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12. PSYCHOLINGUISTICALLY ORIENTED SECOND LANGUAGE RESEARCH

Alan Juffs

This chapter reviews recent research that investigates second language performance from the perspective of sentence processing (on-line comprehension studies) and word recognition. It concentrates on describing methods that employ reaction time measures as correlates of processing difficulty or knowledge representation. This research suggests that second language learners employ much the same on-line processing strategies as native speakers, but that the L1 can also influence L2 processing. Reaction times in lexical decision experiments have been useful in exploring the relationship between the first and second language lexicons and automatic processes in lexical access. Finally, the chapter mentions some of the problems in this line of research, in particular the issue of individual differences in working memory and technological challenges.

In principle, most second language experimental research based on theories of grammar and development can be described as psycholinguistic because it seeks to test psychologically plausible models of knowledge of language against performance data from groups or individuals. However, this chapter will limit itself to research that uses reaction time data in an experimental approach. The primary assumption underlying the instruments used is that differences in reaction time to various linguistic tasks are an indirect reflection of mental processes. It is assumed that faster or slower reading times at crucial points in a sentence, or in reaction to words presented in isolation, can provide an insight into difficulties in second language sentence processing and the functioning of language processes in the mind in general.

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It is actually slightly embarrassing for the SLA research community that reaction time data have been used in psychometric experiments for nearly a century in order to gain insight into mental abilities and mental processes (Gregory, 1996), whereas in mainstream second language acquisition syntax research, reaction time measures have been used only in the past dozen years or so. Of course, part of the reason for this lies in the history of SLA research and its origins in more pedagogical concerns. This overview will therefore present the principal uses of reaction times in second language research and describe some of the main procedures. The goal is to focus on method rather than results, since far too many questions remain unanswered for any sound conclusions to be drawn at this early stage. I do not revisit controversial issues on the epistemology of second language knowledge, which have been raised in previous articles (Segalowitz & Lightbown, 1999). The fact is that formal linguistics plays a key role in investigating knowledge of a second language, regardless of the outcome of the debate over the access to Universal Grammar.

Reaction Times to Whole Sentences

Grammaticality judgments (GJ) have been used in second language acquisition research to gain an insight into the learner s linguistic competence (White, 1989); the assumption is that if learners knowledge of what is possible and not possible in the second language matches that of native speakers, they may be claimed to have a competence which is based on similar mental constructs. However, GJ tasks have been criticized on a number of grounds (e.g., Birdsong, 1989; Gass, this volume; Schütze, 1996). Specifically, grammaticality judgments may elicit data that are inconclusive with regard to precisely why a learner either rejected or accepted a sentence. In addition, learners may bring irrelevant metalinguistic knowledge to bear on subtle linguistic knowledge that is the focus of a study. In order to mitigate these limitations, researchers have sought to complement GJ data with other measures.

Reaction time data have been used as one such supplementary measure (Bley-Vroman & Masterson, 1989; Cook, 1990; White & Genesee, 1996; White & Juffs, 1998). It is assumed that ungrammatical sentences may take longer to judge because there is no structural description in the learner s grammar which matches that ungrammatical sentence: as a result, the parser may attempt a number of different analyses before giving up and assigning an ungrammatical status to it. This process will take longer than one in which a grammatical sentence can be quickly identified as such. One example of a study that used reaction time data in addition to GJ judgments is White and Juffs (1998). The study involved Chinese-speaking learners of English L2. The target

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structures involved grammatical and ungrammatical *wh*- questions: two examples of such questions are given in (1). In (1a) a subject is extracted from an embedded clause, whereas in (1b) an object is extracted. (The original location of the fronted *wh*- phrase is marked with a t in these examples).

1. a. *Who* does John know *t* saw Mary?
   b. *Who* does John know Bill saw *t*?

Participants in this study read whole sentences on a computer and decided whether these sentences were grammatical or not. The time that the learners took to make their judgments was also recorded. Results showed learners were less accurate at accepting *wh*- extractions from the subject position of an embedded clause and that they also took longer to judge such sentences than object extractions. White and Juffs argue that the increased time the learners took to judge the subject extractions supports earlier claims by Schachter and Yip (1990) that subject extractions are more difficult to process than object extractions. They further suggest that it is this processing difficulty that underlies the lower accuracy on sentences like (1a) and not a problem with the underlying grammar of the learners. The problem with reaction times for whole sentences is that this technique does not allow one to hone in on precisely where in the sentence the processing difficulty is. This issue was taken up in Juffs and Harrington (1995) and will be discussed in the context of the methodology described in the next section.

Another example of the use of reaction times is the Sentence Matching Paradigm (Crain & Fodor, 1987; Freedman & Forster, 1985). This technique has been used in second language acquisition research by Clahsen & Hong (1995), Duffield and White (1999), Eubank (1993), and Eubank, Bischof, Huffstutler, Leek, and Nest (1997), among others (see Klein, 1998, pp. 202 204 for a review). Let us consider Duffield and White s (1999) study as an example. Duffield and White investigated the knowledge of clitic pronoun placement in Spanish L2 by English-speaking and French-speaking learners. In Spanish, clitics can be in a variety of positions, some of which are illustrated in (2a) (2c); while clitic placement in Spanish is variable, clitics cannot appear in the positions in (3). Hence, learners must learn some constraints on clitic placement that may not be apparent from simple generalizations from the input.

2. a. Juan la encuentra complemente estúpida.
      Juan her finds completely stupid
      John finds her completely stupid.

   b. Marta quiere comprarlas con cheque
      Martha want to buy-them with check
      Martha wants to buy them with a check.

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c. Marta las quiere comprar con cheque
Martha them want to buy with check
Martha wants to buy them with a check.

3. a. * Juan encuentra la complemente estúpida.
Juan finds her completely stupid
John finds her completely stupid.

b. * Marta quiere las comprar con cheque
Martha want them to buy with check
Martha wants to buy them with a check.

In the sentence-matching paradigm, two sentences at a time are presented on a computer screen: some pairs are grammatical, with both members having the same structure, whereas some pairs have one grammatical and one ungrammatical member. The task for the participants is to say whether the sentences are the same or not. Pairs that are grammatical, the same, usually take a shorter time to judge than the pairs that consist of a grammatical and an ungrammatical sentence. If these differences in latencies are reliable, researchers infer that learners show a sensitivity to ungrammaticality, and therefore to constraints. In this way, methods from psycholinguistics can tap competence indirectly, as all other measures do without actually asking for a judgment that may reflect a range of factors which have no bearing on competence. The Duffield and White study is particularly interesting because the results from their reaction times are confirmed by their paper and pencil judgment task. This is a reassuring result since much of our knowledge about L2 syntactic representation relies on the results of GJ tasks. One issue with this research approach is that it may not be appropriate for certain sentence types, in particular subjacency violations (Crain & Fodor, 1987).

Reaction Times Word by Word During Processing of a Whole Sentence

In addition to recording the time it takes for a participant to read a whole sentence, or a pair of sentences, researchers are interested in how learners process data in the second language *word by word*, since an understanding of processing *breakdown* may be a key to understanding how processing takes place under normal circumstances. It is also generally believed that processing breakdown may provide insights into the causes of change in underlying competence (Fodor, 1998; Klein, 1998; White, 1987). Detailed knowledge of processing in a second language is similarly important for understanding second language development. It is especially important to understand processing for classroom L2

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development in view of current claims concerning the importance of input processing as an instructional technique (e.g., VanPatten, 1996).

A vast literature on first language sentence processing exists, and space does not permit a thorough review here (for recent collections of papers see Fodor & Ferreira 1998, and Vincenzi & Lombardo, 2000). Briefly, psycholinguists believe that the human sentence processor (parser) does not wait for a whole string of words and then try to assign a structure to that string in one analysis; rather, the parser begins immediately building clause structure which is based to a large extent on the syntactic requirements of predicates. Hence, if the parser encounters a transitive verb, it will expect an object NP, but not if the verb is intransitive. As the structure is built, it is reanalyzed as necessary to incorporate new information, which may tell the parser that the first analysis was not the correct one. Debate in mainstream psycholinguistics has centered on the timing of the integration of pragmatic information during the course of parsing: some researchers believe that pragmatic information is immediately available for use by the parser, whereas others favor a view in which pragmatics is only used when the syntactic parser has made its first analysis. In addition, researchers are divided about the effects of the frequency of a particular structure in the input on the probability that the parser will construct a particular clause type (e.g., Bever, 1992).

Although it is possible to investigate syntactic processing off-line (e.g., Ying, 1996), investigations that seek to examine word by word processing use the technique called the moving window or self-paced reading technique. In the moving window (Just, Carpenter, & Woolley, 1982), data are collected using a procedure on a personal computer. Each sentence is presented in random order on a computer screen, one word at a time. The words appear in linear position in the sentence moving across the screen from left to right (i.e., the words are usually not centered on the screen). Presentation may be centered between the top and the bottom of the screen. The presentation of each word is controlled by the participant, who presses a key to continue reading. (Hence the reading speed is determined by the participant and not the experimenter.) As each successive word in the sentence is prompted, the previous word disappears. Thus, only one word appears on the screen at a time as the sentence is read. After the last word of the sentence is read, the participant presses a key to provide a response either to a grammaticality judgment or to a comprehension question. It is customary to run analyses on reaction times for correct responses only.

Researchers who have investigated word-by-word processing in second language acquisition include Hoover and Dwivedi (1998), who investigated the processing of clitics in L2; French, Juffs, & Harrington

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(1995, 1996), who investigated *wh*- processing; and Juffs (1998a, b), who investigated issues of argument structure and ambiguity resolution. Juffs and Harrington (1995) used the moving window technique to confirm the claim made by White and Juffs (1998) that it was the subject gap in sentences like (1a) that was the source of difficulty. It is also possible to look for insights into second language reading with this technique and to consider issues in mainstream psycholinguistics in an L2 context. For example, Juffs (1998a) explored L2 knowledge of main verb vs. reduced relative clause ambiguity in English L2 by Japanese, Chinese, and Romance speaking learners. Main verb versus reduced relative clause ambiguity can cause conscious reanalysis problems. These problems have been dubbed the so-called Garden Path effect because readers and hearers are misled as to the structure of a sentence and they have to backtrack in order to achieve the correct analysis. The most famous example of this is Bever s (1970) sentence in (4), (¿ = Garden Path sentence), which causes reanalysis problems when the verb fell is encountered. Readers have great difficulty in understanding this sentence because reanalyzing raced as a reduced relative is difficult if raced remains the main verb, fell will have no subject and the sentence will not make sense.

4. ¿The horse raced past the barn fell.

Although extensive research had been carried out on such structures since Bever s original work, MacDonald (1994) was interested in the fact that sentences like (5) pose no processing problems at all, even though such sentences have exactly the same structure as sentences like (4) at the point where the *first* verb, interviewed, is encountered.

5. The homeless people interviewed in the documentary were calm, articulate and intelligent by any standard.

There is clearly something about the sentence in (5), unavailable in (4), which makes the parser able to recover from an initial misparse. MacDonald suggests that two kinds of information in particular are relevant: first, the transitivity properties of raced vs. interviewed : race can be either a transitive or an intransitive verb, whereas interview can only be transitive; second, the material immediately following the verb interviewed in (5), the prepositional phrase in the documentary, signals that an object is almost certainly not present. This is because NP objects must normally be adjacent to their verbs in English. Given this cue and the argument structure of the verb, the parser is left with only one possibility for the interpretation of interviewed : a reduced relative. In (4), however, two possible interpretations for raced remain: the intransitive and the reduced relative readings. It is this ambiguity that causes the difficulty in sentences such as (4) according to MacDonald.

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Juffs (1998a) researched this issue with second language learners. Like MacDonald (1994), he looked at 6 different sentence types, given in (6). There are three kinds of reduced relative: in (6a b) the reduced relative is *unambiguous* because of the morphology of the verb it is clearly a past participle. In (6c d), the verb is like interviewed in (5); it can only be transitive. In (6e f), the verb may be either transitive or intransitive, as in raced in (4).

6. a. The bad boys /seen during the morning/ were playing/ in the park.
b. The bad boys /seen almost every day/ were playing/ in the park.
c. The bad boys /criticized during the morning/ were playing/ in the park.
d. The bad boys /criticized almost every day/ were playing/ in the park.
e. The bad boys /watched during the morning/ were playing/ in the park.
f. The bad boys /watched almost every day/ were playing/ in the park.

After each verb is a cue to the correct analysis: during the morning is a good cue because it is a preposition and cannot be the beginning of an object NP; it helps the parser realize that the verb is not a main verb. In contrast, almost every day is a bad cue because almost every could be the beginning of an object NP; it continues to allow the parser to maintain the main verb analysis. A good cue will force the parser to abandon a misparse early and thereby make errors easier to recover from. The prediction is that (6a) should be easiest to process, whereas (6f) should pose the most problems. The moving window procedure permits on-line observation of how the second language reader processes the differences in transitivity of verbs, how sensitive they are to morphology, and whether different cues are as useful to second language readers as they are to native speakers. The level of difficulty is assessed by recording and comparing the reading time on the second verb phrase in slashes were playing. Learners should take more time to read that portion of (6a) than (6f).

The results of the Juffs study revealed that, like native speakers, the advanced L2 participants in his study build structure incrementally and revise it as they progress. (In contrast, in a study that did not use RT data, Fernandez [1998] claims that processing by Spanish-speaking learners of English L2 shows clear differences between the way natives and non-natives attach adjunct phrases.) Juffs study also showed that the Chinese were the least sensitive to the cue provided by an irregular past participle and that all learners showed some sensitivity to the transitivity and strength cues provided. These results are important because they show

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on-line that some learners may need additional training in *noticing* bottom up processes such as morphology. This research can be seen as complementary to the reading research done with eye-tracking technology, for example that reported by Bernhardt (1991) and Frenck-Mestre and Pyntte (1997). Indeed, these research tools deserve more attention from researchers interested in understanding the reading process.

Lexical Decision Tasks in Lexical Processing, Vocabulary Assessment, and Word Recognition

The third area in which reaction times are used is in the area of lexical processing and word recognition (e.g., de Bot, Cox, Ralston, Schaufeli, & Weltens, 1995; van Hell & De Groot, 1998; van Heuen, Dijkstra, & Grainger, 1998; Segalowitz, Segalowitz, & Wood, 1998; Segalowitz, Watson, & Segalowitz, 1995). These are very important areas of research which syntacticians interested in second language development have not been drawn to. Indeed, there is a curious lack of dialog between researchers interested in syntactic development and those interested in lexical representation and learning. This lack of communication is odd because most current theories of syntax, e.g., Minimalism (Chomsky, 1995) and Head-driven Phrase Structure Grammar (Sag & Wasow, 1999), insist on the importance of lexical information in determining clause structure. The research on lexical representation therefore has a great deal to offer syntax-based researchers. We will start with a study that addresses the knowledge structures in the bilingual lexicon with data from reaction times.

In research discussed by de Bot, Cox, Ralston, Schaufeli, and Weltens (1995), lexical decision tasks are used to gain an insight into the nature of the bilingual lexicon. The questions addressed in this research are familiar ones: are the lexicons of the bilingual interdependent or independent? The structure of the lexicon that de Bot is working with has three levels: a conceptual level, which is the real-word referent; a lemma level that includes morphological and syntactic requirements; and the lexeme level which is more restricted to the phonological form of the word. Relationships among words in one language, and among words from different languages that a bilingual speaks, may exist at every one of these three levels, only a subset, or none. The program of research is to determine these relationships.

Once again, reaction times are key in determining the inferences researchers make about knowledge representation: in de Bot et al. s study, which looks at Dutch-English bilinguals, participants are primed with a word that may be a cognate in English-Dutch, but may range from being phonologically identical (e.g., *nest* - *nest*), to phonologically similar (e.g., *double* - *dubbel*), to merely being translation equivalents (e.g., *tree* -

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boom). Participants are presented with a prime on the computer (in this case through ear-phones); a second word is then presented, and the participant has to decide whether it is related to the first one; the time taken to decide is recorded. Researchers use the latencies to infer relationships among deeper meaning representations and/or phonological representations. Latencies for words that are related in some way to the prime are generally shorter than for those trials in which the prime and the second word are unrelated. Hence, if an L1 word primes a related L2 word faster than another unrelated L1 word, we can infer a relationship between these two words from different languages in the mental lexicon. From the results of their own and other studies, de Bot et al. suggest that visual and phonological processing are in fact different. In particular, they find robust effects for semantic links in their auditory study that had not been found in earlier work.

The results of such research have the potential to inform both word-by-word reading time research described above and other reading research. Researchers interested in isolating syntactic processes from other factors will have to control lexical items carefully. If cognates give learners from closely related languages an advantage at the lexical access level of the lexeme (phonological encoding) when processing syntax, any increased facility in syntactic processing may be due to faster lexical access and not superior ability to deploy syntactic resources on-line. On the other hand, if no advantage is available and only conceptual priming is helpful, close lexical choices need not be avoided. Moreover, de Bot points out that as of the mid 1990s, little is understood concerning the level of the lemma and how such knowledge can be related from L1 to L2. Relating research from the word-by-word reading paradigm (e.g., Juffs, 1998b) to lexical access should result in a better understanding of crosslinguistic influence at the lemma level. This is because lemma-level influence can be observed when parsing since different languages encode the syntactic requirements of verbs in slightly different ways; for this reason, lemma-level influence is deployed when incremental building of structure occurs and can be observed in the moving window paradigm.

A study presented in Segalowitz, Watson, and Segalowitz (1995) also relied on timed lexical decision tasks, but in this case with a different goal. The assumption was that faster lexical access would enable learners to process text better; the corollary was that more rapid local lexical processing should correlate with higher general reading ability. The methods involved recording reaction times from an individual learner across a span of three weeks in order to track the process of making word recognition faster through study of words that were individually meaningful to the participant. In addition, reaction times to high and low frequency words were investigated in order to determine whether a higher frequency in the input would lead to a more rapid and hence more

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automatic recognition. Segalowitz and his colleagues reached the tentative conclusion that the study of words makes access faster and that therefore reading comprehension might be enhanced. In their study, reaction times were used to infer processes and changes in automaticity of lexical access, rather than the nature of knowledge representation. Nevertheless, the results make clear that investigations of knowledge representation must control for word frequency when using reaction times to make claims about such representation. While this may slow down the research at the preparation stage, the results of studies that control for frequency will be much more convincing.

Problems with Use of Reaction Time Data

The main intervening variable that arises when using reaction time data to try to get an indirect view of second language competence and second language processing is individual differences in working memory. Individual variation in working memory has already been suggested as a variable that can be used to explain variation in second language development (e.g., Ellis & Sinclair, 1996; Harrington & Sawyer, 1992, Miyake & Friedman, 1998). It is certainly well known that individual differences in working memory among native speakers can affect comprehension (e.g., MacDonald, Just, & Carpenter, 1994). Hence, future research will not only have to take into account processing differences based on frequency of words and clause types in the input, differences in proficiency level among participants, and crosslinguistic differences in lemma structure, but also in individual differences in working memory. Such a complicated array of factors ensures that the psycholinguistic study of L2 knowledge representation and access will be very complex indeed; in fact, any model that does NOT incorporate components that allow for variation along these lines will have to be considered incomplete.

A practical issue needs to be raised in any review of this literature. The computer software that is used (e.g., MicroExperimental Laboratory, or MEL; Schneider, 1990) is sometimes difficult to program without significant technical help. Second language researchers who use these techniques need to properly prepare themselves. In addition, testing of subjects is usually done on an individual basis and is very time and cost intensive. These considerations make the whole enterprise expensive. However, the technology available is advancing: PsyScope and MEL have joined forces so that software will be available on both Mac and PC platforms. (See the new E-prime web site for details: http://www.pstnet.com/e-prime/e-prime.htm, or for Macintosh, see: http://psyscope.psy.cmu.edu/).

Finally, difficulties may be encountered by researchers in the statistical analysis. These issues need to receive careful attention from

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trained statisticians. One remaining gray area is the important issue of what to do with data for sentences for which an incorrect grammaticality judgment is made or to which an incorrect response is provided in a comprehension task (Duffield & White, 1999; Juffs & Harrington, 1996; MacDonald, 1994). In L1 experiments, error data tend to be quite limited and so their exclusion can be more easily defended, but in L2 studies error data can be as high as 33%. Such large amounts of error data pose serious questions about conclusions that are drawn based on the remaining data.

Conclusion

Psycholinguistically oriented L2 research has a long tradition as far as studies of the bilingual lexicon are concerned, but syntacticians have only recently adopted research tools long used in mainstream psycholinguistics. As a result, they have much ground to make up, both in terms of research design and statististical sophistication. To some extent, researchers with training in psychology and those with training in linguistics are also working with different assumptions and models (see Segalowitz, this volume). This research is increasing in volume, but only slowly, in part because of the technical problems discussed above. However, as Klein (1998, p. 210) points out, many of these studies must be replicated before firm conclusions can be drawn. In future, the field can move forward by integrating psychological methods with linguistic perspectives; such research will afford a much richer, and hence, more accurate, picture of the complex mental representation(s) possessed by a speaker of more than one language and will permit a better understanding of how such representations develop.

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One theoretical article every second language researcher interested in parsing and acquisition should read is this recent one by Fodor. From it, researchers will gain a clear understanding of the importance of the parser in first language development. Fodor concentrates on the issues of how a learner can select a grammar from the input. She brings the failure of the early Principles and Parameters view of acquisition flipping switches to the attention of both first and second language researchers. She

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suggests that parameter setting can be saved by proposing that parameters are in fact pieces of trees (treelets) that a learner uses to parse the input and determine whether the treelet is the appropriate one for the ambient language.

de Groot, A. M. B., & Kroll, J. F. (Eds). (1997). *Tutorials in bilingualism: Psycholinguistic perspectives*. Mahwah, NJ: Lawrence Erlbaum Associates.

This is an important edited volume that contains papers relevant to the kind of research program carried out by de Bot et al. (1995), but also a wide range of other authors including well-known figures in SLA: for example, Harley and Wang discuss critical period issues, Ellis and Laporte have a paper on implicit and explicit learning; N. Segalowitz contributes a paper on ultimate attainment. In addition, the volume contains a paper by Cook to give the whole volume a real cross-section of the kind of research discussed in this review.

Healy, A., & Bourne, L. (Ed.). (1998). *Foreign language learning: Psycholinguistic studies on training and retention*. Mahwah, NJ: Lawrence Erlbaum Associates.

This important volume has a variety of new research papers. The first section is more linguistic and has chapters on a range of topics from the effect of first language phonological configuration on lexical acquisition in a second language to mediated processes in foreign language vocabulary acquisition and retention. The second section is more applied, but includes chapters on cognitive strategies in discourse processing. The third section contains classroom research on the enhancement of text comprehension through highlighting and the effect of alphabet and fluency on reading. The final section discusses cognitive aspects of bilingualism, including working memory.

Nicol, J. L. (Eds.) (2000). *One mind, two languages: Bilingual language processing*. Malden, MA: Blackwell.

There are no monograph length works written by second language syntacticians that incorporate reaction time methodology into their work. However, this recent edited volume by Nicol is by a researcher who has a strong reputation in L1 psycholinguistics and research methods. The volume focuses on how bilinguals represent and process language. It contains chapters on methodological issues in bilingual research, new empirical research, and summaries of past work.

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