

# Second language processing

*Norman Segalowitz and Pavel Trofimovich*

---

## Introduction

[T]o every outward voluntary action there correspond inner acts of volition ... Therefore ordered expression of thought in speech corresponds as outward volitional activity.

*(Wilhelm Wundt, 1912/1973, p. 146)*

The above quote from Wilhelm Wundt (1832–1920), a German psychologist considered to be the founder of modern psychology and psycholinguistics (Blumenthal, 1970), is remarkably relevant today. Wundt considered language comprehension and production as cognitive activities, driven by the “inner” train of thought. The speaker’s verbal message starts with his or her “apperception” of the overall idea (concept or general impression) to be communicated. The speaker then organizes this mental content into structured, ordered linguistic constituents, which Wundt believed to be specific to a particular language, and prepares and articulates the phonetic detail of the message. The listener, whose aim is in turn to recover the speaker’s overall idea, uses this phonetic detail as cues to reconstruct the structural relations in the speaker’s message and to create his or her own “inner” thought.

Wundt’s ideas about language have had a lasting impact on psycholinguistics. He provided an accurate description of the psycholinguistic processes involved in language comprehension and production. This description is now part of virtually all current theoretical frameworks of language processing (e.g., Bock and Levelt, 2002). He also conceptualized language within a broader context. For Wundt, language was a cognitive phenomenon, characterized by the transformation of mental representations into ordered linguistic elements. As can be seen from our opening quote, Wundt saw language as a volitional activity as well, suggesting that speakers use language as a tool to accomplish particular goals. Emphasizing both speaker and listener in his writings, Wundt most likely also viewed language as a social act.

These three dimensions of language so aptly captured by Wundt—cognitive, volitional, and social—in a nutshell characterize our approach to discussing processing research in this chapter. We first define language processing research and provide a brief historical discussion of it, with a particular focus on second language (L2) processing. We then discuss several core issues in L2 processing research and describe what we call a “traditional” view of L2 processing research, one that emphasizes language as a cognitive activity but largely overlooks its volitional and social dimensions. Finally, we outline an alternative view of L2 processing research that encompasses many language dimensions, including cognitive, volitional, social, and what we call variational.

## Historical discussion

Before we identify some of the important issues in L2 processing research, we first describe L2 processing research in relation to psycholinguistics in general, and then we place L2 processing research in historical perspective (see Blumenthal, 1970, and Altmann, 2006, for a detailed history of psycholinguistics, and Dörnyei, 2009a, for an introduction to the psychology of L2 learning). Language processing is a term central to psycholinguistics. In fact, describing what psycholinguists do would be utterly impossible without referring to language processing in some form or fashion. In one of the first reviews of psycholinguistic literature, Ervin-Tripp and Slobin (1966) defined the challenge of psycholinguists to be “finding the processes by which the competence described by linguists ... is reflected in performance under a variety of conditions” (p. 436). More recently, Harley (2008) identified the need “to discover the actual processes involved in producing and understanding language” as the primary theme of psycholinguistics (p. 19). Explicit in these statements is the emphasis on language *in action*, that is, language as it is being used for comprehension and production. Psycholinguists are interested in what people do with the language: how they learn and use it, and ultimately what processes, mechanisms, or procedures underlie language learning and use. Language processing, therefore, has come to refer to research that aims to uncover these processes, mechanisms, and procedures, typically using the research techniques of experimental psychology.

Some of the first L2 processing experiments were carried out by Cattell (1886a, c, 1887), who worked in Wundt's psychological laboratory at the University of Leipzig. While in Leipzig, Cattell perfected the use of the chronoscope to study people's reaction times (RTs) to various stimuli, including letters and words. The chronoscope was a sophisticated device which allowed researchers to record participants' RTs with millisecond accuracy when participants pressed a telegraphic key or spoke in response to a stimulus (see Cattell, 1886b). In his L2 experiments (1887), Cattell hypothesized that speakers of two languages are slower at associating words and concepts in their L2 than in their native language (L1), and believed that the strength of this association depended on speakers' familiarity with the language. To test his ideas, Cattell measured the time it took his participants to name words and pictures in both the L1 and the L2 and to translate words in both directions. He found that it took longer to name pictures in the L2 than in the L1, and that it took longer to translate words from the L1 to the L2 than in the reverse direction. Cattell concluded that the processing in an L2 is often not as rapid (and perhaps not as efficient) as the processing in one's L1.

Many of Cattell's ideas are still pertinent. For example, researchers continue to investigate how L2 users associate words with concepts in each of their two languages (e.g., Kroll and Tokowicz, 2005), and how L2 skills develop as a result of language experience (e.g., Piske and Young-Scholten, 2009). Cattell is credited with the discovery of semantic priming (Harley, 2008), the phenomenon that a prior experience with a word facilitates recognition or production of a word related in meaning. Semantic priming has been used widely in processing research which focuses on how L2 users organize and use their lexicons (see McDonough and Trofimovich, 2008). Cattell also examined the effect of practice on processing colors, words, and letters (1886d), concluding that RTs “become shorter as they become more automatic but that a limit is reached beyond which further practice has little or no effect” (p. 536). This theme is central to current research on skill learning (e.g., DeKeyser, 2007a) and on processing efficiency and automaticity (e.g., Segalowitz and Hulstijn, 2005).

However, due to a shift in research paradigms in linguistics (see Blumenthal, 1970), L2 processing research of the kind conducted by Cattell would not resume until decades later, the 1950s to be exact. In that decade, Weinreich (1953) published a model of bilingual memory

organization. Ervin and Osgood (1954) elaborated the distinction between compound and coordinate bilingual processing systems and, importantly, they did so using the theoretical constructs of internal mediating processes that came to characterize cognitive approaches of the day. Penfield and Roberts (1959) proposed a “language switch” to explain how L2 users can code-switch from one language to another. The details of these theoretical proposals are not relevant to the present discussion; what is important is that these and other publications spurred a flurry of processing research (e.g., Kolers, 1963, 1966a, 1996b; Lambert *et al.*, 1958; see Keatley, 1992, for review). This upsurge in interest occurred, in no small part, because it seemed that linguistic, psychological, and neuropsychological approaches to second language learning and bilingualism were successfully converging to make possible an integrated understanding of these phenomena. From then on, L2 processing has become an active and burgeoning area of research whose scope reaches far beyond these early investigations of language organization in L2 users.

Today, L2 processing research covers virtually all aspects of language. A number of major review chapters and edited books, in addition to the present volume, provide an excellent introduction to L2 processing in the areas of phonology (Cutler and Broersma, 2005; Sebastián-Gallés and Bosch, 2005), syntax (Clahsen and Felser, 2006a, b; Frenck-Mestre, 2002), and lexicosemantics (Kroll and Tokowicz, 2005). L2 processing research also deals with different levels of analysis: processing of words (Francis, 2005), sentences (Heredia and Altarriba, 2002), and larger discourse (Raney *et al.*, 2002; Roberts *et al.*, 2008). There is research on L2 processing in different skills: reading (Healy and Bourne, 1998), writing (Francis *et al.*, 2002), listening (Cutler, 2000), and speaking (Kilborn, 1994). Last but not least, L2 processing research also intersects with other areas of cognitive psychology: language and emotion (Altarriba *et al.*, 2008; Pavlenko, 2005a), cognitive development (Nicoladis, 2008), thought (Pavlenko, 2005b), attention and automaticity (Segalowitz and Hulstijn, 2005), memory (Heredia, 2008; John Williams, Chapter 26, this volume), and aging (Schrauf, 2008).

## Core issues

In his overview of processing perspectives in the field of second language acquisition (SLA), Pienemann (2004) noted that “[l]anguage processing research has been a key aspect of SLA ... right from the beginning” (p. 37). The beginning is marked by the publication of Pit Corder’s now classic 1967 paper “The significance of learner’s errors” which, for Pienemann and others (e.g., Larsen-Freeman, 2002), defined SLA as an independent discipline. Corder argued that L2 learners’ errors constitute a rich source of evidence of what strategies or procedures learners use in their language learning. He also argued that learners’ performance is not simply a reflection of the language input they receive. Rather, learners’ performance reflects the language input they can effectively *use* at a given stage of development. Corder suggested that L2 acquisition can be seen as a complex interaction between language input and learner-internal processes, and implied that understanding these learner-internal processes is key to explaining L2 acquisition. In a nutshell, these ideas defined what could be called the overall research agenda for L2 processing research in SLA: to determine how L2 learners process language input and, ultimately, to provide a theoretical description of the “L2 processor.”

There is a rich body of published literature dealing with this goal of L2 processing research, including Krashen’s Monitor Model (1985), Levelt’s and McLaughlin’s work on procedural skills (Levelt, 1978; McLaughlin, 1987), VanPatten’s work on input processing (2007, Chapter 16, this volume), Andersen’s conception of operating principles (1984), MacWhinney and Bates’ Competition Model (1989) and MacWhinney’s more recent Unified Model (2008; Chapter 13, this volume), Clahsen’s writing on processing strategies (1984), Pienemann’s Processability

Theory (2007; Pienemann and Keßler, Chapter 14, this volume), as well as Carroll's Autonomous Induction Theory (2007). Much of this work is described elsewhere in this volume (see also Pienemann, 2003). Current L2 processing research reaches far beyond SLA; we outline here several major strands of this processing research.

The goals of L2 processing research today are manifold. One strand of research, for example, investigates the organization of the two languages in L2 users, including L2 learners. Do L2 users represent and use the forms and meanings of words in a separate or a shared manner (e.g., Francis, 2005)? Do they use separate or shared syntax (e.g., Hartsuiker and Pickering, 2008)? Another strand of research focuses on documenting how L2 processing is different from L1 processing (e.g., De Bot, 1992; Levelt, 1999). There is a growing body of literature on language switching. For example, how do L2 users keep their two languages apart when they use them and yet seamlessly switch from one to the other (e.g., Gollan and Ferreira, 2009; Meuter, 2005)? Another active strand of research focuses on how innate language knowledge is, including L2 knowledge (e.g., Mehler *et al.*, 2005; see also DeKeyser, Chapter 27, this volume). Other researchers investigate how L2 processing (procedural) skills develop (e.g., DeKeyser, 2007b), whether and how explicit rules are involved in L2 processing (e.g., Hulstijn, 2005b; Paradis, 2009), and how L2 users allocate and use attentional resources (e.g., Taube-Schiff and Segalowitz, 2005; Tomlin and Villa, 1994). Yet others study relationships among different language processes and examine whether these processes are modular or interactive (e.g., Costa, 2005; Truscott and Sharwood Smith, 2004). Finally, there is some research investigating whether L2 learning relies on processing specific to language or, instead, on general cognitive processing capacity (e.g., DeKeyser, Chapter 27, this volume; Goldberg and Casenhiser, 2008).

As mentioned earlier, most L2 processing research has overwhelmingly focused on *cognitive* information processing issues and has characterized L2 processing as performance in well-controlled laboratory situations. However, as Wundt pointed out long ago, language also involves volitional and social dimensions. A lot has been learned about these dimensions since Wundt's time, and so these will be discussed here with respect to L2 processing. We also discuss a variational dimension that is important to consider in L2 processing.

### *Volitional*

Wundt's idea that speech acts correspond to inner acts of volition has important implications for both L1 and L2 processing. The first and most central implication is that when speakers use a language, they behave as active agents, not passive recipients of messages or mechanical producers of speech. Being an active agent has consequences for processing. It means that the linguistic information being exchanged is embedded in a cognitive environment marked by communicative intentions. When an L2 user produces speech, the output is driven by communicative intentions (e.g., the speaker wants to persuade the listener of something). These intentions have their own underlying processing mechanisms that recruit appropriate linguistic resources so that the speech produced will serve to promote the speaker's goals. This means that the processing underlying speech output includes the processing underlying the formation of communicative intentions. Likewise, the perception of speech involves trying to understand the communicative intentions of the interlocutor. This is because the interlocutor's communicative intentions provide crucial contextual information that helps to constrain possible interpretations of the incoming speech and thereby facilitate accurate comprehension.

The importance of this last idea has been emphasized in usage-based (Barlow and Kemmer, 2000) accounts of L1 and L2 acquisition (Robinson and Ellis, 2008; Tomasello, 2003). For example, according to Tomasello, language use does not involve simply putting an acoustic message "out there" or taking in a message. It involves engaging with the interlocutor in joint

attentional activities (in which each person monitors the other's attention and together they attend to the objects and events that are the focus of the communication) and in intention reading (in which each person engages in identifying the other person's communicative and social intentions). These attentional functions are just as important in L2 acquisition and use as they are in L1, and they point to the importance of thinking about how language involves attentional processing. Moreover, the use of an L2 to engage interlocutors in joint attention and intention reading can pose certain L2-specific challenges.

In terms of establishing joint attention with the interlocutor and trying to read his or her intentions, the L1 and L2 can in some ways be relatively congruent in how they afford possibilities for doing this and in other ways quite discrepant, giving rise to processing challenges. For example, one way a speaker can use language to harness a listener's attention is by naming the objects and events that the listener should attend to. There is usually a great deal of overlap in the way different languages allow one to do this and, other than having to learn the specific names for things and taking into account how the lexicons of the two languages are interconnected (Kroll and Tokowicz, 2005), the processing involved in L2 naming requires linking words to concepts, much as in the L1. The L2 should pose relatively little challenge in this case.

However, communication is not just about naming things. Speakers try to convey their *perspective* regarding the *relationships* between the things they are naming. Consider, for example, these sentences:

- (1) John passed his exam and he had partied the night before.
- (2) John passed his exams despite having partied the night before.
- (3) John passed his exams despite supposedly having partied the night before.

The first sentence draws attention to two events, John's passing the exam and John's partying. The second sentence draws attention to the connection between the two events (partying was definitely not the reason for passing the exam). The third sentence conveys a message similar to the second but the focus here is to suggest that the speaker has doubts about the connection (perhaps John really did study the night before). The relational information in these sentences is conveyed by the use of grammaticized words (*and*, *despite*, *supposedly*), not by simple naming. In general, grammaticized words do not map onto translation equivalents from one language to another as directly as content words seem to do (which also is seldom in a clear one-to-one fashion).

These kinds of cross-linguistic differences, which have been especially well documented with respect to spatial prepositions (e.g., Levinson and Wilkins, 2006), can place a processing burden on the L2 user, particularly if knowledge of the L2 is relatively weak. The L2 user—whether speaking or listening—has to engage in extra processing in order to accurately insert or extract the appropriate perspective on the relational information in the message. There has been relatively little cognitive processing work on this topic in the L2. Taube-Schiff and Segalowitz (2005) and Segalowitz and Frenkiel-Fishman (2005) showed that attention focus in the processing of simple grammaticized aspects of language involved a greater cognitive load in the L2 than in the L1. The processing implication of these ideas is that speakers have to think about the perspective they wish to convey in a way that is compatible with how the language makes it possible for them to do so. Slobin (1996) referred to this as “thinking for speaking,” a mode of thinking that can present a processing burden in the L2.

### *Social*

The social dimension of L2 processing arises naturally from the fact that communication is a social process, as discussed in more detail by Lantolf, Chapter 4, in this volume. What is important to

recognize is that there are specific types of social information that are always part of a speaker's communicative intentions. These types of information include knowing how to speak appropriately according to the social norms of the target language community (Hymes, 1967, 1972). Hymes commented that every L1 speaker acquires "the communicative competence that enables a member of the community to know when to speak and when to remain silent, which code to use, when, where and to whom, etc." (1967, p. 13). The communication of these types of social information draws upon particular features of language (Canale and Swain, 1980; Pawley and Syder, 1983; Wray, 2002). For example, interlocutors normally wish to maintain good social relations with each other. This usually involves speaking in an appropriate register and shifting from one register to another in a socially appropriate way, using correct forms of politeness, etc. Languages provide different ways of accomplishing such sociolinguistic functions, and L1 users normally process sociolinguistic information contained in the phonology, prosody, grammatical constructions, fixed expressions, and lexis of messages quite unconsciously. For L2 users, this can be a challenge if they are not as familiar with how the target language handles these sociolinguistic functions as they are in the L1 (e.g., Segalowitz, 1976).

This social dimension of communication has processing implications for speakers, especially in the L2. Wray (2002) describes some of these implications in her account of speaker-hearer alignment. Her idea is that L1 speakers try to help each other by minimizing the processing loads they place on each other. They can do this, for example, by using formulaic expressions and partially fixed strings: pre-assembled, lexicalized utterances and expressions that mark out the structure of the discourse to make it more predictable (e.g., *In the first place ...*). Speakers also often provide clues as to their place of origin, background, etc. (sometimes volitionally, sometimes not) by the expressions they use and through their accent, thereby informing the interlocutor about which fixed expressions they are likely to understand. All this helps reduce processing load. Of course, engaging in speaker-hearer alignment may be difficult for some L2 speakers; this activity, which lies behind the communication of the main cognitive content of the message, can thus constitute a processing burden for L2 speakers.

There is yet another processing challenge for L2 users, associated with the social dimension of L2 processing and its volitional nature. As mentioned earlier, the L2 speaker/listener's normal focus of attention will be on the establishment of joint attention with the interlocutor and reading that person's communicative and social intentions. Also, as mentioned, it will involve efforts to achieve speaker-hearer alignment. These will depend on correctly perceiving and interpreting subtle speech features. Because these aspects of speech are almost never taught explicitly, and because most proficient speakers of either an L1 or L2 are usually not consciously aware of how utterances systematically provide social messages alongside their cognitive content, the learning of these aspects of speech will be implicit rather than explicit. Hulstijn (2005a) defines this implicit/explicit distinction as follows: "Explicit learning is input processing with the conscious intention to find out whether the input information contains regularities and, if so, to work out the concepts and rules with which these regularities can be captured. Implicit learning is input processing without such an intention, taking place unconsciously" (p. 131). Thus, an important aspect of L2 ability involves the processing and learning of the implicit knowledge associated with the social dimension of communication (see also Ellis, 1994). This can be problematic for many L2 speakers.

### *Variational*

By "variational" we mean that contexts in which the L2 is used—in the classroom, in natural settings, in laboratory studies—can be characterized in terms of variability features that establish

the cognitive processing demand characteristics for L2 performance in a particular context. (This meaning is not to be confused with the important but quite different “variationist perspective” discussed by Bayley and Tarone, Chapter 3, this volume.) A variational continuum can be described ranging from closed to open skill environments (Allard and Starkes, 1991), although most communicative situations will include many characteristics of both. A closed skill environment is one where variability in the conditions under which performance takes place has negligible impact on performance, and where the goal of performance is to repeat some action (physical or cognitive) as precisely as possible to meet some standard. In sport, weight lifting and basketball free throws are often given as examples. In these cases, variability in the environment has a negligible impact on performance and the goal of performance is to execute the required movements as precisely as possible. A language-based example might be a (very narrowly conceived) L2 instruction requiring the recitation of memorized material or heavily scripted role play activities.

An open skill environment is one where there is a great deal of variability in the conditions under which performance takes place and where dealing with this variability is fully part and parcel of skilled performance. As well, the goal of an open skill is to bring about some change in the environment, as opposed to simply repeating an action precisely. Examples of open skill environments include competitive team sports such as basketball or hockey, where the goal is to place an object in a particular location (the puck into the net, the basketball through the hoop). Here the performance conditions change unpredictably from moment to moment as players try to outmaneuver each other, and achieving the performance goal requires overcoming this variability. A language-based example here would be L2 learning that takes place in naturalistic contexts (e.g., during stay abroad or in some immersion classrooms).

Natural communicative contexts are examples of open skill environments because the goal is to change the environment (e.g., persuade someone to believe or do something) in the face of the unpredictability of the interlocutor’s reactions and of unanticipated interruptions and distractions from the environment. Open skills, in contrast to closed skills, carry processing demands that draw on attention, given how important it is to notice and then respond quickly to unexpected changes in the environment. Thus, not only does L2 processing in natural communicative contexts require the ability to harness linguistic resources in the social dimension of language as discussed earlier, but it also requires being able to handle changes as they occur in real time (e.g., adapting to an interlocutor who unexpectedly responds emotionally to a message, or who tries to change the topic, or refuses to yield the floor). Closed skill environments do not carry such demand characteristics and L2 learning that takes place in such environments is unlikely to elicit appropriate processing activities that will enable full transfer of learning outside the learning context (we return to this point below in the section on applications).

## Data and common elicitation measures

What defines L2 processing research (and language processing research in general) is that it employs methodologies targeting the processes, mechanisms, and procedures that language users rely on in the many ways that they use language. Early L2 processing research, apart from Cattell’s pioneering studies, employed two major methodologies (for review, see Keatley, 1992). These two methodologies were recall (in which participants retrieve from memory previously heard or seen words, sentences, or texts) and recognition (in which participants indicate whether or not they had previously heard or seen words, sentences, or texts). It was not until the late 1970s and early 1980s that what we now consider to be typical processing methodologies—those relying on timed responses—became mainstream. In the 1970s, researchers questioned whether recall and

recognition provided an accurate depiction of how people access and use language (e.g., Posner and Snyder, 1975). These researchers reasoned that recall and recognition were examples of slow and consciously controlled language processing influenced by participants' test-taking strategies. They argued instead that only automatic processing accurately reflected how languages are organized and used. In the terminology of the day, processing was considered automatic when it was not subject to conscious control and when it proceeded without much attention or awareness (see Neely, 1977, and Favreau and Segalowitz, 1983, for examples of studies targeting automatic processing in L1 and L2, respectively).

Automatic processing can be elicited through methodologies requiring participants to respond to language stimuli as quickly as possible, under time pressure or in situations where more than one task competes for participants' attention. Examples of such methodologies, all using RT measures, include lexical decision, repetition priming, and phoneme detection. In lexical decision, participants indicate whether a letter string spells a word (e.g., *brain*) or non-word (e.g., *brone*). In repetition priming, participants perform the same or similar task more than once so that RTs can be compared. And in phoneme detection, they press a key as soon as they detect a particular target in a stimulus, for example, the phoneme /n/. The logic of all these and most other RT-based methodologies is the following: because the tasks are speeded (performed under time pressure), participants' reliance on test-taking strategies is minimized, and RTs become a measure of the time (and sometimes the effort) needed to complete a given language processing task (see Posner, 1978; Sternberg, 1969).

Of course, not all RT-based methodologies elicit automatic processing. For example, in self-paced reading or listening (the so-called moving window technique), participants read sentences or texts one word at a time so that the time required to read each word can be recorded. Depending on how the task is set up (i.e., whether participants read or listen under time pressure), it may not elicit automatic processing; nevertheless, the measures collected by researchers using such tasks will be "on-line," that is, reflecting processing in real time. For example, self-paced reading tasks are considered on-line, but grammaticality judgment tasks (in which participants read a sentence and then indicate, on paper, whether a sentence is acceptable in a language) are not.

Modern on-line processing techniques also include the use of eye-tracking and event-related brain potentials to study various aspects of L2 processing (e.g., Frenck-Mestre, 2005; Libben and Titone, 2009). We refer interested readers to the following additional references on the use of particular processing methodologies and tasks: auditory, semantic, and syntactic priming (McDonough and Trofimovich, 2008), lexical decision (Altarriba and Basnight-Brown, 2007; Goldinger, 1996), cross-modal priming (Marinis, 2003; Tabossi, 1996), various measures of speech processing (reviewed in Grosjean and Frauenfelder, 1997), picture-word interference (Costa *et al.*, 2003), translation recognition (de Groot, 1992), and self-paced reading and listening (Marinis, 2003).

### *Empirical verification*

Hulstijn (2002), in a broad overview of processing issues in L2 acquisition, called for more attention to the emotional, motivational and social aspects of L2 processing. He wrote, "... eventually cognition should be conceived as a much broader construct, encompassing not only information or knowledge, but also *emotion and motivation ... and that cognition develops and exists in a social and cultural environment*" (emphasis added; p. 195).

Putting all these elements together will be a challenge. The challenge is all the greater because the different dimensions—cognitive, volitional, social, variational, emotional, and even

motivational—will interact in complex ways. For example, the acquisition of L2 processing skills along the cognitive dimensions—say, highly efficient and rapid word retrieval, grammatical parsing, etc.—is likely to increase a person’s motivation to engage in L2 contact compared to a person whose efficiency of L2 cognitive processing remains low. Increased motivation will lead to decisions that result in more frequent exposure to the L2 in communicative contexts where the learner experiences a great deal of language repetition that, in turn, will strengthen cognitive processing efficiency and the acquisition of the implicit linguistic knowledge. A number of self-reinforcing loops between the cognitive, motivational, social, and experiential aspects of L2 use can emerge, all leading to increased L2 processing skills (see Segalowitz, 2010). Very likely, a multidimensional, dynamic theoretical framework will be needed to capture these complex interactions among different dimensions of L2 processing (see De Bot *et al.*, 2007, and Larsen-Freeman and Cameron, 2008).

In addition to conceptual challenges of integrating several processing dimensions into a coherent (and testable) theoretical framework of L2 processing, an even greater challenge is for L2 researchers to identify appropriate methodologies for studying complex interactions among these dimensions. At the beginning of this chapter, we discussed several methodologies typically used in current L2 processing research. However, the more complex picture of L2 processing that emerged here will clearly require either using existing methodologies in novel ways or developing new ones capable of capturing subtle dynamic effects and interactions among the many different aspects of language processing. While we are unable to point to any such new methodologies at this time, we see great potential in using existing research tools in novel ways. The edited volume by Trueswell and Tanenhaus (2005) contains excellent examples of existing processing methodologies used to study what they term “world-situated language use,” that is, language processing in contextually rich and socially appropriate environments. Some of these examples include the use of eye-tracking to study real-time reference resolution in an unscripted conversation, as participants perform a common task, or the use of syntactic priming to examine interlocutors’ linguistic accommodation and alignment in a dialog. Although this volume focuses on L1 processing, many (if not all) methodologies described in it are appropriate to the study of L2 processing as well.

## Applications

These L2 processing considerations have considerable instructional relevance with respect to a number of topics, including motivation and L2 learning (e.g., Dörnyei, 2009a, b; Ushioda and Dörnyei, Chapter 24, this volume), the transfer of learning from one context to another (e.g., Lightbown, 2007; Trofimovich and Gatbonton, 2006), and the promotion of automaticity and L2 processing efficiency within a communicative language teaching framework (Gatbonton and Segalowitz, 2005). At least one way to conceptualize the instructional relevance issue is to pose two questions about transfer: (a) What target L2 processing skills does the learner need to acquire during instruction for transfer later to different communicative situations both in and outside the classroom? (b) What is the best way for instruction to optimize this transfer?

From the account presented here, the target processing skills required for communication include the ability to process the basic cognitive information in a message, while at the same time participating in an exchange of sociolinguistic information. Moreover, this processing of cognitive and social information needs to take place while the speaker is engaged in trying to accomplish several other goals simultaneously: establishing joint attention with the interlocutor; trying to read

the interlocutor's social and communicative intentions; and pursuing his or her own communicative intentions. All this has to be done in an open communicative environment characterized by variability that must be taken into account for communication to succeed.

How can instruction optimize successful acquisition and transfer of these L2 processing skills? According to the principle of transfer-appropriate processing (Morris *et al.*, 1977; see Lightbown, 2007, for L2-specific examples), learners need to engage in the kinds of cognitive processing that include establishing joint attention, reading communicative intentions, processing perspective/construal information, etc. because it is these aspects of L2 processing that will need to be transferred to other communicative settings. Perhaps the most direct way to accomplish this is for learning activities to require participants to engage in *authentic interaction*, where speakers have a psychologically genuine need to successfully receive and convey the cognitive information at the core of the communication (see Gatbonton and Segalowitz, 2005, for discussion of how to accomplish this). Instruction that includes activities imbued with authentic interaction will bring into the picture the volitional, social, and variational elements discussed earlier, because these elements are inherent to such communication, thereby eliciting more transfer appropriate L2 processing. Also, following from the earlier discussion, language instruction needs to promote the development of efficient L2 processing (DeKeyser, 2007b). For this, there must be ample repetition of the targeted L2 processing during communicative learning activities, in real time. The challenge here is to provide this repetition in a way that does not undermine the authenticity of the communication. This can be achieved by designing learning activities that are *inherently repetitive* (Gatbonton and Segalowitz, 2005), that is, activities that require the learner to repeat targeted L2 processing in order to achieve his or her genuine communicative goals (e.g., in gathering multiple pieces of information for a problem-solving activity).

In closing, if there is one overriding point to emphasize regarding the instructional relevance of the L2 processing issues discussed in this chapter, it is that successful use of the L2 requires cognitive multitasking in several dimensions of processing at once. That is why instructional settings need to promote L2 processing in a pedagogically sound and cognitively engaging multitasking context if learning is to transfer beyond the instructional setting.

## Future directions

We began this chapter by citing Wilhelm Wundt's ideas on language as primarily a volitional activity, one that likely occurs in a constantly changing, and therefore highly variable, social environment. Our goal was to describe language processing, and L2 processing in particular, not only as a purely cognitive activity, a view that has dominated language processing research to date, but also as a phenomenon that involves volitional, social, and variational aspects. We conclude our chapter by citing Wundt again. In his lectures on psychology as a science, he wrote, "... [I]t is experience and reflection which constitute each and every science. Experience comes first; it gives us our bricks. Reflection is the mortar, which holds the bricks together. We cannot build without both ... It is therefore essential for scientific progress that the sphere of experience be enlarged, and new instruments of reflection from time to time invented" (Wundt, 1894/1977, pp. 8–9). This statement by Wundt aptly captures what we would like to identify as possible future directions of L2 processing research. For L2 processing to be understood more fully, in future studies researchers need to "enlarge" their research experience to include the study of L2 processing not only in decontextualized laboratory settings but also in real-life environments, those that involve the use of language as a volitional, social, and variational activity. Researchers may also need to expand their stock of research tools to enable the study of complex interactions among cognitive,

volitional, social, variational, emotional, and motivational dimensions of language processing, to name a few. All these avenues of future research, we hope, will lead to coherent and testable theoretical conceptualizations of L2 processing and will allow for a greater understanding of how L2 processing issues relate to L2 acquisition in various instructional contexts.

## References

- Allard, F. and Starkes, J. L. (1991). Motor-skill experts in sports, dance, and other domains. In K. A. Ericsson and J. Smith (Eds.), *Toward a general theory of expertise* (pp. 126–152). Cambridge: Cambridge University Press.
- Altarriba, J. and Basnight-Brown, D. M. (2007). Methodological considerations in performing semantic- and translation-priming experiments across languages. *Behavior Research Methods*, 39(1), 1–18.
- Altarriba, J., Pavlenko, A., and N. Segalowitz (Eds.) (2008). Emotion words in the monolingual and bilingual lexicon [Special issue]. *The Mental Lexicon*, 3(1).
- Altmann, G. T. M. (2006). History of psycholinguistics. In K. Brown (Ed.), *The encyclopedia of language and linguistics* (pp. 257–265). Oxford: Elsevier.
- Andersen, R. (1984). The one-to-one principle of interlanguage construction. *Language Learning*, 34(4), 77–95.
- Barlow, M. and Kemmer, S. (Eds.) (2000). *Usage based models of language*. Stanford: CSLI Publications.
- Blumenthal, A. L. (1970). *Language and psychology: Historical aspects of psycholinguistics*. New York: John Wiley.
- Bock, K. and Levelt, W. J. M. (2002). Language production: Grammatical encoding. In G. T. M. Altmann (Ed.), *Psycholinguistics: Critical concepts in psychology* (Vol. 5, pp. 405–452). London: Routledge.
- Canale, M. and Swain, M. (1980). Theoretical bases of communicative approaches to second language teaching and testing. *Applied Linguistics*, 1(1), 1–47.
- Carroll, S. E. (2007). Autonomous induction theory. In B. VanPatten and J. Williams (Eds.), *Theories in second language acquisition: An introduction* (pp. 155–173). Mahwah, NJ: Lawrence Erlbaum.
- Cattell, J. M. (1886a). The time it takes to see and name objects. *Mind*, 11, 63–65.
- Cattell, J. M. (1886b). The time taken up by cerebral operations, Parts 1 and 2. *Mind*, 11, 220–242.
- Cattell, J. M. (1886c). The time taken up by cerebral operations, Part 3. *Mind*, 11, 377–392.
- Cattell, J. M. (1886d). The time taken up by cerebral operations, Part 4. *Mind*, 11, 524–538.
- Cattell, J. M. (1887). Experiments on the association of ideas. *Mind*, 12, 68–74.
- Clahsen, H. (1984). The acquisition of German word order: A test case for cognitive approaches to L2 development. In R. W. Andersen (Ed.), *Second languages: A cross-linguistic perspective* (pp. 219–242). Rowley, MA: Newbury House.
- Clahsen, H. and Felser, C. (2006a). Grammatical processing in language learners. *Applied Psycholinguistics*, 27(1), 3–42.
- Clahsen, H. and Felser, C. (2006b). How native-like is non-native language processing? *Trends in Cognitive Sciences*, 10(12), 564–570.
- Corder, S. P. (1967). The significance of learner's errors. *International Review of Applied Linguistics*, 5(4), 161–170.
- Costa, A. (2005). Lexical access in bilingual production. In J. F. Kroll and A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 308–325). New York: Oxford University Press.
- Costa, A., Colomé, A., Gómez, O., and Sebastián-Gallés, N. (2003). Another look at cross-language competition in bilingual speech production: Lexical and phonological factors. *Bilingualism: Language and Cognition*, 6(3), 167–179.
- Cutler, A. (2000). Listening to a second language through the ears of a first. *Interpreting*, 5(1), 1–23.
- Cutler, A. and Broersma, M. (2005). Phonetic precision in listening. In W. J. Hardcastle and J. M. Beck (Eds.), *A figure of speech: A festschrift for John Laver* (pp. 63–91). Mahwah, NJ: Lawrence Erlbaum.
- De Bot, K. (1992). A bilingual production model: Levelt's "Speaking" model adapted. *Applied Linguistics*, 13(1), 1–24.
- De Bot, K., Lowie, W., and Verspoor, M. (2007). A dynamic systems theory approach to second language acquisition. *Bilingualism: Language and Cognition*, 10(1), 7–21.
- de Groot, A. M. B. (1992). Determinants of word translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 18(5), 100–1018.
- DeKeyser, R. (2007a). Skill acquisition theory. In B. VanPatten and J. Williams (Eds.), *Theories in second language acquisition* (pp. 97–113). Mahwah, NJ: Lawrence Erlbaum.

- DeKeyser, R. M. (Ed.). (2007b). *Practice in a second language: Perspectives from applied linguistics and cognitive psychology*. Cambridge: Cambridge University Press.
- Dörnyei, Z. (2009a). *The psychology of second language acquisition*. Oxford: Oxford University Press.
- Dörnyei, Z. (2009b). The L2 motivational self system. In Z. Dörnyei, E. Ushioda. (Eds.), *Motivation, language identity and the L2 Self* (pp. 9–42). Bristol, UK: Multilingual Matters.
- Ellis, N. (1994). Implicit and explicit language learning: An overview. In N. Ellis (Ed.), *Implicit and explicit learning of languages* (pp. 1–32). London: Academic Press.
- Ervin, S. and Osgood, C. E. (1954). Second language learning and bilingualism. *Journal of Abnormal Social Psychology, Supplement*, 49, 139–146.
- Ervin-Tripp, S. M. and Slobin, D. I. (1966). Psycholinguistics. *Annual Review of Psychology*, 17, 435–474.
- Favreau, M. and Segalowitz, N. (1983). Automatic and controlled processes in the first and second language reading of fluent bilinguals. *Memory and Cognition*, 11(6), 565–574.
- Francis, W. S. (2005). Bilingual semantic and conceptual representation. In J. F. Kroll, A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 251–267). New York: Oxford University Press.
- Francis, W. S., Romo, L. F., and Gelman, R. (2002). Syntactic structure, grammatical accuracy, and content in second-language writing: An analysis of skill learning and on-line processing. In R. R. Heredia and J. Altarriba (Eds.), *Bilingual Sentence Processing* (pp. 317–337). Amsterdam: Elsevier.
- Frenc-Mestre, C. (2002). An on-line look at sentence processing in the second language. In R. R. Heredia and J. Altarriba (Eds.), *Bilingual Sentence Processing* (pp. 217–236). Amsterdam: Elsevier.
- Frenc-Mestre, C. (2005). Ambiguities and anomalies: What can eye movements and event-related potentials reveal about second language sentence processing? In J. F. Kroll and A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 268–281). New York: Oxford University Press.
- Gatbonton, E. and Segalowitz, N. (2005). Rethinking communicative language teaching: A focus on access to fluency. *The Canadian Modern Language Review*, 61(3), 325–353.
- Goldberg, A. E. and Casenhiser, D. (2008). Construction learning and second language acquisition. In P. Robinson and N. C. Ellis (Eds.), *Handbook of cognitive linguistics and second language acquisition* (pp. 197–215). New York: Routledge.
- Goldinger, S. D. (1996). Auditory lexical decision. *Language and Cognitive Processes*, 11(6), 559–567.
- Gollan, T. H. and Ferreira, V. S. (2009). Should I stay or should I switch? A cost-benefit analysis of voluntary language switching in young and aging bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(3), 640–665.
- Grosjean, F. and Frauenfelder, U. (Eds.) (1997). *A Guide to spoken word recognition paradigms*. Hove, England: Psychology Press.
- Harley, T. A. (2008). *The psychology of language: From data to theory* (Third Edition). New York: Psychology Press.
- Hartsuiker, R. J. and Pickering, M. J. (2008). Language integration in bilingual sentence production. *Acta Psychologica*, 128(3), 479–489.
- Healy, A. F. and Bourne, L. E., Jr. (Eds.) (1998). *Foreign language learning: Psycholinguistic studies on training and retention*. Mahwah, NJ: Lawrence Erlbaum.
- Heredia, R. R. (2008). Mental models of bilingual memory. In J. Altarriba and R. R. Heredia (Eds.), *An introduction to bilingualism: Principles and processes* (pp. 39–67). Mahwah, NJ: Lawrence Erlbaum.
- Heredia, R. and J. Altarriba (Eds.). (2002). *Bilingual sentence processing*. Amsterdam: Elsevier.
- Hulstijn, J. (2002). Towards a unified account of the representation, processing and acquisition of second language knowledge. *Second Language Research*, 18(3), 193–223.
- Hulstijn, J. H. (2005a). Theoretical and empirical issues in the study of implicit and explicit second-language learning: Introduction. *Studies in Second Language Acquisition*, 27(2), 129–140.
- Hulstijn, J. H. (Ed.) (2005b). Implicit and explicit second-language learning [Special issue]. *Studies in Second Language Acquisition*, 27(2), 129–359.
- Hymes, D. (1967). Models of the interaction of language and social setting. *Journal of Social Issues*, 23(1), 8–28.
- Hymes, D. (1972). On communicative competence. In J. B. Pride and J. Holmes (Eds.), *Sociolinguistics* (pp. 269–293) Middlesex, UK: Penguin Books.
- Keatley, C. W. (1992). History of bilingualism research in cognitive psychology. In R. J. Harris (Ed.), *Cognitive processing in bilinguals* (pp. 15–49) Amsterdam: Elsevier.
- Kilborn, K. (1994). Learning a language late: Second language acquisition in adults. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 917–944). San Diego, CA: Academic Press.
- Kolers, P. A. (1963). Interlingual word associations. *Journal of Verbal Learning and Verbal Behavior*, 2(4), 291–300.

- Kolers, P. A. (1966a). Interlingual facilitation of short-term memory. *Journal of Verbal Learning and Verbal Behavior*, 5(3), 314–319.
- Kolers, P. A. (1966b). Reading and talking bilingually. *The American Journal of Psychology*, 79(3), 357–377.
- Krashen, S. D. (1985). *The Input Hypothesis: Issues and implications*. London: Longman.
- Kroll, J. F. and Tokowicz, N. (2005). Models of bilingual representation and processing: Looking back and to the future. In J. F. Kroll and A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 531–553). New York: Oxford University Press.
- Lambert, W. E., Havelka, J., and Crosby, C. (1958). The influence of language acquisition contexts on bilingualism. *Journal of Abnormal and Social Psychology*, 56(2), 239–244.
- Larsen-Freeman, D. (2002). Making sense of frequency. *Studies in Second Language Acquisition*, 24(2), 275–285.
- Larsen-Freeman, D. and Cameron, L. (2008). *Complex systems and applied linguistics*. Oxford: Oxford University Press.
- Levelt, W. J. M. (1978). Skill theory and language teaching. *Studies in Second Language Acquisition*, 1(1), 53–70.
- Levelt, W. J. M. (1999). Producing spoken language: A blueprint of the speaker. In C. Brown and P. Hagoort (Eds.), *The neurocognition of language* (pp. 83–122). Oxford: Oxford University Press.
- Levinson, S. C. and Wilkins, D. (Eds.) (2006). *Grammars of space: Explorations in cognitive diversity*. Cambridge: Cambridge University Press.
- Libben, M. R. and Titone, D. A. (2009). Bilingual lexical access in context: Evidence from eye movements during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(2), 381–390.
- Lightbown, P. (2007). Transfer appropriate processing as a model for classroom second language acquisition. In Z. Han (Ed.), *Understanding second language process* (pp. 27–44). Clevedon, UK: Multilingual Matters.
- MacWhinney, B. (2008). A Unified Model. In P. Robinson and N. C. Ellis (Eds.), *Handbook of cognitive linguistics and second language acquisition* (pp. 341–371). New York: Routledge.
- MacWhinney, B. and Bates, E. (Eds.). (1989). *The crosslinguistic study of sentence processing*. Cambridge: Cambridge University Press.
- Marinis, T. (2003). Psycholinguistic techniques in second language acquisition research. *Second Language Research*, 19(2), 144–161.
- McDonough, K. and Trofimovich, P. (2008). *Using priming methods in second language research*. New York: Routledge.
- McLaughlin, B. (1987). *Theories of second language learning*. London: Edward Arnold.
- Mehler, J., Sebastián-Gallés, N., and Nespó, M. (2005). Biological foundations of language acquisition: Evidence from bilingualism. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 825–836). Cambridge, MA: MIT Press.
- Meuter, R. (2005). Language selection in bilinguals: Mechanisms and processes. In J. Kroll and A. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 349–370). Oxford: Oxford University Press.
- Morris, C. D., Bransford, J. D., and Franks, J. J. (1977). Level of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior*, 16(5), 519–533.
- Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General*, 106(3), 1–66.
- Nicoladis, E. (2008). Bilingualism and language cognitive development. In J. Altarriba and R. R. Heredia (Eds.), *An introduction to bilingualism: Principles and processes* (pp. 167–182). Mahwah, NJ: Lawrence Erlbaum.
- Paradis, M. (2009). *Declarative and procedural determinants of second languages*. Amsterdam: John Benjamins.
- Pavlenko, A. (2005a). *Emotions and multilingualism*. New York: Cambridge University Press.
- Pavlenko, A. (2005b). Bilingualism and thought. In J. F. Kroll and A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 433–453). New York: Oxford University Press.
- Pawley, A. and Syder, F. (1983). Two puzzles for linguistic theory: Nativelike selection and nativelike fluency. In J. Richards and R. Schmidt (Eds.), *Language and communication* (pp. 191–226). London: Longman.
- Penfield, W. and Roberts, L. (1959). *Speech and brain mechanisms*. Princeton, NJ: Princeton University Press.
- Pienemann, M. (2003). Language processing capacity. In C. J. Doughty and M. H. Long (Eds.), *Handbook of second language acquisition* (pp. 679–713). Malden, MA: Blackwell.
- Pienemann, M. (2004). Processing perspectives in SLA research and their compatibility. *Bilingualism: Language and Cognition*, 7(1), 37–39.
- Pienemann, M. (2007). Processability theory. In B. VanPatten and J. Williams (Eds.), *Theories in second language acquisition: An introduction* (pp. 137–154). Mahwah, NJ: Lawrence Erlbaum.

- Piske, T. and Young-Scholten, M. (Eds.). (2009). *Input matters in SLA*. Toronto: Multilingual Matters.
- Posner, M. (1978). *Chronometric explorations of mind*. Hillsdale, NJ: Lawrence Erlbaum.
- Posner, M. and Snyder, C. (1975). Facilitation and inhibition in the processing of signals. In P. Rabbitt and S. Dornic (Eds.), *Attention and performance V* (pp. 669–683). New York: Academic Press.
- Raney, G. E., Obeidallah, S. M., and Miura, T. K. (2002). Text comprehension in bilinguals: Integrating perspectives on language representation and text processing. In R. R. Heredia and J. Altarriba (Eds.), *Bilingual sentence processing* (pp. 165–183). Amsterdam: Elsevier.
- Roberts, L., Gullberg, M., and Indefrey, P. (2008). Online pronoun resolution in L2 discourse: L1 influence and general learner effects. *Studies in Second Language Acquisition*, 30(3), 333–357.
- Robinson, P. and Ellis, N. (Eds.) (2008). *Handbook of cognitive linguistics and second language acquisition*. London: Routledge.
- Schrauf, R. W. (2008). Bilingualism and aging. In J. Altarriba and R. R. Heredia (Eds.), *An introduction to bilingualism: Principles and processes* (pp. 105–127). Mahwah, NJ: Lawrence Erlbaum.
- Sebastián-Gallés, N. and Bosch, L. (2005). Phonology and bilingualism. In J. F. Kroll and A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 68–87). New York: Oxford University Press.
- Segalowitz, N. (1976). Communicative incompetence and the non-fluent bilingual. *Canadian Journal of Behavioural Science*, 8(2), 122–131.
- Segalowitz, N. (2010). *Cognitive bases of second language fluency*. London: Routledge.
- Segalowitz, N. and Frenkiel-Fishman, S. (2005). Attention control and ability level in a complex cognitive skill: Attention-shifting and second language proficiency. *Memory and Cognition*, 33(4), 644–653.
- Segalowitz, N. and Hulstijn, J. (2005). Automaticity in bilingualism and second language learning. In J. F. Kroll and A. M. B. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 371–388). Oxford: Oxford University Press.
- Slobin, D. (1996). From “thought and language” to “thinking for speaking”. In J. J. Gumperz and S. C. Levinson (Eds.), *Rethinking linguistic relativity* (pp. 70–96). Cambridge: Cambridge University Press.
- Sternberg, S. (1969). Memory-scanning: Mental processes revealed by reaction-time experiments. *American Scientist*, 57(4), 421–457.
- Tabossi, P. (1996). Cross-modal semantic priming. *Language and Cognitive Processes*, 11(6), 569–576.
- Taube-Schiff, M. and Segalowitz, N. (2005). Within-language attention control in second language processing. *Bilingualism: Language and Cognition*, 8(3), 195–206.
- Tomasello, M. (2003). *Constructing a language*. Cambridge, MA: Harvard University Press.
- Tomlin, R. and Villa, V. (1994). Attention in cognitive science and second language acquisition. *Studies in Second Language Acquisition*, 16(2), 183–203.
- Trofimovich, P. and Gatbonton, E. (2006). Repetition and focus on form in L2 Spanish word processing: Implications for pronunciation instruction. *The Modern Language Journal*, 90(4), 519–535.
- Trueswell, J. C. and Tanenhaus, M. K. (Eds.). (2005). *Approaches to studying world-situated language use: Bridging the Language-as-Product and Language-as-Action traditions*. Cambridge, MA: MIT Press.
- Truscott, J. and Sharwood Smith, M. (2004). Acquisition by processing: A modular perspective on language development. *Bilingualism: Language and Cognition*, 7(1), 1–20.
- VanPatten, B. (2007). Input processing in adult second language acquisition. In B. VanPatten and J. Williams (Eds.), *Theories in second language acquisition: An introduction* (pp. 115–135). Mahwah, NJ: Lawrence Erlbaum.
- Weinreich, U. (1953). *Languages in contact*. New York: The Linguistic Circle of New York.
- Wray, A. (2002). *Formulaic language and the lexicon*. Cambridge: Cambridge University Press.
- Wundt, W. (1912/1973). *An introduction to psychology*. New York: Arno Press.
- Wundt, W. (1894/1977). *Lectures on human and animal psychology*. Washington, D.C.: University Publications of America.