automatic Effects	**Strategic/Controlled Effects**
Faster reaction times	**Slower reaction times**
Minimal prime-target separation **(< 250 ms)**	**Longer prime-target separation** **(> 250 ms)**
Facilitation relative to baseline	**Inhibition relative to baseline**
No Metalinguistic Operations	**Metalinguistic Operations**
Low-Proportion-Related Items	**High-Proportion-Related Items**

Table 2: Cell Means for Reaction Time Analysis in Cued Shadowing

(F_1 and F_2 averaged; standard errors in parentheses)

	NOUNS	VERBS	TOTAL
CONGRUENT	752.1 ms (11.2)	749.2 ms (11.7)	750.6 ms (8.1)
NEUTRAL	759.5 ms (11.0)	763.8 ms (11.0)	761.0 ms (7.1)
INCONGRUENT	770.5 ms (11.5)	768.3 ms (11.5)	769.4 ms (8.1)
TOTAL	760.2 ms (6.5)	760.4 ms (6.6)	760.3 ms (4.6)
Overall Priming	18.4 ms	19.1 ms	18.8 ms
Facilitation	7.4 ms	14.6 ms	10.4 ms
Inhibition	11.0 ms	4.5 ms	8.4 ms

Table 3: Cell Means for Percent Correct in Picture Naming

(F_1 and F_2 averaged; standard errors in parentheses)

	NOUNS	VERBS	TOTAL
CONGRUENT	90.5% (1.5)	84.8% (1.8)	87.6% (1.2)
NEUTRAL	89.1% (1.6)	81.5% (1.8)	85.3% (1.3)
INCONGRUENT	82.8% (2.0)	70.9% (2.4)	76.8% (1.6)
TOTAL	87.5% (1.0)	79.1% (1.2)	83.3% (0.8)
Overall Priming	7.7%	13.9%	10.8%
Facilitation	1.4%	3.3%	2.3%
Inhibition	6.3%	10.6%	8.5%

Table 4: Cell Means for Reaction Time Analysis in Picture Naming

(F_1 and F_2 averaged; standard errors in parentheses)

	NOUNS	VERBS	TOTAL
CONGRUENT	960.6 ms (21.5)	1100.9 ms (29.4)	1030.5 ms (19.2)
NEUTRAL	988.0 ms (24.3)	1142.6 ms (28.9)	1065.0 ms (20.0)
INCONGRUENT	1016.4 ms (25.7)	1188.9 ms (33.1)	1102.3 ms (21.9)
TOTAL	988.3 ms (13.8)	1144.1 ms (17.6)	1066.0 ms (11.9)
Overall Priming	55.8 ms	88.0 ms	71.8 ms
Facilitation	27.4 ms	41.7 ms	34.5 ms
Inhibition	28.4 ms	46.3 ms	37.3 ms

Table 5: Correlations Among the Ten Predictor Variables (Computed over Items, Nouns and Verbs Combined)

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	Word Familiarity (1 = low; 5 = high)	-----									
2.	Picture Familiarity (1 = low; 5 = high)	+.55***	-----								
3.	Log Frequency	+.26**	- .01	-----							
4.	1st-syllable type density	+.04	- .00	+.20*	-----						
5.	1st-syllable token density	–.03	–.04	+.13	+.81***	-----					
6.	2nd-syllable type density	–.09	–.12	–.11	–.01	–.01	-----				
7.	2nd-syllable token density	–.05	–.03	–.08	+.02	–.01	+.88***	-----			
8.	Semantic Transparency (1 = transparent; 2 = nontransparent)	+.11	–.06	+.33***	–.11	–.06	–.23**	–.12	-----		
9.	Word Structure Typicality (nouns: NN = 1; other = 0; verbs: VN = 1; other = 0)	–.07	–.14	–.06	+.13	+.11	+.24**	+.15	–.30***	-----	
10.	Form Class (noun = 0; verb = 1)	+.13	–.28***	+.05	+.06	+.06	+.24**	+.16*	+.00	+.35***	-----

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

Table 6: Factor Loadings among Predictor Variables -- Factor Analysis I: All Variables Relevant to Cued Shadowing

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FORM CLASS	+.4145	+.1361	+.4049	+.5734
WORD RATINGS	–.1738	+.1824	+.5882	+.2404
LOG FREQUENCY	–.2448	+.4232	+.6124	–.0886
1ST-SYLLABLE TYPE DENSITY	+.2046	+.9000	–.1528	–.1619
1ST-SYLLABLE TOKEN DENSITY	+.1889	+.8772	–.2056	–.1866
2ND-SYLLABLE TYPE DENSITY	+.8637	–.2092	+.2473	–.3014
2ND-SYLLABLE TOKEN DENSITY	+.7971	–.1932	+.3087	–.4184
WORD STRUCTURE TYPICALITY	+.5507	+.1484	–.0856	+.6055
SEMANTIC TRANSPARENCY (1 = transparent; 2 = opaque)	–.4756	+.0375	+.5425	–.2339
MAJOR LOADINGS	Hi Syll. 2 Density/ Word Structure Typicality	Hi Syll. 1 Density/ Frequency	Frequency/ Word Familiarity/ Sem. Opacity	Word Structure Typicality/ Lo Syll. 2 Density

FORM CLASS	+.4480	+.1383	+.0763	+.5150	+.5302
WORD RATINGS	–. 3062	+.1964	+.8001	+.0560	+.3017
PICTURE RATINGS	–.3617	+.0318	+.7065	–.4770	+.0519
LOG FREQUENCY	–.2431	+.4198	+.2456	+.5769	–.1193
1ST-SYLLABLE TYPE DENSITY	+.1865	+.9032	–.0406	–.1709	–.1508
1ST-SYLLABLE TOKEN DENSITY	+.1837	+.8786	–.1241	–.1649	–.1833
2ND-SYLLABLE TYPE DENSITY	+.8339	–.1924	+.3450	+.0668	–.2949
2ND-SYLLABLE TOKEN DENSITY	+.7527	–.1756	+.4210	+.0768	–.4084
WORD STRUCTURE TYPICALITY	+.5562	+.1550	–.0539	–.0099	+.5966
SEMANTIC TRANSPARENCY (1 = transparent; 2 = opaque)	–.4370	+.0267	+.0418	+.6674	–.2928
MAJOR LOADINGS	Hi Syll. 2 Density/ Word Struct. Typicality	Hi Syll 1 Density/ Frequency	Word & Picture Familiarity/ Hi Syll 2 Density	Sem. Opacity/ Frequency (esp verbs.)	Word Struct. Typicality/ Lo Syll 2 Density (esp. verbs)

Table 7: Correlations of all Predictor Variables with Accuracy and Reaction Times (Collapsed over Priming Conditions)

		CUED SHADOWING: Reaction Times:			PICTURE NAMING: Reaction Times:			Accuracy:		
		Total	Nouns	Verbs	Total	Nouns	Verbs	Total	Nouns	Verbs
1.	Word Familiarity Rating (1 = low; 5 = high)	+.02	–.23	+.26*	–.20*	–.28*	- .24*	+.08	+.21	+.04
2.	Picture Familiarity Rating (1 = low; 5 = high)	- .05	–.15	+.06	- .42***	- .34**	- .40***	+.31***	+.19	+.30*
3.	Log Frequency	- .10	–.17	- .04	–.04	- .28*	+.13	+.11	+.26*	+.01
4.	1st-Syllable Type Density	+.22**	+.25*	+.19	+.24**	+.11	+.35**	–. 11	+.03	–.22
5.	1st-Syllable Token Density	+.14	+.07	+.24*	+.18*	–. 01	+.39***	–. 09	+.06	–.25*
6.	2nd-Syllable Type Density	+.14	+.27*	+.03	+.10	+.02	+.03	–. 13	+.05	–.08
7.	2nd-Syllable Token Density	+.14	+.28*	+.03	+.07	–. 01	+.05	-. 08	+.05	–.10
8.	Semantic Transparency (1= transparent; 2 = opaque)	–.30***	–.33**	–.27*	+.05	–.05	+.15	–.08	+.08	–.23*
9.	Word Structure Typicality (nouns: NN = 1; other = 0; verbs: VN = 1; other = 0)	+.10	+.06	+.17	+.08	+.20	–.27*	+.01	–.03	+.27*
10.	Compound Status (nouns only) (0 = compound; (1 =non-compound)	-----	–.08	-----	-----	–.12	-----	-----	+.07	-----
11.	Transitivity (verbs only) (0 = intransitive; 1 = transitive)	-----	-----	-.00	-----	-----	+.23	-----	-----	–.00
12.	Sublexical element (verb only) (0 = absent; 1 = present)	-----	-----	+.08	-----	-----	–.01	-----	-----	+.03
13.	Form Class (noun = 0; verb = 1)	–. 01	-----	-----	+.30***	-----	-----	–.30***	-----	-----

** p < .05 ** p < .01 ***p < .001* ----- = *Not applicable, excluded from the analysis*

Table 8: Regression Analyses of Reaction Times in Both Tasks Using Factor Scores as Predictors

	CUED SHADOWING: OVERALL	NOUNS	VERBS
TOTAL R-SQUARE	8.8%*	20.4%**	13.5%*
UNIQUE VARIANCE DUE TO INDIVIDUAL FACTOR SCORES:			
Factor 1: (Hi Syll. 2 Density/Word Typicality)	+ 5.4%**	+ 7.1%*	+ 7.6%*
Factor 2: (Hi Syll. 1 Density/Frequency)	+ 1.5%	< 1%	+ 8.9%*
Factor 3: (Frequency/Familiarity/Opacity)	+ 2.4%	– 6.2%*	< 1%
Factor 4: (Word Typicality/Lo Syll. 2 Density)	< 1%	– 2.7%	+ 5.4%
TOTAL R-SQUARE	22.1%***	14.7%	32.9%***:
UNIQUE VARIANCE DUE TO INDIVIDUAL FACTOR SCORES:			
Factor 1: (Syll. 2 Density/Typicality)	+ 7.7%***	+ 3.0%	+ 1.4%
Factor 2: (Syll 1 Density/Frequency)	+ 3.8%*	< 1%	+ 11.0%**
Factor 3: (Word & Picture Ratings)	– 8.9%***	– 8.5%*	– 11.6%**
Factor 4: (Frequency/Opacity)	+ 5.9%**	< 1%	< 1%
Factor 5: (Word Typicality/Lo Syll 2 Density)	< 1%	< 1%	– 5.7%

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