7 The Comprehension of Words and Sentences in Two Languages

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7.1 Introduction

Psycholinguists have only recently taken seriously the idea that bilinguals are more representative language users than their monolingual counterparts. The consequence has been a dramatic increase in research on language processing in bilinguals and second language learners. In part, this recent research focuses on how individuals who understand and speak more than a single language negotiate the boundaries of two language systems that may or may not share common features. However, another equally important focus is to use bilingualism as a tool to address questions about the nature of mental representations and processes and the learning mechanisms that support them. In this chapter we review evidence on the perception and comprehension of words and sentences in bilinguals. At each level of analysis we attempt to address issues that arise from each of these foci. We will consider research on the perception and comprehension of words and sentences when bilinguals are reading or listening in one language only and also when they find themselves in a mixed-language context in which the two languages may be used interchangeably.

For the purpose of our review, we assume a broad definition of bilingualism. We take anyone who actively uses two languages at some level of proficiency to be bilingual. Because few bilinguals are genuinely balanced in their use of two languages, we assume that for most bilinguals there will be one dominant language, although it need not necessarily be the native language. In reporting the results of different studies, the specific characteristics of the participants' language experience will be described to enable cross-study comparisons. Most of the research that we review examines language processing in late bilinguals who acquired their second language (L2) sometime after early childhood, although there are a few exceptions. Among the factors that distinguish different

bilingual groups, the age at which the L2 was acquired and the relative dominance of the two languages will be important considerations.

The two main sections of the chapter, one on words and the other on sentences, are organized around a set of critical issues. First, we review the evidence and models within each of these aspects of language processing and address the relation of this evidence to claims about monolingual performance. An important aspect of the comparison of bilingual and monolingual performance is to consider how independently the bilingual's two languages are processed. As we will see in the sections that follow, the recent evidence suggests a great deal of permeability across language boundaries. One consequence of cross-language interaction is that the bilingual will potentially encounter competition from the presence of alternative lexical candidates in the case of word recognition and alternative parsing preferences in the case of sentence processing. Second, we consider how cross-language competition may be resolved. The solution to this problem has implications not only for our understanding of how bilinguals manage to negotiate their two languages, but also for fundamental assumptions about the relation between language and cognition.

7.2 Understanding Words

How do bilinguals understand words in each of their languages? Models of the bilingual lexicon make different assumptions about the relation of words in bilinguals' two languages. For the purpose of the present discussion, we review three models that focus on different aspects of lexical processing and consider the evidence that supports them. Because much more research has been performed on comprehension of the written word in comparison to the spoken word, these models were specifically proposed to characterize bilingual performance during reading and other tasks initiated by visual input (e.g. translation), but we also consider extensions to the case of spoken word recognition.

7.2.1 Models of the bilingual lexicon

The models of the bilingual lexicon can each be viewed as a different answer to the question of what is shared across words in the bilingual's two languages. We describe three models, one of which explores the way in which the orthography of the written languages may be shared, another which considers the implications of shared semantics, and a third which examines the implications of the way in which aspects of lexical form may be linked to semantics for each of the bilingual's two languages.

7.2.1.1 The Bilingual Interaction Activation model (BIA)

The BIA model (Dijkstra and Van Heuven, 1998; Dijkstra, Van Jaarsveld, and Ten Brinke, 1998; Van Heuven, Dijkstra, and Grainger, 1998) is a connectionist

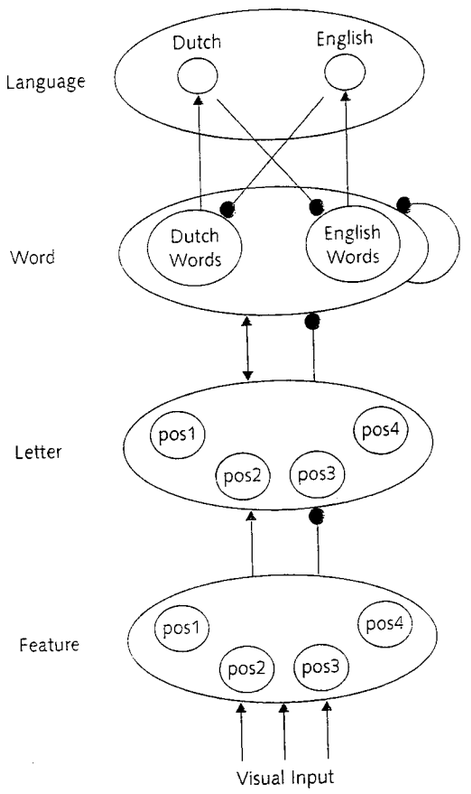

Figure 7.1 The bilingual interaction activation model (adapted from Dijkstra, Van Heuven, and Grainger, 1998).

model that extends the McClelland and Rumelhart (1981) Interactive Activation (IA) model to the bilingual case. The architecture of the model, shown in figure 7.1, assumes the same basic architecture as the IA model, namely letter features, letters, and words. Like monolingual word recognition, processing is hypothesized to be initiated bottom-up upon presentation of visual input and nonselectively so that all information similar to the input is activated. Unlike the monolingual case, the BIA model assumes that nonselectivity extends to orthographically similar letter strings in any of the languages the bilingual reads. Thus words sharing overlapping or identical orthography in the bilingual's two languages will all receive some activation. Inhibitory connections then modulate competition among both same- and other-language alternatives. The BIA model includes an additional layer of language nodes, one for each language, to allow top-down inhibition of the nontarget language.

A critical feature of the BIA model is the assumption that when words are read in one language, lexical form relatives of those words are activated in both the target and nontarget languages. Thus, when a Dutch-English bilingual reads the word *room* in English, not only do similar-looking English words become active (e.g. *roof, boom*) but similar-looking Dutch words also become active, including the word *room* itself, which happens to be an interlexical homograph which means 'cream' in Dutch. Bilingual word recognition is therefore thought to reflect the process of sorting out the activation and resulting competition among lexical alternatives in both of the bilingual's languages.

A key source of evidence for the BIA model has come from studies in which aspects of word type have been experimentally manipulated. For example, if a Dutch-English bilingual is asked to decide whether the word *room* is a valid letter string in English (i.e. to perform language-specific lexical decision), will he or she perform any differently than when asked to decide whether an unambiguously English word is a valid letter string? If access to the lexicon is language-specific, then bilinguals should perform no differently on words that share properties across their two languages than on those that do not. A large number of recent studies taking this approach have provided support for the claim that lexical access is nonselective and that bilinguals cannot help but respond as if information in both languages was active. These studies include the use of interlingual homographs, words that share lexical form but not meaning (e.g. De Groot, Delmaar, and Lupker, 2000; Dijkstra, Van Jaarsveld, and Ten Brinke, 1998; Dijkstra, Timmermans, and Schriefers, 2000; Jared and Szucs, 2002; Von Studnitz and Green, 2002), cognates, words that share both lexical form and meaning (e.g. Dijkstra, Van Jaarsveld, and Ten Brinke, 1998; Van Hell and Dijkstra, 2002), and cross-language neighbors, words belonging to a cohort of words that resemble the target word but in the nontarget language (e.g. Jared and Kroll, 2001; Van Heuven, Dijkstra, and Grainger, 1998). In general, bilingual performance on word recognition tasks, even when focused on one language only, appears to reflect the activation of information in the other language. A number of recent papers and chapters provide detailed reviews of this evidence (e.g. Brysbaert, 1998; Dijkstra and Van Heuven, 2002; Kroll and Dijkstra, 2002; Kroll and Sunderman, 2003). We therefore only briefly illustrate the nature of the empirical results for the purpose of the present discussion.

Dijkstra, Van Jaarsveld, and Ten Brinke (1998) examined the lexical decision performance of highly proficient Dutch-English bilinguals on English and Dutch words that were unambiguous within each language or interlingual homographs (e.g. *room*). When the task was simply to decide whether the letter string was a real word in English, and to say "no" to pseudowords (i.e. letter strings that are legal in English but not real words), the Dutch-English bilinguals were as fast to judge the homographs as the unambiguous English control words, as if they were able to selectively access English and switch off their Dutch. However, a second condition in that experiment suggested otherwise. When the English words were cognates, words with similar form and the same meaning in both English and Dutch, they were significantly faster to

judge them as words than the controls. In a second experiment, Dijkstra et al. increased the difficulty of the task by including real Dutch words among the pseudowords. The task was still English lexical decision, but now the task was to respond "yes" if the letter string was a real English word and "no" otherwise (i.e. to both pseudo-words and real Dutch words). With this change in the composition of the materials, bilinguals were now slower to accept letter strings as English words when they were interlingual homographs, suggesting that it was difficult to ignore the irrelevant sense of the word. In a final experiment, Dutch-English bilinguals were asked to perform a generalized lexical decision task which required them to respond "yes" to any real word in either language. Under these conditions, the bilinguals were faster to judge homographs than controls, again suggesting that both readings of the word were available. Dijkstra et al. argued that the results supported the predictions of the BIA model in that shared orthographic properties of words in both languages affected performance regardless of whether the task required attention to one language only.

The fact that the BIA model restricts cross-language interaction to shared orthographic information might be taken as a criticism of its generality because many languages are not alphabetic, or use different alphabets, or differ on other dimensions of the written form. However, recent work has shown that the same general principles that apply to orthography also appear to extend to phonology and to the recognition of spoken words (e.g. Brysbaert, Van Dyck, and Van de Poel, 1999; Dijkstra, Grainger, and Van Heuven, 1999; Jared and Kroll, 2001; Marian and Spivey, 1999; Schulpen, Dijkstra, Schriefers, and Hasper, submitted; Schwartz, Kroll, and Diaz, in preparation).

Notably absent in the BIA model is the representation of semantics. The assumption at this level of analysis is that lexical form properties of words in the bilingual's languages are activated in a bottom-up fashion and only later in processing does the output of the lexical identification system interact with semantics and higher-level context. The questions of how the phonology and semantics are represented, how interactions across these levels eventually take place, and how deeply the system can be affected by contextual factors and task goals are topics of current research activity and theorizing (e.g. Altarriba, Kroll, Sholl, and Rayner, 1996; Dijkstra and Van Heuven, 2002; Elston-Güttler, 2000; Van Heuven, 2000; Von Studnitz and Green, 2002; Von Studnitz and Green, forthcoming). We will return to this issue when we consider the question of negotiating cross-language competition.

7.2.1.2 *The distributed feature model*

In the past literature, there are two different research traditions that have given rise to alternative accounts of bilingual semantics. One line of research, investigating the representations of words and concepts in two languages, assumes that in most essential respects the same semantics support meaning representations in the bilingual's two languages (Kroll, 1993; Kroll and De Groot, 1997). For example, research on picture naming and translation, Stroop-type interference tasks, semantic priming, and semantic categorization

all suggest that words in each language access conceptual representations that are common to both languages (e.g. Altarriba, 1990; Caramazza and Brones, 1980; Chen and Ng, 1989; Costa, Miozzo, and Caramazza, 1999; Dufour and Kroll, 1995; Hermans, Bongaerts, de Bot and Schreuder, 1998; La Heij, Kerling, and Van der Velden, 1996; La Heij et al., 1990; Potter, So, von Eckardt, and Feldman, 1984; Schwanenflugel and Rey, 1986; Tzelgov and Eben-Ezra, 1992). Moreover, recent neuroimaging studies have shown that the same neural tissue appears to support semantic processing in each of the bilingual's two languages, suggesting a common representation (Illes et al., 1999). Bilinguals may take longer to understand the meaning of words in the L2 than in the L1, and they may have more extensive knowledge of the meanings of L1 than L2 words, but the same underlying representations and processes are assumed (see Francis, 1999 for a general review of the literature on bilingual semantics). A criticism of much of this work is that its scope is necessarily restricted by the focus on pictured objects and their names, thereby excluding many concepts and grammatical categories other than nouns that are also representative of bilinguals' vocabulary.

An alternative view is that the larger cultural and linguistic context in which the bilingual's two languages are used have profound consequences for the understanding of even common words. Research on linguistic relativity reflects this assumption (see Green, 1998, and Pavlenko, 1999, for recent discussions of this issue). Observations of language use both within and outside the laboratory make it clear that not all words in one language possess direct, single-word translation equivalents in another language, and that sometimes translation equivalents are only approximate. Within the literature on bilingual psycholinguistics, these ideas have been developed most extensively by the work of De Groot and her colleagues (De Groot, 1992, 1993, 1995; De Groot, Dannenburg, and Van Hell, 1994; Van Hell, 1998; Van Hell and De Groot, 1998). The distributed feature model, shown in figure 7.2, represents the relation between translation equivalents in terms of the overlap of a set of semantic features. As in other recent proposals in the domain of semantics and computational modeling (e.g. McRae, de Sa, and Seidenberg, 1997; Vigliocco, Vinson, Damian, and Levelt, 2002), the notion is that the similarity of word meanings is graded and that the resulting representations account for many of the emergent properties of category structure and word type. In the case of bilinguals, the similarity of the meaning representation that is retrieved for translation equivalents will be a function of how much the concepts that are activated by words in the two languages overlap. The claim is that some words, notably concrete nouns and cognates, are more likely to map onto virtually the same pool of semantic features across languages than abstract nouns and noncognates. The more overlap between semantic features, the more quickly the translation will be retrieved and the more likely bilinguals will be to consistently produce the same response.

The evidence for the distributed feature model comes primarily from studies of translation by proficient bilinguals (e.g. De Groot, 1992, 1993, 1995; De

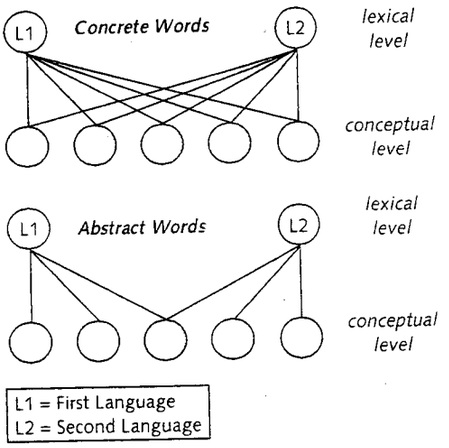

Figure 7.2 The distributed feature model (adapted from Van Hell and De Groot, 1998).

Groot, Dannenburg, and Van Hell, 1994; Van Hell, 1998; Van Hell and De Groot, 1998). As the model predicts, performance is faster and more accurate for concrete than for abstract words and for cognate than for noncognate translations (see Van Hell, 1998 for converging support from word association and lexical decision tasks). Critical questions for the distributed feature model are whether there is any consequence of which particular features are shared across languages and whether the number of features required to identify a particular concept is an important factor in determining cross-language similarity. The model as it stands makes predictions that are primarily quantitative so that response time will be fastest when the highest proportion of features overlap, regardless of their status.

Another issue that requires examination is whether a special similarity mechanism is required in the bilingual case. It is possible that any factor that affects the ease of concept retrieval will also influence cross-language performance in tasks in which semantics is engaged. For example, the concreteness of words within a single language has been shown to affect performance in a variety of tasks (e.g. Kroll and Merves, 1986; Paivio, 1971; Schwanenflugel, Harnishfeger, and Stowe, 1988; Schwanenflugel and Shoben, 1983). It is possible that the observed cross-language effects are only a reflection of more general aspects of semantic and conceptual representation. One recent set of studies suggests that this may be the case for words that have more than a single translation equivalent in one or the other of the bilingual's two languages (Kroll and Tokowicz, 2001; Schönpflug, 1997; Tokowicz and Kroll, in preparation; Tokowicz, Kroll, De Groot, and Van Hell, 2002). These studies show that the time to translate is a function of the number of translation equivalents, with

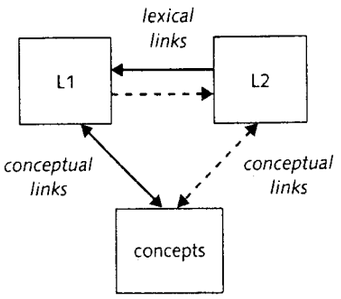

Figure 7.3 The revised hierarchical model (adapted from Kroll and Stewart, 1994).

longer latencies when words in one language map to more than one alternative in the other language. These effects are even more robust than the concreteness effects previously reviewed and provide support for the hypothesis that the ambiguity of the lexical and/or semantic representation will have consequences for understanding and speaking words across languages.

Just as the BIA model does not include or make a commitment about the nature of semantics, the distributed feature model does not make any claims about the representation of the lexical form itself nor how lexical form and meaning might interact during word recognition. Indeed, one might consider a model in which both lexical form and semantic aspects of the lexicon are represented as distributed features (see Kroll and De Groot, 1997, for an illustration of this approach, Dijkstra and Van Heuven, 2002, for an extension of the BIA model, and Van Hell, 1998, for an example of a distributed model at both levels). The final model at the lexical level that we consider addresses the nature of the interconnection between lexical forms and meaning.

7.2.1.3 The revised hierarchical model (RHM)

The models described thus far examine aspects of the bilingual lexicon for individuals who have achieved a relatively high level of proficiency in their second language. However, as we noted at the outset of the chapter, few bilinguals are balanced across the two languages; typically one language, often the native language, is more dominant than the other. The revised hierarchical model (RHM) was proposed by Kroll and Stewart (1994) to characterize the consequences of differential expertise in the two languages for the connections between words and concepts. The model, shown in figure 7.3, includes independent lexical representations for each language, with L1 assumed to be larger than L2, and a shared conceptual representation. Unlike the BIA and distributed feature models, the RHM does not make a detailed commitment to the structure of the lexical and conceptual information, but rather focuses on the connections between them. The model assumes that words in the L1 can more readily access their respective meanings than words

in L2. This asymmetry in the strength of connections between words in the two languages and meaning is a feature of the model that is implicitly, if not explicitly, shared with other research on this topic. The unusual claim of the model, and the one that has received the most scrutiny, is that lexical representations in L2 are strongly associated to their translations in L1. In this respect, the model represents the consequences of the learning history of the late second language learner for whom lexical and conceptual representations are already in place for L1 when L2 learning begins. The hypothesis is that L2 words take advantage of the existing lexical-to-meaning connections by accessing the L1 translation. This process will be most salient for learners but still evident even for relatively proficient bilinguals. The model thus assumes asymmetric connections in two ways. At the lexical level, L2 words are more strongly associated to their L1 translations than the reverse. At the level of accessing concepts, L1 words have stronger connections to meaning than their L2 counterparts.

Extensive reviews of the evidence supporting and failing to support the RHM are available in recent chapters (e.g. Gollan and Kroll, 2001; Kroll and De Groot, 1997; Kroll, Michael, and Sankaranarayanan, 1998; Kroll and Sunderman, 2003; Kroll and Tokowicz, 2001). For present purposes we describe the major results.

The empirical observation that led to the RHM initially was the finding that translation from L1 to L2, the forward direction, is typically slower and more error-prone than translation from L2 to L1, the backward direction. According to the model, the asymmetry in performance in the two directions of translation can be understood as a consequence of the asymmetric connections between words and concepts in the two languages. In the L2 to L1 direction, the strongly associated translation equivalents will be accessed directly. In the L1 to L2 direction, the bias to activate the meaning of the L1 word will encourage reliance on a translation route that engages semantics. The latter process will require additional processing and also the potential negotiation of lexical competition prior to selecting an L2 response. The L1 to L2 direction is hypothesized to be particularly difficult for less proficient bilinguals for whom the concept to L2 links are relatively weak. Experiments on translation generally support these predictions, with a larger translation asymmetry at lower levels of L2 proficiency and L1 to L2 translation changing most dramatically with increasing L2 skill (e.g. Kroll, Michael, Tokowicz, and Dufour, 2002, but see De Groot and Poot, 1997 for evidence to the contrary).

If the claims of the RHM about the two directions of translation are correct, then concepts are accessed in only one of the two translation directions, from L1 to L2. Kroll and Stewart (1994) tested this prediction by examining the effect of a semantic variable, the presence of a list context that was semantically categorized or not, on the two translation tasks. The experiment, performed with highly proficient Dutch-English bilinguals, provided clear support for the predictions. In the L1 to L2 direction, bilinguals suffered interference when translating in the context of categorized lists. In the L2 to L1 direction,

hypothesized to be accomplished directly via access to lexical-level translations, there was no effect of the semantic manipulation. The results thus supported the main features of the RHM (see Sholl, Sankaranarayanan, and Kroll, 1995; Sunderman, 2002; and Talamas, Kroll, and Dufour, 1999, for other tests of the model including an examination of the implications for development of L2 proficiency, and La Heij, Kerling, and Van der Velden, 1996, for evidence that both directions of translation may be semantically processed).

As we noted earlier, the RHM does not make a precise commitment to the structure of lexical and conceptual representations. Although it might be possible to incorporate aspects of the BIA and distributed feature models while, at the same time, maintaining the differential asymmetries proposed by the RHM (see Kroll and De Groot, 1997, for a specific proposal along these lines), the models were proposed to answer different questions about bilingual lexical representation. In particular, the claim of the BIA model that lexical form relatives are active during word recognition is quite distinct from the claim of the RHM that translation equivalents are accessed by L2 words. These differences may be understood if one remembers that the RHM is fundamentally a model of the development of L2 proficiency and that the BIA model is a model of the state of the lexicon in the proficient bilingual. It is possible that translation equivalents play a critical role during early stages of development, but by the time a bilingual is reasonably proficient in L2, representations for L2 words are established and function like L1 words (see Frenck-Mestre and Pynte, 1997, for evidence that L2 words are processed autonomously even early in L2 acquisition). An alternative way to understand these different claims about lexical activation is to consider that the RHM may be more likely to capture the processes engaged in production tasks that require the top-down lexicalization of concepts to words, whereas the BIA model may better account for the bottom-up aspects of processing during the earliest stages of word recognition. (For a discussion of bilingual production models, see Costa, chapter 8 in this volume, and La Heij, forthcoming.) Although perception and production may contact the same lexical representations, the manner in which the output of the lexical system is used may differ depending on the nature of the task that is performed (see Kroll and Dijkstra, 2002, for a comparison of lexical processing in perception and production). (For additional discussion of the RHM, see chapter 9.)

7.2.2 *Negotiating cross-language competition*

If words in both of the bilingual's languages are active at some level, even when the bilingual reads or hears spoken language in only one of his or her two languages, then some mechanism must be in place to allow effective negotiation of the potential cross-language competition. Because there does not appear to be a simple language 'switch that enables language selection based on the intention of the reader or speaker or on the language-specific properties of the input (e.g. Thomas and Allport, 2000), the problem of how

cross-language competition is resolved requires additional assumptions about the architecture of the recognition system.

One solution to the control problem, illustrated by the BIA model discussed earlier, is to assume that there is a level of representation within the lexicon, the language nodes, that accumulates information about the intended language and serves to inhibit the unintended language (e.g. Dijkstra, Van Jaarsveld, and Ten Brinke, 1998; Van Heuven, Dijkstra, and Grainger, 1998). If the internal properties of the lexical system are sensitive to factors that signal language membership, then differential levels of information might be needed to recognize a word as belonging to one language rather than the other. For example, an early study by Grainger and Beauvillain (1987) showed that there was a cost to switching between the bilingual's two languages in lexical decision that appeared to be overcome when words possessed language-specific orthography. However, a more recent study by Thomas and Allport (2000) revealed a confounding in the Grainger and Beauvillain study such that only the real words in lexical decision contained language-specific sequences. When the confounding was removed, the effect of language-specific cues was independent of switch costs, suggesting that the switch costs themselves arise outside of the lexicon. The result is surprising in some ways, because one might expect, especially when the cues to language membership are salient (e.g. in bilinguals for whom one language is alphabetic and the other is not, or where one language utilizes diacritical markings and the other does not), that selection would be possible on the basis of the input alone. To the contrary, the observation of cross-language effects based on phonology alone, even in the absence of common orthography, suggests that early selection may not be possible, at least in comprehension (e.g. Gollan, Forster, and Frost, 1997; Jiang, 1999; but see Vaid and Frenck-Mestre, 2002 for an illustration of how orthographic cues may be used to decide language membership).

A number of recent papers have argued that there are processes outside the lexicon that serve to modulate and influence the output of the lexical system (e.g. Dijkstra and Van Heuven, 2002; Green, 1998). On this account, the degree of cross-language activity within the lexicon is determined by a bottom-up process engaged by the similarity of the input to lexical and sub-lexical features in each of the bilingual's two languages. However, because the configuration of different tasks will make distinct demands on the way the lexical output is used and require different decision criteria to be adopted (see Green, 1998, for a discussion of the notion of task schemas), a variety of cross-language patterns will be observed (e.g. Dijkstra, De Bruijn, Schriefers, and Ten Brinke, 2000; Michael, Dijkstra, and Kroll, 2002; Von Studnitz and Green, 2002, forthcoming).

How can these alternatives be distinguished? One empirical approach has been to determine whether the homograph interference effect in lexical decision (De Groot et al., 2000;), taken to reflect the presence of nonselective activation of information in both of the bilingual's languages, can be modulated. Dijkstra et al. (2000) reported that advance knowledge that words in the nontarget

language would be present did not affect the presence of the homograph interference effect; only the actual presentation of those words appeared to induce the effect. This result suggests that the observed cross-language effects were the outcome of a bottom-up process that proceeded independently of task instructions. Using a related but slightly different manipulation, Von Studnitz and Green (2002) demonstrated that informing participants about the presence of interlingual homographs did modulate the magnitude of the effects; they also argued that the observed modulation was primarily due to mechanisms likely to fall outside the lexicon itself. Furthermore, Michael, Dijkstra, and Kroll (2002) showed that individual differences in working memory capacity, a factor that is related to performance on a range of language-processing tasks including translation, did not affect the magnitude of homograph interference in lexical decision. To the extent that differences in working memory capacity reflect differences in the ability to select among multiply active alternatives, then the result suggests that at least in the case of homograph interference, the enhanced ability to juggle alternatives does not eliminate the apparently bottom-up contribution of cross-language activation.

7.2.3 *Summary on understanding words*

The picture that emerges from the research we have reviewed is one of permeable lexical systems in which sources of shared information interact. The question of how the resulting activation and competition across languages is resolved is an active area of research that will require that additional evidence from a variety of tasks and approaches be considered before a clear conclusion can be reached. For example, a very recent neuroimaging study by Rodriquez-Fornells et al.. (2002) examined brain activity while Spanish-Catalan bilinguals read words in one language and ignored the other language. Contrary to the claims of most of the behavioral studies cited above, they argue that phonological information can be used during lexical access to block the nontarget language. It will remain to be seen whether different approaches to this question produce converging evidence.

A further critical issue for the models we have discussed is how context modulates cross-language activation. Although many previous bilingual studies have examined the effects of single word semantic and/or translation context on lexical access (e.g. Altarriba, 1990; Chen and Ng, 1989; Gollan, Forster, and Frost, 1997; Jiang, 1999; Keatley, Spinks, and De Gelder, 1994; Meyer and Ruddy, 1974; Schwanenflugel and Rey, 1986; Tzelgov and Eben-Ezra, 1992), only a few studies have examined the consequences of sentence context for lexical access (e.g. Altarriba, Kroll, Sholl, and Rayner, 1996; Elston-Güttler, 2000). The findings of the semantic priming studies are mostly consistent with the claim that semantics is generally shared across the bilingual's two languages, regardless of whether the two languages also share lexical form. Consistently with the claims of the revised hierarchical model, these effects are typically larger from the L1 to L2 than the reverse, which is consistent with the

notion that semantic representations for L1 words are accessed more rapidly than those for L2 words. The findings of the few sentence priming studies are also consistent with the claim that semantics may be shared across languages, but are less clear about the conditions under which the language nonselectivity that is such a compelling feature of out-of-context word recognition performance is maintained or eliminated in context. At a theoretical level, Dijkstra and Van Heuven (2002) argue that sentence context effects should reflect linguistic interactions that would be permissible within an encapsulated lexical system, and thus distinct from the apparent insensitivity of the system to task-level expectations described earlier. However, virtually all of the research on bilingual word recognition has been conducted in a framework that is independent of sentence-level considerations. We turn now to the question of how bilinguals process sentences in one or both of their languages. At the end of the chapter we discuss briefly the connections and future directions that emerge from considering these two levels of processing together. (For additional discussion of bilingual lexical processing, see chapters 2, 7, 9, and 28.)

7.3 Understanding Sentences

Sentence comprehension is a highly complicated process. Within the span of a few thousand milliseconds, the average reader or listener is able to identify the players in a sentence, the roles that these players fulfill, the events and states being described, and the meaning of the sentence as a whole. Given the speed with which this process takes place, it is quite remarkable that people are rarely unsuccessful at understanding sentences. Few other human tasks are accomplished so quickly, efficiently, and successfully by so many. What is even more surprising is that we are able to arrive at the intended interpretation of sentences that we have never encountered before. So how do we accomplish this? Much of the research on sentence processing has been directed precisely at answering this question. A number of accounts have emerged which make different claims about how the sentence parser computes the initial syntactic structure of sentences. Distinguishing among these accounts is beyond the scope of this paper. However, we will outline the assumptions made by two different types of accounts: restricted and unrestricted (for a detailed discussion, see Pickering, 1999).

Restricted accounts claim that during initial sentence processing (i.e. the stage at which a first analysis is formed), the parser can only employ a limited number of all the relevant existing sources of information. Perhaps the most well-developed instantiation of a restricted account is Frazier's *Garden-Path* model (1978; see also Frazier and Rayner, 1982; Rayner, Carlson and Frazier, 1983). The model, which is principle-based, assumes that the sentence processor is faced with computational limitations that require it to ignore potentially useful information during initial parsing decisions. Confronted with the task of assigning a structural analysis to a sentence, the parser initially consults

only limited grammatical information; discourse context and semantic information play a role only during subsequent stages, when late-arriving grammatical information or extra-grammatical information, i.e. pragmatic context or plausibility, indicate that some other legitimate interpretation is preferred to the first analysis. To explain how the parser assigns a single immediate analysis to a sentence fragment, Frazier and her colleagues postulated the existence of a small set of universal parsing principles, the most important of which are *Minimal Attachment* and *Late Closure*. For illustrative purposes, we will describe the latter principle.

(1) Late Closure: "If grammatically permissible, attach new items into the clause or phrase currently being processed." (Frazier, 1987, p. 562)

To show how Late Closure works, consider (2):

(2) Peter fell in love with the daughter of the architect who studied in Spain.

Example (2) is structurally ambiguous in that the relative clause *who studied in Spain* can modify the first or the second noun in the complex noun phrase *daughter of the architect*. *Late Closure* predicts attachment of the relative clause to *the architect*, since the phrase containing this noun phrase is also the phrase more recently postulated.

Although both Minimal Attachment and Late Closure receive empirical support from a number of studies involving a variety of languages (e.g. Carreiras, 1992; Cuetos and Mitchell, 1988; Ferreira and Henderson, 1990; Frazier and Clifton, 1996; Frazier and Rayner, 1982; Igoa, Carreiras, and Meseguer, 1998; Mitchell and Cuetos, 1991), the Garden-Path model has undergone considerable revision because of the existence of cross-linguistic evidence that challenges the universality of Late Closure as a parsing principle (see Frazier and Clifton, 1996).

In marked contrast with restricted accounts of parsing, unrestricted accounts put forward the claim that all sources of information can be employed during initial parsing decisions. This is the position adopted in *Constraint-based Satisfaction* models of sentence parsing (e.g. MacDonald, 1994; MacDonald, Pearlmutter and Seidenberg, 1994; Trueswell, Tanenhaus and Kello, 1993), which assume that multiple alternative analyses are available during initial sentence parsing, but that their availability undergoes continuous changes caused by the strength of probabilistic syntactic and non-syntactic cues (or constraints) and by the availability of alternative analyses. For example, MacDonald, Pearlmutter and Seidenberg (1994) postulate that the semantic, phonological, orthographical and morphological (e.g. past tense vs. past participle) information of words, as well as information about their alternative argument structure and frequencies of occurrence is encoded in the lexicon and is activated to differing degrees during sentence parsing.

The different models outlined above raise interesting questions regarding sentence processing in bilinguals. Given the existence of cross-linguistic variation in argument structure, for example, how do bilinguals use information about the two languages in assigning initial structure to a sentence? And how do bilinguals' different language histories influence the strategies employed during real-time sentence parsing? Does language comprehension in bilinguals differ qualitatively from that of native readers (or listeners) when faced with phrase structure violations, or is there only a quantitative difference between the two? The fundamental goal of this line of inquiry is not only to arrive at an understanding of the precise nature of bilingual sentence processing, but also to contribute to the understanding of the fundamental properties of the human sentence-processing mechanism.

7.3.1 *Sentence processing in bilinguals*

Although syntactic parsing has been the object of much investigation and heated debate in the monolingual literature, few studies have examined sentence parsing from a second language (L2) perspective. Harrington (2001) offers a number of explanations for the limited attention that sentence processing has received in the SLA literature. Mainstream sentence-processing research is largely interested in the process of structure building by mature speakers, and is less preoccupied with issues related to learning and individual differences. SLA research, on the other hand, being primarily concerned with explaining how individuals acquire proficiency in an L2, focuses both on the learning process and on individual outcomes. The divergent goals in the two fields, coupled with the lack of technical resources and methodological expertise among SLA researchers, have kept L2 sentence processing research in a peripheral setting. However, as Gregg (2001) rightly points out, a theory of second language acquisition needs both a property theory – a specific theory of linguistic knowledge, *and* a transition theory – a theory that accounts for the cognitive mechanisms responsible for explaining changes of state within the L2 learner's linguistic system. It is in the latter that parsing research is relevant to SLA acquisition. A second language learner's encounter with input from the second language is filtered through the parser, a device whose role is to apply the facts of a grammar it has available to an input word string. The parser acts as a mediator between word strings and the grammatical representation that such strings are assigned during real-time sentence processing. If second language learners use the available processing strategies from their L1 to process L2 input, and if these processing strategies are not suited for parsing the incoming L2 string – for example, if they are different from those employed by monolingual speakers of the target language – L2 learners may be drawing incorrect conclusions about the target language grammar and about its properties, with the result that the interlanguage grammar is not restructured in ways that approximate the target linguistic system. The empirical question that stems from this line of reasoning, then, is whether what may be

preventing learners from acquiring the L2 grammar is the set of processing strategies that are used during syntactic parsing (see Fernández, 1999; Van Patten, 1996).

L2 sentence processing research is useful in another respect. It is a well-known fact that languages vary cross-linguistically with regard to verb-argument structure. Given the assumptions that (1) comprehension processes are guided by rule-based representations which are used by the parser (Frazier and De Villiers, 1990), and (2) that verb-subcategorization and verb-thematic information affect parsing decisions (Gorrell, 1995; Pritchett, 1992; Trueswell, Tanenhaus and Garnsey, 1994), it follows that sentence parsing research can be used as an indirect measure for investigating differences in semantics–syntax representations between monolingual and second language speakers, in cases where the L1 and the L2 differ with respect to the way in which concepts in verb roots are lexicalized. In other words, sentence parsing research can be used to make claims about the competence that learners have at any particular point during the process of second language acquisition (see, e.g. Juffs, 1998b).

Finally, L2 parsing research complements L2 research devoted to the investigation of how language is understood and used in communicative contexts. To best illustrate this, consider the case of understanding written sentences. To understand written text, L2 speakers must, among other things, identify individual words and compute the structural relationships among them. Comprehending written sentences can be particularly challenging for L2 learners, since printed text lacks the prosodic information that presumably helps listeners to make decisions about phrasal groupings during spoken language comprehension. Now, if one of the goals of communication is to arrive at a common interpretation of the written text, readers must, minimally, parse sentences in ways that are consistent with the intentions of the interlocutor. In other words, L2 learners must be able to parse sentences in the L2 in a manner *similar* to that of native speakers of the target language. Although this task may turn out to be successful when the processing routines that are used to parse the L1 and the L2 converge, when a particular reading of a sentence is linked to the application of language-specific parsing strategies, one expects to find differences in sentence interpretation in cases where the L1 parsing routines are not adequate for parsing L2 input.

7.3.1.1 L2 comprehenders: How different are they from monolinguals?

One obvious fact about language comprehension is that L2 speakers approach the task of L2 sentence comprehension with a fully developed processing system from their L1. One natural question that follows, then, is whether the specific semantic and syntactic subprocesses engaged during L2 language comprehension are different for second language speakers as compared to native speakers. As we will show, L2 speakers resemble their monolingual counterparts in the semantic domain of sentence comprehension; however, when syntactic processes are involved, differences arise.

The most compelling type of evidence in support of this claim comes from studies that have used event-related brain potentials (ERPs) while L2 speakers are exposed to sentences that vary systematically with respect to particular linguistic characteristics. (ERPs are recordings of brain electrical activity, measured at the scalp, that are used to obtain temporal information regarding different subprocesses during language comprehension.) Weber-Fox and Neville (1996) investigated semantic and syntactic processing during reading in proficient Chinese-English bilinguals who had learned the L2 at the ages of 1–3, 4–6, 7–10, 11–13, and after 16 years. Participants read semantically anomalous sentences in their L2 (e.g. *The scientist criticized Max's event of the theorem.*), as well as sentences containing phrase structure rules violations (e.g. *The scientist criticized Max's of proof the theorem.*), and specificity-constraint violations (e.g. *What did the scientist criticize Max's proof of?*). The results indicated that, in response to semantic anomalies, the learners who were exposed to the L2 before age 11 were remarkably similar to the monolingual speakers. Moreover, the differences observed between the participants who acquired the second language after age 11 and the monolinguals were only quantitative in nature. That is, whereas the two groups of participants displayed the expected (*N400*) brain activity typically associated with the processing of semantic anomaly, the peak latency for the participants who acquired the L2 after age 11 was delayed. With respect to syntactic processing, marked qualitative differences in the responses were noted, with learners exposed to English after age 16 consistently displaying the greatest differences in ERP patterns compared with those observed in monolinguals (for similar findings regarding semantic aspects of language processing in bilinguals, see Ardal et al., 1990; Kutas and Kluender, 1991).

In a more recent study using the same methodological tool, Hahne (2001; see also Hahne and Friederici, 2001) compared semantic and syntactic processing in proficient second language learners of German who are native Russian speakers. ERP responses to auditory stimuli containing semantic and syntactic anomalies were recorded. Similarly to Weber-Fox and Neville (1996), they found that the differences in processing semantic incongruities between native and L2 speakers were quantitative only, but there were qualitative differences with regard to syntactic processing between the two groups, suggesting that the second language learners did not process or integrate syntactic information into the existing phrase structure in the same way that native listeners did.

These studies indicate that semantic processing in bilinguals parallels that of monolingual speakers and that the differences observed between the two groups arise because these processes are slowed down in L2 speakers. On the other hand, when syntactic processes are involved, the differences between the two groups are both quantitative and qualitative in nature. One question that arises from this observation is whether during the process of assigning structure to an incoming string of words (i.e. sentence parsing), bilinguals are less like monolingual speakers where syntactically based information plays a role in biasing readers toward a particular parse vis-à-vis some alternative competitor.

To address the question at hand, we examine studies that investigate how thematic role assignment proceeds during sentence processing when the bilingual's two languages rely on different sources of information to arrive at a decision. We also review research on influence of verb argument structure during L2 parsing, and then follow with a discussion of parsing adjunct phrases and modifiers by second language speakers, as this topic is revealing of the parsing processes that L2 readers follow in the absence of lexical information carried by the verb.

7.3.1.2 *The assignment of theta roles during L2 sentence processing*

Early work on theta-role assignment in bilingual sentence processing is grounded in the *Competition Model* (Bates and MacWhinney, 1982; MacWhinney, 1987). The model aims to explain how speakers determine semantic relationships (e.g. agent, patient, goal, etc.) among elements in a sentence. To capture particular relations between surface forms and associated functions, the notion of cue is brought into play. Sentence processing is seen as convergence of or competition among various cues, each contributing to a different resolution in sentence interpretation. Cues are said to converge when they concomitantly designate the same thematic relation, and to compete when they point to different relations. For example, in the English sentence *The girl sees the plant*, three cues converge to assign *the girl* the function of agent: word order, subject agreement on the verb, and animacy. However, in *The pencil kicks the donkey*, word order and agreement enter into competition with animacy.

Studies involving a variety of typologically different languages have shown the existence of cross-linguistic variation in the way forms map onto semantic functions, as well as in the weights associated with different form–function mappings. Given this, researchers of this persuasion ask whether second language learners are able to learn the mappings and weights that are specific to the second language. Although this issue has been investigated extensively in the past fifteen years, the overall picture is somewhat unclear. Gass (1987, for L1 Italian speakers learning English) and Harrington (1987, for L1 Japanese speakers learning English) found evidence that learners who favored semantically based cues (e.g. noun animacy) as the primary source of information in their L1, were strongly dependent on these cues when assigning thematic roles in English, a language in which word order provides the strongest cue (for additional results see Liu, Bates and Li, 1992, and Su, 2001 for Chinese; McDonald, 1987 for Dutch; Heilenman and McDonald, 1993, and McDonald and Heilenman, 1991 for French; Sasaki, 1994 for Japanese; and Hernandez, Bates and Ávila, 1994 and Wulfeck, Juárez, Bates and Kilborn, 1986, for Spanish). On the other hand, Gass (1987) and Sasaki (1991) found that L1 English learners of Italian and Japanese were able to abandon their reliance on word order and to employ animacy as the primary cue in interpreting Japanese and Italian sentences. This directional asymmetry may indicate that semantic cues occupy a position of universal importance relative to grammatical cues (Gass, 1987).

However, subsequent studies have not supported this proposal. A recent study examining whether transfer patterns change as a function of proficiency (Su, 2001) found differences between Chinese adult learners of English and English adult learners of Chinese. Overall, the English learners used English word-order strategies most of the time in processing Chinese sentences. At the same time, there was evidence that as proficiency increased, the learners became more aware of the important role of animacy in Chinese processing. For the Chinese learners of English, the pattern was quite different. Beginning learners used their L1 animacy cue as their strongest cue when reading English and Chinese, and intermediate learners used both animacy and word order at about the same rate in both of their languages. Advanced learners more closely resembled the English native speakers in employing the word-order cue when reading English. These findings indicate that language proficiency is an important factor, and hint at the preponderance of syntactic cues over semantic cues.

Recent work by Juffs and Harrington (1995, 1996) examines theta-role assignment under a framework that attributes parsing preferences to argument preference principles. Following Pritchett (1992), these authors assume that the parser attempts to arrive at a complete syntactic analysis of a sentence, with principles of grammar such as Case and Theta Attachment satisfied as soon as possible. In a series of experiments, the authors examined how Chinese learners of English processed sentences such as *Who did Ann believe ____ likes her friend*? and *Who did Ann believe her friends like ___*?. The sentences differ in that the first one is assumed to require extraction of the *wh* element from a subject site (indicated by the ____), whereas the second requires extraction from an object site. Juffs and Harrington (1995) predicted that subject extraction sentences ought to present more difficulty for the parser than object extraction sentences, because the former would force the parser to reanalyze the wh-gap several times before finally arriving at a complete analysis of the sentence. Data collected using a moving-window technique confirmed the predictions, but also revealed that L2 learners parsed the structures in question qualitatively and quantitatively differently from native English monolingual speakers. By and large, these studies suggest that L2 speakers exhibit non-native-like processing patterns during the assignment of thematic roles to noun phrases in their second language.

7.3.1.3 *The influence of lexical information during L2 parsing*

A common assumption in the L2 parsing literature is that when verb meaning and argument structure in the L1 and L2 match, speakers are not expected to show L2 parsing difficulties whose source is argument structure. This is because the transfer of L1 information onto the L2 will result in a structure that conforms to the L2 grammar. Conversely, differences between the two languages are expected to cause differences in parsing decisions.

There are only a handful of studies on the influence of verb subcategorization information during L2 language processing. Contrary to what we reported in

the previous section, these studies find that the bilinguals are guided by L2 argument structure information during processing, and indeed parse sentences in the second language in accordance with the lexical constraints of that language.

In one such study, Frenck-Mestre and Pynte (1997, Experiment 2) recorded the eye movements of French-dominant and English-dominant bilinguals while reading sentences that contained temporary subject/object ambiguities, as in *Every time the dog obeyed the pretty girl showed her approval.* The critical difference between French and English is that in English, the noun phrase *the pretty girl* can be interpreted as the object of the verb *obeyed* in the subordinate clause, or as the subject of the forthcoming clause. In other words, it is the optional transitivity of the verb that gives rise to the ambiguity. In French, the ambiguity does not exist because the verb is used with an intransitive reading. The results failed to show any qualitative differences between the native and second language speakers.

Additional support for the claim that L2 speakers make use of lexical-semantic information from the L2 during sentence comprehension comes from a study conducted by Juffs (1998a). Using a word-by-word reading task, Juffs examined how L2 learners from different language backgrounds processed sentences containing reduced relative clause ambiguities such as *The bad boys criticized almost every day were playing in the park.* He found that the advanced L2 learners were slower than native speaker controls, but processed the experimental sentences in a way similar to that of native speakers. As in Frenck-Mestre and Pynte (1997), the results suggested that L2 learners were guided by information about the L2 argument structure during sentence parsing.

In a related experiment, Hoover and Dwivedi (1998) investigated syntactic processing in highly fluent L2 French learners while they were reading sentences containing constructions that do not exist in their L1 (English). The construction under investigation involved pre-verbal pronominalization in French causative and non-causative constructions. The findings revealed similar patterns of reading times for French second language learners and French L1 speakers, indicating, once again, that L2 readers exhibit L2-like syntactic processing during the on-line analysis of L2 constructions not found in their L1 (but see Juffs, 1998b).

7.3.1.4 The processing of adjunct phrases

In the previous section we saw that processing L2 sentences where the argument structures of the L1 and the L2 differ sometimes results in L2 parsing patterns that are like those of native speakers. An interesting question that has been raised in the L2 sentence parsing literature regards the issues of how the L2 parser proceeds in the absence of lexical constraints, as in the cases of adjunct phrases or modifier phrases. Although several studies exist that have examined the way L2 learners process adjunct phrases in real time, the results obtained are far from conclusive.

The first study to explicitly investigate the processing strategies used by L2 learners during the parsing of modifier phrases was Fernández (1995) (see also Fernández, 1998, 1999; Juffs and Harrington, 1995, 1996). Fernández examined the intuitions of early and late learners of English about the preferred reading of temporarily ambiguous sentences like *Roxanne read the review of the play that was written by Dianne's friend.* In sentences of this type, the ambiguity arises because the relative clause ('that was written . . .') can be attached high to 'the review' or low to 'the play.' Fernández found that the strongest preference for low attachment was displayed by the English monolinguals, followed by the early bilingual group and then by the late bilingual group. She also reported that language proficiency seemed to be the best predictor of attachment preferences. That is, subjects who rated their Spanish proficiency higher than their English proficiency favored high attachment, and subjects who rated English as their dominant language tended to show a preference for low attachment.

Somewhat different results were obtained by Dussias (1998a,1998b), see also Dussias, 2001; Dussias and Sagarra, 2001) in a self-paced reading task with Spanish-English and English-Spanish bilinguals. The study investigated the attachment preferences with the structure NP1-of-NP2-RC (e.g. *El perro mordió al cuñado de la maestra que vivió en Chile con su esposo*/ 'The dog bit the brother-in-law of the teacher (fem.) who lived in Chile with her husband.') She found that the control groups (i.e. Spanish and English monolinguals) showed the conventional bias for high attachment and low attachment, respectively, that has been reported in the literature for Spanish and English. The English-Spanish bilinguals did not exhibit any preference for high or low attachment when processing the ambiguous sentences. This result adds to the evidence indicating that L2 speakers are not like monolinguals when they parse structures in the L2. Strikingly, the Spanish-English speakers showed a consistent preference for low attachment when reading sentences in both their first and second languages, suggesting that the parsing routines used to process the second language had an impact on the processing of the first language as well.

In a more recent study, Papadopoulou and Clahsen (2001) compared relative clause attachment preferences of Spanish, Russian and German L2 speakers of Greek with those of native Greek speakers. The materials were similar in structure to the ones described in previous studies, where a relative clause is preceded by a complex noun phrase. In one condition, the second noun in the complex NP carried genitive case (. . . *of the teacher*), and in another condition the second noun was the complement of the preposition *with* (. . . *with the teacher*). The findings showed that monolingual Greek speakers and second language learners of Greek performed similarly (i.e. preferred low attachment) in cases where the second noun phrase was the complement of *with*. However, for cases with the genitive construction, the Greek monolingual speakers preferred high attachment, but the learners did not show any preference for one attachment site over the other. Given that the native languages involved have all been shown to exhibit a high attachment preference with the genitive

construction, these findings argue against an L1 transfer explanation (for similar findings, see also Felser, Roberts, Gross, and Marinis, 2003).

7.3.2 *Summary on understanding sentences*

To examine the question of whether bilingual speakers resemble monolingual speakers in the domain of sentence comprehension, we reviewed a number of studies that looked at sentence processing by bilingual speakers of different language backgrounds and language proficiencies. We also examined studies that investigated parsing processes in languages whose structures reflect different syntactic properties. As the studies reviewed suggest, the picture that emerges is a complex one. Sometimes, bilinguals behave like monolingual speakers; at other times, they transfer L1 information when processing the L2; at still other times they don't resemble monolingual speakers of either of their languages.

Admittedly, this apparent complexity in the research findings may arise because the theoretical underpinnings that motivate the study of L2 sentence parsing are vastly different. In addition, researchers employ a variety of psycholinguistic techniques, from untimed intuitions about the preferred interpretation of a sentence, to self-paced reading tasks and eye-tracking data (which are presumed to reflect more directly the initial decisions), to the analysis of brain activity. In our discussion, we have abstracted away from the differences across these studies to explore L2 sentence processing as broadly as possible with the intention of opening up this area of study.

We saw that research on sentence processing by bilinguals has been primarily concerned with investigating whether second language speakers use the same syntactic and semantic information as monolingual speakers do during sentence processing. Although this question is still at the core of L2 sentence processing studies, much impetus is being directed at the study of sentence parsing by second language learners, with the goal of explaining (1) whether incomplete second language attainment may come about when learners use L1 parsing strategies that are not suitable for the development of the underlying grammar of the target language, and (2) the effects of second language learning on first language sentence parsing.

Clearly, there is much ground yet to be covered. Few studies have examined in detail the variables that may affect parsing in a second language. These factors include, but are not restricted to, language proficiency and exposure, age of acquisition, and working memory capacity. This direction of research will contribute not only by deepening our knowledge of the processes that govern sentence understanding in speakers of two languages, but, most importantly, it will also allow us to examine under different perspectives and using different sets of data, the validity and generality of current monolingual language processing theories, with the purpose of formulating models capable of accounting for bilingual as well as monolingual behavior.

7.4 Conclusions: Comparing Words and Sentences

The research reviewed in this chapter examines the way in which bilinguals understand words and sentences. Although the frameworks that guide research on each of these topics owe their intellectual commitments to different theoretical traditions in psychology, linguistics, and cognitive science, a number of common themes emerge. In this final section we identify some of these issues and the ways in which examining these two levels of language processing together might inform research in the future.

If there is a single conclusion that can be drawn from both the bilingual word and sentence processing literatures, it is that the language systems of the bilingual are permeable in the sense that processing in both languages is affected by the acquisition and use of more than a single language. We note three implications of this observation. First, the availability of alternative parsing preferences in sentence comprehension and/or additional lexical candidates in word recognition, requires that we formulate a theory of control. The fact that proficient bilinguals are able to code switch in a systematic manner but at the same time understand and speak in each language with few errors, suggests that they possess highly developed skills for negotiating cross-language competition (see also Costa, chapter 8 in this volume, for a discussion of this issue with respect to language production). In word recognition, it appears that even when lexical forms differ across languages, by virtue of the nature of the written code or by differences in the regularity of spelling-to-sound correspondences, there are still cross-language interactions that suggest that even in the presence of distinctive cues and with the intention to use one language alone, there is still activity in the nontarget language. Identifying the locus of control in recognition will require that we better understand how these effects occur in and out of context and for bilinguals whose language experiences differ in terms of how independently the two languages are used in everyday life. In the context of sentence comprehension, it may be that control is modulated by the presence or absence of particular types of structural information in the input. We saw, for example, that when structural information guided parsing decisions, bilinguals behaved much like monolingual speakers; in the absence of such information, they generally failed to show a parsing preference. It could be, then, that structural cues are more salient than non-structural ones, and that this saliency favors the selection of a particular type of parse, with the result that alternative competitors are suppressed. Clearly, it remains to be seen whether all types of structural information have the same effect on bilingual sentence parsing. This is also an area in which there may be important theoretical connections between word and sentence processing, in considering, for example, whether the conditions which give rise to language-specific parsing

preferences also give rise to language-selective lexical access when words are processed in these sentence contexts.

Second, for words and sentences alike, there is evidence showing not only that L1 affects L2, but that L1 is itself also affected by L2. Although the direction of these effects is typically stronger from the more dominant to the less dominant language, the observation that L1 changes at all in the face of proficiency in L2 has profound implications for our efforts to model language processing. For word recognition, this observation has important consequences for understanding the consequence of age of acquisition and for theories of automaticity (e.g. Segalowitz and Segalowitz, 1993). At the sentence level, we noted that learning a second language can sometimes result in the convergence of parsing routines, so that one particular parse, typically one that is available in the bilingual's two languages, is used to process not only the L2, but also the L1. Why this should be the case is, at this point, a matter of speculation, although one possible explanation may have to do with bilingual sentence comprehension and workload (see, for example, Hasegawa, Carpenter, and Just, 2002).

Finally, research in both areas suggests that those aspects of the linguistic representation that are critical for computing meaning may be shared across languages. At the level of word recognition and lexical access, it is possible that much of the functioning semantic representation for the L2 is borrowed directly from the L1 (see Jiang, 2000, for a model of how the L2 lexical representation develops). Although meanings for words in the two languages may be computed to form distinct concepts, the pool of features on which these computations are based appears to be accessed in a manner that is blind to language. In future research it will again be important to understand how the semantic interface is established across languages and how second language learners come to understand the subtle senses of meaning that differ in their two languages. The most convincing type of evidence on this issue at the sentence level comes from ERP studies which provide incontrovertible evidence that in the semantic domain of sentence processing, bilinguals are much like their monolingual counterparts. We anticipate that our research agenda will be increasingly sensitive to each of these concerns as we seek to develop models of word and sentence processing and their relation. (For more on models and theories, see chapters 1–3, 8, and 9.)

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