See also: connectionism and SLA, emergentism, psycholinguistics of SLA, statistical learning, theoretical constructs in SLA, working memory

References

Dijkstra, T. and Van Heuven, W.J. B. (1998). The BIA-model and bilingual word recognition. In J. Grainger and A. Jacobs (eds), *Localist Connectionist Approaches to Human Cognition*, pp. 189–225. Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Haarmann, H.J. and Usher, M. (2001). Maintenance of semantic information in capacity-limited item short-term memory. *Psychonomic Bulletin and Review*, *8*(3), 568–578.

Léwy, N. and Grosjean, F. (2001). *The Computerized Version of BIMOLA: A Bilingual Model of Lexical Access*. Manuscript in preparation, University of Neuchâtel, Switzerland.

Li, P. and Farkas, I. (2002). A self-organizing connectionist model of bilingual processing. In R. Heredia and J. Altarriba (eds), *Bilingual Sentence Processing*. Amsterdam: Elsevier Science Publisher.

Rohde, D.L. T. and Plaut, D.C. (2003). Connectionist models of language processing. *Cognitive Studies*, *10*(1), 10–28.

Rumelhart, D.E., McClelland, J.L. and the PDP Research Group (1986). *Parallel Distributed Processing: Explorations in the Microstructure of Cognition, Vol. 1: Foundations*. Cambridge, MA: MIT Press.

Thomas, M.S. C. and van Heuven, W.J. B. (2005). Computational models of bilingual comprehension. In J.F. Kroll and A.M. B. de Groot (eds), *Handbook of Bilingualism*, pp. 202–225. New York: Oxford.

Van Heuven, W.J. B., and Dijkstra, T. (2010). Language comprehension in the bilingual brain: fMRI and ERP support for psycholinguistic models. *Brain Research Reviews*, *64*(1), 104–22.

Further reading

Dijkstra, T. and Van Heuven, W.J. B. (2002). Modeling bilingual word recognition: Past, present and future. *Bilingualism: Language and Cognition, 5(3)*, 219–24.

Ellis, N.C. (1998). Emergentism, connectionism and language learning. *Language Learning*, *48* (4), 631–64.

McClelland, J.L. (2011). *Explorations in Parallel Distributed Processing: A Handbook of Models, Programs, and Exercises*. Second edition, draft. Available from www.stanford.edu/group/pdplab/pdphandbook/

O'Reilly, R.C. and Munakata, Y. (2000). *Computational Explorations in Cognitive Neuroscience: Understanding the Mind by Simulating the Brain*. Cambridge, MA: MIT Press.

Thomas, M. and Van Heuven, W. (2005). Computational models of bilingual comprehension. In J.F. Kroll and A. de Groot (eds), *Handbook of Bilingualism: Psycholinguistic Approaches*. New York: Oxford University Press.

Parsing sentences

Paola E. Dussias and
Rosa E. Guzzardo Tamargo
Pennsylvania State University

Understanding the sentence (1) *The CIA director confirmed the rumor could mean a security leak* involves a set of interconnected processes. Listeners and readers must retrieve the meaning of each word, as well as group words together into syntactic constituents and create dependencies between them to assign the grammatical roles of subject, verb, and complement. In the psycholinguistic literature, the process of classifying word strings in terms of structural categories and of establishing appropriate syntactic relations between them is referred to as "syntactic parsing" (Mitchell, Cuetos, and Zagaand, 1990). Our experience as listeners and readers tells us that the parsing process is very rapid and efficient. The parser computes the syntactic structure of sentences in a remarkably short period of time, allowing us to determine with much success "who did what to whom."

Much of the work toward developing a theory of the architecture of the human sentence parsing mechanism has relied on the operations that the

parser follows when it is confronted with temporary structural ambiguity. Why is this so? Because it is assumed that the parser's initial choice when faced with a syntactically ambiguous phrase will provide insight into the processes underlying its architecture. An example is (1) above, taken from Wilson and Garnsey (2009). The ambiguous noun phrase (NP) "the rumor" can initially be interpreted as the direct object (DO) of the verb "confirm" or as the subject of the embedded clause "(that) the rumor could mean a security leak." Past research has shown that English readers incorrectly choose the DO interpretation as the initial analysis and only later, once they encounter the embedded verb phrase "could mean," reanalyze the NP as the subject of the embedded phrase. This example shows that the parser's operations during syntactic analysis are better understood when they are disrupted. In other words, it is because readers erroneously interpret the ambiguous NP as a DO that we infer that the parser has made a decision to attach it to the main verb. Structural ambiguities of this type, then, offer an avenue to study the parsing mechanism.

Several parsing models have been proposed to explain why readers commit to one interpretation of an ambiguous phrase at points in the sentence where two or more alternative interpretations are possible. *Syntax-first* models (e.g., Frazier, 1979) postulate that early parsing decisions are determined by a small set of fixed structure-driven principles, whose function is to increase the speed and efficiency with which the syntactic representation of sentences is built during real-time processing, in order to reduce computational load. One such principle, *minimal attachment*, ensures that the parser constructs the syntactic analysis of a string of words using the fewest number of syntactic nodes. Due to this, in (1) above the prediction is that the parser's initial preference should be to attach the ambiguous NP directly to "confirm." *Constraint-based lexicalist accounts* (e.g., Garnsey, Pearlmutter, Myers, and Lotocky, 1997; MacDonald, Pearlmutter, and Seidenberg, 1994; Trueswell, Tanenhaus, and Kello, 1993) make the same prediction but for a different reason. These theories propose that usage-based and exposure-based factors, such as readers' expectations about the likely complement of a verb (i.e., subcategorization bias), guide the initial interpretation of an ambiguous clause and can ease the difficulty encountered during temporary ambiguity resolution. To illustrate, although *confirm* can be followed by several types of verbal complements, it is most often used with a direct object. Accordingly, processing disruptions arise in structures like (1), where "confirm" is followed instead by an embedded clause.

A critical question in the second language (L2) sentence parsing literature concerns whether the specific sub-processes that learners engage during L2 language comprehension differ from those followed by monolinguals as they process input in their native language. Numerous variables that affect sentence processing among L2 learners have been identified. Some are linguistic in nature in that they are concerned with the specific sources of linguistic information that L2 learners use during L2 sentence comprehension. Others are related to the characteristics of learners and their linguistic experience.

Experimental work in L2 sentence comprehension has investigated similarities and differences between native language (L1) and L2 processing using an array of psycholinguistic methods, ranging from offline tasks and behavioral tasks, which measure reaction times or provide records of eye-movements, to electrophysiological responses recorded through the scalp while participants are exposed to stimuli (e.g., Kroll, Gerfen, and Dussias, 2008 and references therein). This rapidly growing body of work suggests that L2 learners' performance is sometimes strikingly close to that of native speakers, but not always. For example, recent research suggests that the syntactic representations constructed by L2 learners while processing input in their L2 are "shallower" and less detailed than those computed by adult L1 speakers. Whereas monolinguals prioritize on structure-driven strategies and syntactic information, L2 speakers privilege lexico-semantic and pragmatic information (Clahsen and Felser, 2006).

Data in favor of "shallow processing" come from studies that contrast the behavior of L1 and L2 speakers while reading syntactically ambiguous relative clauses, such as (2) *The dean liked the secretary of the professor who was reading a letter*. Attachment preferences concerning these structures

have been found to differ cross-linguistically. In languages, such as English, Brazilian Portuguese, and Norwegian, the general preference is to attach the relative clause ("who was reading a letter") to the second noun ("the professor"), resulting in the following interpretation: "the professor was reading the letter." By contrast, in Spanish, German, French, and Greek, readers show a clear preference to attach the relative clause to the first noun ("the secretary"), giving rise to an interpretation where "the secretary was reading the letter." Papadopoulou and Clahsen (2003) asked native speakers of high-attaching languages to read ambiguous constructions in their L2 Greek, a language where high attachment is also the preferred strategy. They found that proficient L2 speakers showed no particular preference for high or low attachment when processing an L2 that, like their L1, favored high attachment. This finding, coupled with results of clear attachment preferences when lexical cues guided attachment decisions, was interpreted as evidence that L2 speakers do not use structure-based information, but rather are guided by lexico-semantic cues (see Felser, Roberts, Gross, and Marinis, 2003 for similar findings, but Frenck-Mestre and Pynte, 1997; Dussias, 2003; Dussias and Sagarra, 2007, for counter-evidence).

There is, however, some indication in the literature that the difficulties L2 speakers experience while parsing some temporarily ambiguous structures could be explained by universal, structure-based principles of parsing. For example, Frenck-Mestre and Pynte (1997) investigated the way in which advanced English-speaking learners of French and native French speakers resolved attachment ambiguities involving prepositional phrases. Records of eye movements revealed that the L2 speakers momentarily experienced greater difficulty than native speakers with verb phrase attachment of the prepositional phrase in sentences, such as (3) *He rejected the manuscript on purpose because he hated its author*. No such difficulty was observed when they read structures in which the correct analysis required attachment of the prepositional phrase to the noun phrase immediately preceding it, as would be the case in (4) *He rejected the manuscript on horses because he hated its author*. In other words, L2 speakers temporarily adopted a strategy of attaching the ambiguous prepositional phrases to the most recently processed constituent. This analysis resulted in an incorrect interpretation in example (3), but not in example (4). To account for this finding, Frenck-Mestre and Pynte proposed that non-native readers may have a general preference for *late closure* (Frazier, 1978), a structure-based locality principle assumed to be operative during monolingual sentence parsing, which effectively reduces the distance between a potential host site and a modifier within the sentence.

A number of other linguistic variables have been shown to affect L2 learners' choices during syntactic ambiguity resolution. Recent studies have produced empirical evidence demonstrating the rapid influence of plausibility information during L2 sentence processing, and have shown that, in this respect, non-natives can behave in a native-like way. For instance, Williams, Möbius, and Kim (2001) explored differences between native and non-native readers of English by asking whether the semantic plausibility of a potential filler modulated the postulation of a gap during parsing. Their study included native English speakers and advanced learners of English whose first languages had overt Wh-movement, such as German, or non-overt Wh-movement, such as Korean and Chinese. They compared the processing of sentences like (5) and (6) using a self-paced, plausibility judgment task:

(5) Which girl did the man push the bike into late last night?
(6) Which river did the man push the bike into late last night?

For the native and non-native English groups alike, when the *wh*-filler was a plausible DO of the verb, as in (5), it was more costly to discard it as the actual gap filler. Conversely, when it was an implausible DO, as in (6), there was less resistance to reanalysis and, therefore, reading times were faster at the position of the actual filler ("the bike"). This indicates that adult learners of English use plausibility information in a manner that is very similar to that of native speakers, even when parallel structures in their native languages look very different (see also Frenck-Mestre, 1997 and Pynte, 1997).

Non-native comprehenders, just like native speakers, have also been shown to use subcategorization information specific to the L2 to resolve syntactic ambiguity during reading. In an early study conducted by Frenck-Mestre and Pynte (1997), French-dominant and English-dominant bilinguals read sentences in both their L1 and their L2 containing temporary subject/object ambiguities, as in (7) *Every time the dog obeyed the pretty girl showed her approval*. In English, *obey* is optionally transitive. Therefore, it is ambiguous whether the NP "the pretty girl" is the object of "obeyed" or the subject of the ensuing clause. In French, however, this syntactic ambiguity does not exist because the French equivalent of *obey* must be interpreted as an intransitive verb. Eye-movement records from both groups failed to show any qualitative differences between the native and L2 speakers at the point of disambiguation, indicating that L2 speakers were able to activate the correct lexical representation of the L2 verbs, even when these lexical representations were different in each language.

Recently, Dussias and Cramer Scaltz (2008) examined the degree to which Spanish-English L2 learners made structural commitments constrained by verb subcategorization bias while reading syntactically ambiguous sentences in their L2. The temporary ambiguity involved the DO/sentential complement ambiguity exemplified in (1). In a monolingual experiment with English participants, the authors replicated the findings reported in other monolingual studies (e.g., Wilson and Garnsey, 2009), demonstrating that native speakers are guided by subcategorization bias. In a bilingual experiment, they then showed that L2 learners also keep track of the relative frequencies of verb-subcategorization alternatives and use this information when building structures in the L2.

Participant variables, such as the availability of processing resources (e.g., Williams, 2006; Dussias and Piñar, 2010; cf. Juffs, 2004) have also been shown to modulate the extent to which L2 learners are able to exploit various sources of information during L2 sentence comprehension. In Williams (2006), participants were required to perform one of two tasks: (a) to press a button as soon as they thought that a sentence displayed on a computer screen stopped making sense or (b) to perform a memory task involving the completion of a sentence with a word that had appeared in a previously displayed sentence. The results showed that L2 speakers processed the input incrementally, just as native speakers did, when the task encouraged such a type of processing (i.e., in the stop-making-sense task). However, when the task imposed memory demands, the non-native readers did not process the input incrementally, most likely because they were not able to allocate sufficient resources to perform such processing. This suggests that availability of processing resources plays a role during L2 sentence comprehension; it also indicates that L2 readers may be able to overcome processing limitations under the appropriate task conditions.

Other findings indicate that proficiency modulates the ability to access syntactic information during L2 sentence comprehension. Hopp (2006), for instance, found that advanced learners of German displayed the same processing preferences as native Germans when reading subject/object ambiguities, but, contrary to native speakers' syntactic reanalysis, they did not show differences in response latencies. The near-native speakers, on the other hand, reliably used syntactic features in phrase-structure reanalysis, and also showed evidence of incremental reanalysis patterns typically found in native speakers.

To conclude, in order to determine the parser's architectural mechanisms during L2 processing, most research has examined how participants resolve syntactic ambiguity. Taken together, proposed parsing models indicate that structural, lexical, semantic, pragmatic, and experience-based factors are accessed during sentence processing. In addition, studies using various methods and tasks have shown that both linguistic and participant variables affect L2 processing. Regarding comparisons between native and learner parsing, research has presented conflicting results: sometimes L2 learner processing is similar to native processing; other times they seem qualitatively and quantitatively different. More research on L2 sentence parsing is needed to further address these diverging findings.

See also: bilingualism and SLA, discourse processing, eye-tracking, psycholinguistics of SLA, reaction time, working memory

References

Clahsen, H. and Felser, C. (2006). Grammatical processing in language learners. *Applied Psycholinguistics*, *27*, 3–42.

Dussias, P.E. (2003). Syntactic ambiguity resolution in L2 learners: Some effects of bilinguality on L1 and L2 processing strategies. *Studies in Second Language Acquisition*, *25*, 529–57.

Dussias, P.E. and Cramer Scaltz, T.R. (2008). Spanish-English L2 speakers' use of subcategorization bias information in the resolution of temporary ambiguity during second language reading. *Acta Psychologica*, *128*, 501–13.

Dussias, P.E. and Piñar, P. (2010). Effects of reading span and plausibility in the reanalysis of wh-gaps by Chinese-English second language speakers. *Second Language Research*, *26*, 443–72.

Dussias, P.E. and Sagarra, N. (2007). The effect of exposure on syntactic parsing in Spanish-English bilinguals. *Bilingualism: Language and Cognition*, *10*, 101–16.

Felser, C., Roberts, L., Gross, R. and Marinis, T. (2003). The processing of ambiguous sentences by first and second language learners of English. *Applied Psycholinguistics*, *24*, 453–89.

Frazier, L. (1979). *On comprehending sentences: Syntactic parsing strategies*. Unpublished doctoral dissertation, University of Connecticut.

Frenck-Mestre, C. and Pynte, J. (1997). Syntactic ambiguity resolution while reading in second and native languages. *Quarterly Journal of Experimental Psychology*, *50*, 119–48.

Garnsey, S.M., Pearlmutter, N.J., Myers, E.M. and Lotocky, M.A. (1997). The contributions of verb bias and plausibility to the comprehension of temporarily ambiguous sentences. *Journal of Memory and Language*, *37*, 58–93.

Hopp, H. (2006). Syntactic features and reanalysis in near-native processing. *Second Language Research*, *22*, 369–97.

Juffs, A. (2004). Representation, processing and working memory in a second language. *Transactions of the Philological Society*, *102*, 199–225.

Kroll, J.F., Gerfen, C. and Dussias, P.E. (2008). Laboratory designs and paradigms in psycholinguistics. In L. Wei and M. Moyer (eds), *The Blackwell guide to research methods in bilingualism*, pp. 108–31. Cambridge, MA: Blackwell Publishers.

MacDonald, M.C., Pearlmutter, N.J. and Seidenberg, M.S. (1994). Syntactic ambiguity resolution as lexical ambiguity resolution. In K. Rayner (ed.), *Perspectives on sentence processing*, pp. 123–153. Hillsdale, NJ: Erlbaum.

Mitchell, D.C., Cuetos, F. and Zagar, D. (1990). Reading in different languages: Is there a universal mechanism for parsing sentences? In D.A. Balota, G.B. Flores d'Arcais, K Rayner (eds), *Comprehension Processes in Reading*, pp. 285–302. Hillsdale, NJ: Lawrence Erlbaum Associates.

Papadopoulou, D. and Clahsen, H. (2003). Parsing strategies in L1 and L2 sentence processing: A study of relative clause attachment in Greek. *Studies in Second Language Acquisition*, *25*, 501–28.

Trueswell, J.C., Tanenhaus, M.K. and Kello, C. (1993). Verb-specific constraints in sentence-processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 528–53.

Williams, J.N. (2006). Incremental interpretation in second language sentence processing. *Bilingualism: Language and Cognition*, *9*, 71–88.

Williams, J.N., Möbius, P. and Kim, C. (2001). Native and non-native processing of English wh-questions: Parsing strategies and plausibility constraints. *Applied Psycholinguistics*, *22*, 509–40.

Wilson, M.P. and Garnsey, S.M. (2009). Making simple sentences hard: Verb bias effects in simple direct object sentences. *Journal of Memory and Language*, *60*, 368–92.

Pausology and hesitation phenomena in SLA

Michiko Watanabe and Ralph L. Rose
University of Tokyo and Waseda University

Speech by one or more interlocutors may be described as continuous, but a moment's reflection will reveal that it is not really continuous at all. Minimally, speakers must break off their speech to breathe. In extreme cases, their speech may become highly discontinuous, with long breaks, extraneous sounds or words, or reformulations that cause delay in message transfer. These kinds of discontinuities have been studied under the name of pausology and hesitation phenomena (also sometimes called *speech disfluencies*). Studies of pauses and hesitations have focused on several different types of phenomena, though the most common in speech and the most commonly studied are silent and filled pauses. *Silent pauses* (or *unfilled pauses*) are breaks in speech production of any duration. Very short silent pauses below a certain length (e.g., 0.1 seconds, as used in many studies; cf., Griffiths, 1991) are typically regarded as the product of articulatory processes rather than linguistic processes and excluded from pausological studies. Thereafter, silent pauses may be classified into short and long pauses—or more fine-grained analyses may classify short, medium, and long pauses—based on some standards, though these standards have not been consistent across studies. *Filled pauses* (sometimes called *fillers*) involve the articulation of some sound during the delay. The sound may resemble an actual word (e.g., in Spanish, *este* "that" or in Japanese, *ano* "that") or be a non-lexical formation (e.g., in English, *uh* or *um*).

Other hesitation phenomena have been studied somewhat less than pauses, perhaps because they are less frequent. *Lengthenings* (also called *prolongations*) are when the speaker extends the articulation of one or more segments of a word. *Repeats* involve the repetition of one or more words or word segments in an utterance. A repeat which occurs at the beginning of an utterance is called a *restart*. *Self-corrections* involve a sequence of words which are intended to be understood as a repair of a preceding sequence of words. When this occurs at the beginning of an utterance, it is called a *false start*.

Production

Since pausological and hesitation phenomena research began in the mid-twentieth century with work by Howard Maclay, Charles Osgood, and Frieda Goldman-Eisler, many researchers have sought to draw an explicit connection between these phenomena and specific linguistic processes such as lexical access, syntactic processing, or discourse planning. Evidence supporting all of these possibilities has been found in different studies. Hence, the current consensus on pauses and hesitations in first language production is that speakers are making processing decisions (brought upon by high cognitive load or by error, for example) leading to a delay. The complexity hypothesis (Clark and Wasow, 1998), for example, holds that the burden of these processing decisions is related to syntactic complexity: the production of more complex constituents leads to greater processing burden and subsequently the likelihood of greater delay.

Perhaps the most sophisticated model of how second language speakers produce hesitations is based on Levelt's (1983) model of monitoring and error repair. Levelt defined a taxonomy of error types and showed how speakers handle these various errors through the use of editing terms (including silent and filled pauses) and repairs (including restarts and repeats) with respect to rules for well formedness. Research on second-language repairs shows that repairs in second language speech proceed similarly to those in first language speech, though evidence suggests that second language speakers repair error types which are not included in Levelt's original taxonomy (Kormos, 1999) such as message replacement repair—when a speaker completely abandons the original message. For second language learners, processing tasks are much greater and therefore increase the cognitive load, leading to greater chance of error and subsequent repair. Furthermore, limitations in the learners' second language proficiency causes patterns