14

Psycholinguistic Methods

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Introduction

Psycholinguistics is dedicated to studying how the human mind learns, represents, and processes language (Harley, 2013). In recent decades, overlapping interests in psychology and linguistics have resulted in a surge in knowledge about language processing, and the psycholinguistic methods borne out of this research are increasingly of interest to applied linguistics research.

Like other language research methods—such as surveys, interviews, or proficiency tests—psycholinguistic methods can uncover information about language learning and use. Crucially, through experimental and theoretical rigor, psycholinguistic methods also reveal the psychological representations and processes underlying language learning and use. Although research conducted in naturalistic settings—such as in foreign language classrooms—provides important perspectives, such work is inherently confounded with extraneous variables. For example, even if one were to assume that all students receive the exact same input during a Spanish class, there is likely a large range in how much and in what ways (e.g., music, television, friends) each student is exposed to Spanish outside the classroom. This lack of empirical control

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severely limits the precision and clarity with which researchers can measure and interpret language-related cognitive processes, which has consequences for the theories and applications informed by these interpretations. Psycholinguistic experiments, which are carried out in laboratory settings, employ carefully controlled designs that enable researchers to target factors of interest (e.g., the effects of phonological similarity on word recognition) while limiting, or controlling for, potentially confounding variables (e.g., word frequency). Their capacity for collecting detailed and well-controlled information is perhaps the strongest advantage of using these methods in applied linguistics research. Furthermore, psycholinguistic methods can reveal information about language learning and processing where other methods cannot. As we will discuss in more detail, traditional measures of performance or proficiency are often too coarse to distinguish different levels of language processing, but psycholinguistic measures like reaction time and brain recordings are more sensitive and thus can reveal effects where behavioral methods cannot.

In this chapter, we review psycholinguistic methods. We do not cover the entire methodological corpus of psycholinguistics but instead focus on methods that are particularly relevant for addressing compelling questions in applied linguistics. In the first part of the chapter, we discuss psycholinguistic measures and tasks, and in the second part we describe common experimental paradigms.

Tasks and Measures

Psycholinguistic methods are especially useful for studying the cognitive processes about language learning and use, from phonetics and phonology to discourse-level pragmatics. This section reviews common psycholinguistic measures and tasks that are useful for applied linguistics researchers, together with strengths and limitations of these methods. The section begins with behavioral measures—including decision tasks, reaction time, mouse-tracking, and eye-tracking—and ends with a discussion of a popular neurocognitive measure, event-related potentials.

Decision Tasks

We conceptualize decision tasks as experimental tasks that instruct participants to make a decision in response to a stimulus, from which researchers infer some underlying psycholinguistic process or representation. Such tasks are incredibly common in psycholinguistics and can be employed along all language domains. For example, a phoneme discrimination task requires participants to decide whether a pair of speech sounds (e.g., [*pa*] and [*ba*]) are the same or different and provides insight into phonological representations. A lexical decision task (LDT) requires participants to decide whether a string of letters or sounds constitutes a real word (*cucumber*) or not (*nutolon*). LDTs reveal information about the organization of and access to the mental lexicon via a variety of experimental manipulations that tap domains such as orthography, phonology, morphology, and semantics.

At the sentence level, a widely used decision task elicits acceptability judgments, where participants might decide whether a sentence is grammatically well-formed, as in (1) or perhaps whether a sentence makes semantic sense, as in (2).

1. a. The winner of the big trophy *has* proud parents.
   b. The winner of the big trophy *†have* proud parents. (Tanner & Van Hell, 2014)
2. a. Kaitlyn traveled across the ocean in a *plane* to attend the conference.
   b. Kaitlyn traveled across the ocean in a *†cactus* to attend the conference. (Grey & Van Hell, 2017)

Acceptability judgment tasks are popular in second language acquisition research because researchers can design materials to assess knowledge of specific target structures, such as word order (Tagarelli, Ruiz, Moreno Vega, & Rebuschat, 2016) or grammatical gender agreement (Grey, Cox, Serafini, & Sanz, 2015). Additionally, acceptability judgments that impose a time limit on the decision have been shown to reliably tap implicit linguistic knowledge, while those that are untimed tap explicit knowledge (Ellis, 2005).

A limitation of decision tasks is that they require participants to make an explicit and oftentimes unnatural evaluation about the target content: "Are these two sounds the same or different? Is this sentence correct?". This may fundamentally change the way the given linguistic information is processed, which has consequences regarding the extent to which the inferred psychological representations can be said to underlie naturalistic language processing. However, this limitation does not outweigh the benefits: decision tasks are easy and efficient to administer and most are supported by cross-validation through decades of research. Also, in addition to using decision tasks to gather data on a target variable (e.g., accuracy in LDT) researchers can use them to keep participants attentive during an experiment or to mask the goals of the study while other less explicit measures, such as eye movements, are gathered (see Sample Study 14.1).

Latency Measures

Questions about language processing are often associated with the notions of "time" or "efficiency," and as such many psycholinguistic tasks include a measure of latency: the time between a stimulus and a response. Perhaps the most common psycholinguistic measure of latency is reaction time (RT): a measure of the time it takes, in milliseconds, to respond to an external stimulus, usually via button press (or by speech onset in naming tasks). In applied linguistics, RTs gained early popularity in studies of L2 automaticity (Segalowitz & Segalowitz, 1993) and are increasingly employed to study L2 development, for example, in study abroad research (Sunderman & Kroll, 2009) and in testing different pedagogical techniques (Stafford, Bowden, & Sanz, 2012). RT in fact has been critical in clarifying the efficacy of different pedagogical techniques, since latency differences can be observed in the absence of accuracy differences (e.g., Robinson, 1997), thereby revealing finer-grained details about language learning than can be captured with accuracy alone (for a review, see Sanz & Grey, 2015).

RTs are used for button press and similar responses, whereas voice onset time (VOT) is a production-based measure of latency that can be used to examine the timing and characteristics of articulation. VOT is the time, in milliseconds, between the onset of vocal fold vibrations and the release of the articulators. VOT exhibits well-identified cross-linguistic patterns (Lisker & Abramson, 1964), making it an attractive metric for studying the psycholinguistic processes underlying articulation in different language groups. For example, VOT has been used to study speech planning in L2 learners (Flege, 1991) and bilingual code-switching (Balukas & Koops, 2015).

A third latency measure is eye-tracking. Eye-tracking data, like VOT, are ecologically appealing because they measure naturally occurring behavior as it unfolds in time, for example, as participants view scenes or read sentences. Eye movements are measured in terms of fixations, saccades (Rayner, 1998), or proportion of looks to regions of interest (ROIs, e.g., a word or picture; Huettig, Rommers, & Meyer, 2011). Fixations refer to the time spent on a location and can be divided into earlier measures, such as first-fixation duration, and later measures, such as total time in an ROI. Saccades refer to quick eye movements from one location to another and provide information on forward movements in reading (forward saccades, which are rightward movements in most languages) as well as returns to a location, or regressive saccades (Rayner, 1998). Such measures have recently been used to study attention in L2 learning (Godfroid, Housen, & Boers, 2013) and the use of subtitles in foreign language films (Bisson, Van Heuven, Conklin, & Tunney, 2012).

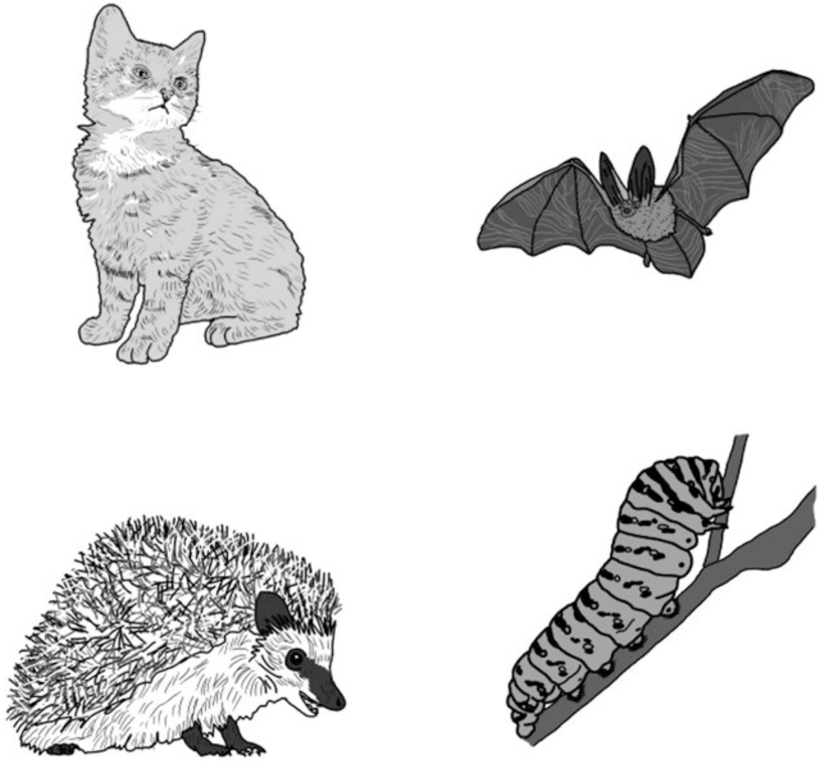

Fig. 14.1 Sample visual world. Note: In this example, "cat" is the target, "caterpillar" is an onset competitor, "bat" is a rhyme competitor, and "hedgehog" is an unrelated distractor. Images are from the Multipic database (Duñabeitia et al., 2017)

Proportion of looks to a target ROI (compared to competitors) is another metric for eye-movement data and is often used to measure language processing in visual world paradigms, where both linguistic and visual information are presented (Fig. 14.1; Sample Study 14.1).

A more recent latency measure is mouse-tracking, which records the trajectory of the computer mouse on the screen by sampling the movement many dozen times a second (Freeman & Ambady, 2010). This technique allows researchers to examine competition and selection between multiple response options with detailed latency information. The continuous trajectory of the mouse as it moves toward a target (see Fig. 14.2) is the core metric, which is often analyzed by calculating its maximum deviation (MD) or area under the curve (AUC). MD refers to the largest perpendicular deviation between the ideal mouse trajectory (straight line to the target) and the observed trajectory, and AUC is the area between the ideal and observed trajectories. Although

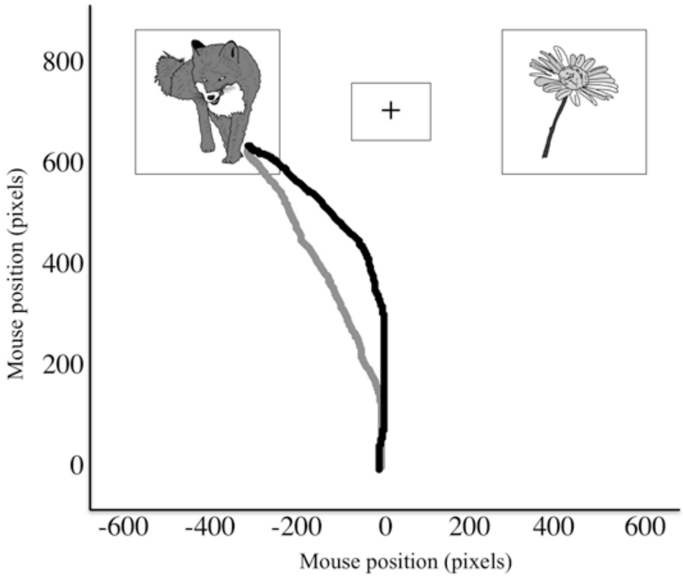

Fig. 14.2 Sample data from mouse-tracking language experiment. Note: The black line represents a competitor trajectory; the gray line represents a target trajectory. Images are from the Multipic database (Duñabeitia et al., 2017)

mouse-tracking methodology is rather new, it is gaining momentum in language research and, unlike many types of psycholinguistic testing software, mouse-tracking software for experimental research is freely available (*MouseTracker*, Freeman & Ambady, 2010) which makes it especially appealing. Of interest to applied linguistics, mouse-tracking has recently been employed to study pragmatic intent (Roche, Peters, & Dale, 2015), syntactic transfer in bilinguals (Morett & Macwhinney, 2013), and lexical competition in monolinguals and bilinguals (Bartolotti & Marian, 2012).

Language Production

Using measures such as VOT, psycholinguistic methods are fruitful in revealing insights about production. One well-studied production task is picture naming, whereby participants are presented with pictures and asked to name them aloud. This task reveals information on lexical access and the organization of the mental lexicon more generally and has been employed across many different populations and languages (Bates et al., 2003). Researchers usually measure naming accuracy and can gather naming latency, as well as VOT. This makes picture naming versatile in the information it provides; it has been used to test questions with implications for applied linguistics, including those pertaining to the effects of semantics on L2 word learning (Finkbeiner & Nicol, 2003) as well as conceptual/lexical representations during lexical access (for a review, see Kroll, Van Hell, Tokowicz, & Green, 2010).

Elicited imitation (EI) is another production task that is impressively simple. Participants listen to a sentence and are asked to repeat it verbatim. The premise of EI is that if participants can repeat a sentence quickly and precisely, they possess the grammatical knowledge contained in that sentence. Under this premise, EI has been established as a reliable measure of language proficiency, both globally (Wu & Ortega, 2013) and on specific linguistic structures (Rassaei, Moinzadeh, & Youhannaee, 2012). Additionally, EI can assess implicit linguistic knowledge (Ellis, 2005; Spada, Shiu, & Tomita, 2015), the attainment of which is a central research area in applied linguistics. EI has also been the subject of increased methodological rigor, spurring a recent meta-analysis of the technique (Yan, Maeda, Lv, & Ginther, 2016) and the extension of EI to assess proficiency in heritage languages (Bowden, 2016).

The main critique of EI is in fact its main design element. Because participants are repeating predetermined sentences outside of a larger discourse context, the language produced is not representative of naturalistic speech. This critique is stronger for designs that include ungrammatical sentences (e.g., Erlam, 2006), which are quite common in L2 research, but by their very nature do not represent genuine language.

The study of speech disfluencies offers a more naturalistic psycholinguistic perspective. Disfluencies occur very frequently in natural language production (Fox Tree, 1995) and include editing terms (e.g., *uh* and *um*), pauses, repetitions, restarts, and repairs. They have long been used as a window into the effects of cognitive load on speech planning and production. For example, disfluencies are more frequent at the beginning of utterances, preceding longer utterances, and for unfamiliar conversational topics (Bortfeld, Leon, Bloom, Schober, & Brennan, 2001; Oviatt, 1995), where cognitive demand is relatively high.

An increasing amount of research examines the effects of speaker disfluencies on language comprehension. Interestingly, these effects appear to be facilitative. For example, disfluencies speed up word recognition (Corley & Hartsuiker, 2011) and serve as cues to new information in discourse (Arnold, Fagnano, & Tanenhaus, 2003), though this may depend on speaker-specific factors such as native versus non-native speech (Bosker, Quené, Sanders, & de Jong, 2014). Growing psycholinguistic interest in disfluencies is promising for future research, in part because they represent naturalistic phenomena with implications for comprehension and production.

Event-Related Potentials

In recent years, psycholinguistic interests have expanded to consider questions on how the human brain acquires, represents, and processes language. One approach for considering such questions is the event-related potential (ERP) technique. Many of the methods discussed above can be coupled with this technique, such as acceptability judgments (Tanner & Van Hell, 2014) and LDTs (Barber, Otten, Kousta, & Vigliocco, 2013). Compared to other neuroimaging techniques like PET, MEG, and MRI, ERP equipment is generally much less expensive, and there are even excellent lower-cost ERP equipment options on the market (e.g., actiCHamp from Brain Products, Germany). As such, ERPs provide applied linguists with a cost-effective method for applying neuroscience technology to timely issues in applied linguistics research (for a review, see Morgan-Short, 2014).

ERPs are derived through recording naturally occurring electroencephalogram data, which consist of changes in the brain's electrical activity measured from electrodes on the scalp. Using ERPs, researchers investigate neurocognitive processes with millisecond precision (see Luck, 2014, for detailed information), which are elicited in response to a time-locked event (e.g., the onset of the words "plane" or "cactus" in (2) above). ERP language studies often use violation paradigms, which are characterized by measuring the neural activations of correct/standard stimuli (e.g., 1a, 2a above; or "cucumber" in LDTs) compared to matched "violation" stimuli (e.g., 1b, 2b; "nutolon" in LDTs). A key ecological advantage of ERPs is that the ERPs themselves serve as automatic, implicit responses to such stimuli, so researchers do not necessarily *have* to elicit an explicit decision from their subjects, which, as discussed above, could result in less naturalistic language processing.

ERP language research has revealed a set of well-studied neural responses, or ERP effects, that are considered to reflect different neurocognitive processes. Table 14.1 summarizes some of these effects and Fig. 14.3 illustrates a sample ERP pattern for semantic processing. In the last 15 years, ERPs have become popular for applied linguistics interests (Morgan-Short, 2014), with studies testing the role of L1/L2 proficiency (Newman, Tremblay, Nichols, Neville, & Ullman, 2012), different L2 training conditions (Batterink & Neville, 2013), cross-linguistic transfer (Gillon Dowens, Guo, Guo, Barber, & Carreiras, 2011), and prediction during L2 reading (Martin et al., 2013), among others. Notably, changes in ERP responses as a result of language development have been observed even when proficiency changes are not apparent at the behavioral level (McLaughlin, Osterhout, & Kim, 2004).

Table 14.1 Common language-related ERP effects

ERP effect	Language domain	Sample stimuli	^Representative study
N400	Semantics	They wanted to make the hotel look more like a tropical resort, so along the driveway they planted rows of *palms* *† pines* *†† tulips* (Federmeier & Kutas, 1999)	McLaughlin et al. (2004)
P600	(Morpho)syntax	The man in the restaurant doesn't like the *hamburgers* that *are* on his plate. The man in the restaurant doesn't like the *hamburger* that *†are* on his plate. (Kaan & Swaab, 2003)	Bowden, Steinhauer, Sanz, and Ullman (2013)
[1]AN	(Morpho)syntax	The scientists criticized Max's *proof of* the theorem. The scientists criticized Max's *†of proof* the theorem. (Neville, Nicol, Barss, Forster, & Garrett, 1991)	Batterink and Neville (2013)
[2]PMN	Pre-lexical phonetics/ phonology	snap – nap snap – *†tap* (Newman & Connolly, 2009)	Goslin, Duffy, and Floccia (2012)
Frontal positivity	Lexical prediction	The bakery did not accept credit cards so Peter would have to write *a check* *†an apology* to the owner (DeLong, Groppe, Urbach, & Kutas, 2012)	Martin et al. (2013)

†Represents violation/unexpected/mismatch item. ^Related to interests in applied linguistics. [1]ANs (anterior negativities) have also been referred to as LANs (left anterior negativities). When present they generally appear as a biphasic AN-P600 response. [2]PMN, phonological mapping negativity

ERPs represent a highly sensitive temporal measure of neural processing, which is important for understanding language. They do not, however, reflect the spatial location within the brain that gives rise to the observed effects. That is, observing an ERP effect in posterior (parietal) scalp locations does not mean the activity originated in the parietal cortex. For this level of spatial detail, researchers use fMRI or MEG, though their high costs and lower temporal resolution make these techniques less common in psycholinguistics.

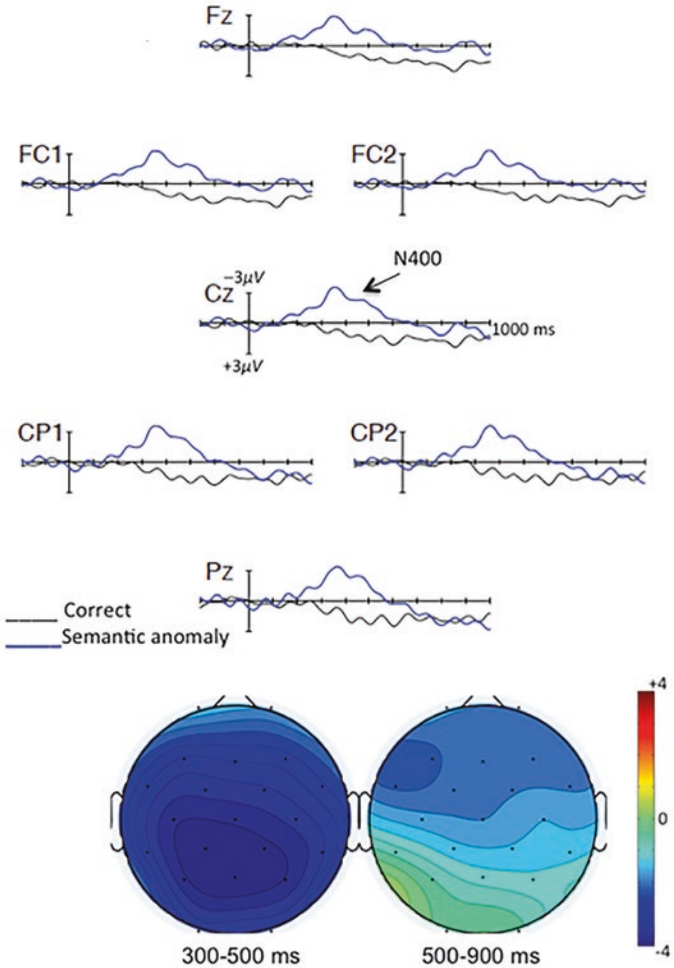

Fig. 14.3 Sample ERP waves and scalp topography maps of the standard ERP correlate of semantic processing (*N400*). Note: Each tick mark on y-axis represents 100 ms; x-axis represents voltage in microvolts, ±3μV; negative is plotted up. The black line represents brain activity to correct items, such as *plane* in example 2a. The blue line represents brain activity to a semantic anomaly, such as *cactus* in example 2b. The topographic scalp maps show the distribution of activity in the anomaly minus correct conditions with a calibration scale of ±4μV. From data reported in Grey and Van Hell (2017)

The use of decision tasks, latency measures, production measures, and brain wave recordings reveals information about the cognitive bases of language and is fundamental to psycholinguistic research. By employing these measures, the psycholinguistic paradigms—or standard experimental designs—described in the following section allow researchers to understand language learning and processing in a way that complements and expands on traditional methods in applied linguistics.

Psycholinguistic Paradigms

Over the last few decades, several reliable psycholinguistic paradigms have been established to investigate the mental underpinnings of language. This section reviews common experimental approaches that are relevant for interests in applied linguistics: priming, visual world, and language learning paradigms.

Priming

Priming refers to the cognitive process whereby exposure to some language (the "prime") influences processing of subsequently presented language (the "target"). This effect can be facilitative, wherein processing of the target speeds up as a result of the prime, or inhibitory, wherein processing of the target slows down. Priming effects generally reflect implicit processes—individuals are sensitive to language details without being aware of how such sensitivities influence subsequent language processing (McDonough & Trofimovich, 2009).

In a standard priming paradigm, the participant is briefly (for <1000 milliseconds) presented with a prime. After a short delay, they are presented with a target and make a decision about it or say something out loud (Fig. 14.4(a)). The properties of primes and targets, as well as the tasks and outcome measures, vary depending on the research question. In masked priming, which aims to isolate automatic, implicit processes, the prime is presented for a very brief time (~40–60 milliseconds) and "masked" so that it is not consciously perceptible. This mask is typically achieved by adding a string of random letters or symbols preceding and/or following the prime (Fig. 14.4(b)). RTs are the most common measure used in priming and are often gathered via decision tasks, especially LDT and semantic categorization (e.g., "Is it an animal?"), though production tasks, like naming, are also used.

Of interest to applied linguists, priming paradigms have been used in bilingualism and L2 research to examine two main questions: "Is priming the same in L1 and L2?" and "Do bilinguals have shared or separate stores for various aspects of language?" (McDonough & Trofimovich, 2009). These questions have been investigated using priming paradigms that tap phonetics, phonology, morphology, semantics, and syntax. Here, we focus on the latter two.

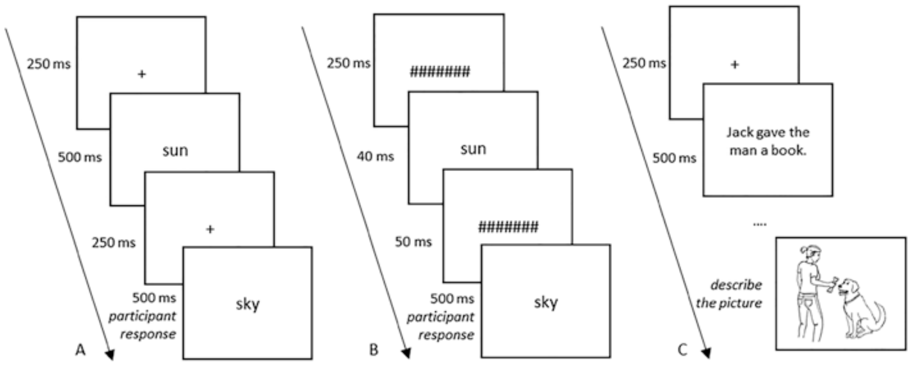

Fig. 14.4 Examples of (**a**) semantic priming using lexical decision, (**b**) masked semantic priming, and (**c**) syntactic priming using a picture description task. Note: Drawing credit: Kyle Brimacombe

Semantic priming examines the extent to which processing of a target is facilitated by a prime with similar meaning. The underlying assumption is that the more semantically related two words are the more one will facilitate the other in a prime-target relationship. In within-language designs, researchers have tested semantic priming in L1 (e.g., *sun-sky*) and comparable L2 (e.g., *soleil-ciel*, sun-sky in French) prime-target pairs (e.g., Crinion et al., 2006). Findings suggest that in bilinguals and high-proficiency L2 speakers, priming effects tend to be similar in both languages, but for low-proficiency speakers, priming effects are stronger in L1 than L2 (Frenck-Mestre & Prince, 1997).

In between-language or cross-language semantic priming, participants are presented with prime-target pairs in the L1-to-L2 or L2-to-L1 direction (e.g., Basnight-Brown & Altarriba, 2007). These can be semantically related (*sun-ciel*) or translation equivalents (e.g., *sky-ciel*). If a bilingual's languages share a lexicon, an L1 prime should facilitate an L2 target, and vice versa. Findings from between-language semantic priming studies have been variable, with L2 proficiency and direction of priming influencing the effects (see Altarriba & Basnight-Brown, 2007, for a review).

Syntactic priming examines the extent to which the processing of a target syntactic structure is facilitated by a prime of similar structure. The focus of syntactic priming is on form. This paradigm tests whether the prime structure increases the likelihood that an individual will produce a sentence using that structure, compared to an equally acceptable structure. This is classically tested using dative constructions (e.g., Bock, 1986; for a review, see Pickering & Ferreira, 2008). For example, if a participant is presented with a double-object dative prime, as in "Jack gave the man the book," syntactic priming would be evidenced by the participant later producing the sentence "Ellen gave the dog the bone," rather than the equivalent sentence with the prepositional dative, "Ellen gave the bone to the dog." In syntactic priming, tasks tend to focus on production, such as picture description (see Fig. 14.4(c)) and sentence completion. Scripted interaction in which a participant has a conversation with a "confederate" who uses the structure(s) of interest (Kootstra, van Hell, & Dijkstra, 2010) is also used. Syntactic priming has been productive in examining the mental representation of grammatical structures, including in cross-linguistic research (Hartsuiker, Pickering, & Veltkamp, 2004) and work on L2 development (McDonough & Mackey, 2008).

Priming studies are limited in the questions they can address. For example, syntactic priming can only test a limited set of structures that have at least one other equivalent form. Additionally, priming studies often focus on very small RT differences, which can be influenced by many linguistic aspects outside the variables of interest. For instance, word frequency and length can impact observed effects. Therefore, stimuli in priming studies must be painstakingly designed to limit effects of confounding variables.

Visual World

The visual world (VW) paradigm allows researchers to investigate the processing of linguistic and visual information together. In a standard VW paradigm, participants are presented with a visual display that might consist of a semi-realistic scene (e.g., a child surrounded by objects in a playroom) or a set of objects displayed on a computer screen (see Fig. 14.1). In a comprehension study, the participant hears an utterance (word or sentence), and in a production study they describe what they see. The dependent variables often consist of the participant's eye movements within the display while listening or speaking. Similar to eye-tracking studies of reading (see Latency Measures section above), analyses in the VW paradigm focus on fixation proportions within and the number of saccades toward ROIs, such as target objects or experimental distractors. The properties of targets and distractors, as well as how they relate to the linguistic information, vary depending on the research questions. This flexibility in the research applications of the VW paradigm is one of its key benefits. Studies using this method have examined a range of questions, including the effects of cognitive biases (Kamide, Altmann, & Haywood, 2003) and linguistic information (Altmann & Kamide, 2007) on our expectations about language, effects of speaker reliability on pragmatic inferences

(Grodner & Sedivy, 2011), and effects of semantic and syntactic context on word recognition (Dahan & Tanenhaus, 2004), among others. For an illustrative study that employed the VW paradigm to study L2 grammatical processing, see Sample Study 14.1.

Sample Study 14.1

Dussias, P. E., Kroff, J. R. V., Tamargo, R. E. G., & Gerfen, C. (2013). When gender and looking go hand in hand. *Studies in Second Language Acquisition, 35*(2), 353–387.

Background

Native-like morphosyntactic processing in L2 is difficult to attain and a central area of investigation in SLA. Regarding the online processing of grammatical gender, L1 work demonstrates that prenominal gender information on the article (*la*, feminine; the) tends to facilitate subsequent processing of the matching noun (*mesa*, feminine; table) whereas mismatching nouns (e.g., *escritorio*, masculine; desk) slow processing. Grammatical gender is studied less in L2, so it is not as well understood.

Research Questions

1. Can L1 speakers whose language does not instantiate grammatical gender show effects of prenominal gender-marking for L2 processing of the subsequent noun?
2. For speakers of an L1 whose language instantiates gender, does L1-L2 overlap in the gender system affect the degree to which the learners show native-like effects of prenominal gender-marking?

Methods

Three groups of participants were tested: 16 monolingual Spanish L1 speakers; 16 Italian L1-Spanish L2 learners; 18 English L1-Spanish L2 learners.

- Italian and Spanish have extensive overlap in their grammatical gender systems; English and Spanish have no overlap.
- Spanish proficiency was assessed in L2 groups with a standardized proficiency test and a picture-naming task. This resulted in two proficiency groups for the English L1-Spanish L2 learners: 9 lower proficiency, 9 higher proficiency.

The experiment presented Spanish sentences, auditorily and one-at-a-time, while participants viewed two pictures of common objects on a computer screen.

Participants' task was to click the picture mentioned in the sentence and, after each sentence, provide an acceptability judgment on sentence plausibility.

- Clicking kept participants attentive and the acceptability judgment task concealed the real experimental purpose.

Eye movement data were recorded throughout the experiment. The dependent measure was proportion of gaze shifts to pictures (target and distractor).

Results

- Monolingual Spanish speakers showed facilitative effects of prenominal gender-marking for processing of the subsequent noun.
- Effects of prenominal gender-marking for Spanish noun processing in the English L1-Spanish L2 learner group depended on proficiency.

- Higher-proficiency English-Spanish learners were similar to the Spanish monolinguals.
- Lower-proficiency learners did not show sensitivity to feminine noun targets and showed, contrary to expectations, facilitation effects when both targets were masculine (facilitation is normally found when targets differ in gender).
- Italian L1-Spanish L2 learners showed sensitivity to feminine noun contexts, similar to the Spanish monolinguals and higher-proficiency English-Spanish learners. No effects were found for masculine noun contexts.

Conclusions

The study provides further evidence that native-like processing of gender can be achieved by learners whose L1 does not instantiate this feature, at least for higher-proficiency learners. Further, the study shows that for L2 learners with a similar L1 gender system, native-like processing is not guaranteed.

While this paradigm is versatile, studies employing it are limited to relatively concrete aspects of language, as the linguistic information has to relate to the visual display. Additionally, the necessary relationship between the visual and linguistic information, and the fact that they are temporally aligned, means that language is likely processed differently in VW paradigms than in other paradigms lacking visual information. Relatedly, the eye movements can reveal what kinds of visual information listeners use, but only within the highly constrained options available. Nevertheless, humans often do process language with some sort of visual scene, which makes this paradigm ecologically appealing. Overall, the VW paradigm is, as Huettig et al. (2011) note, a useful way to investigate the many cognitive processes, including language, vision, and attention, that are implicated in language processing but rarely studied together.

Language Learning Paradigms

Within psycholinguistics, language learning paradigms involve training a group of participants on a specific aspect of language or a language model over a relatively short period of time (i.e., minutes, hours, or days). Unlike more naturalistic language learning, which takes years, these paradigms allow researchers to examine learning at a smaller scale and in a highly controlled way. There are five main types of systems commonly used in language learning paradigms: novel word sets, statistically governed speech streams (word segmentation), artificial grammars, artificial languages, and mini-languages. Figure 14.5 depicts sample experimental designs for these language learning paradigms.

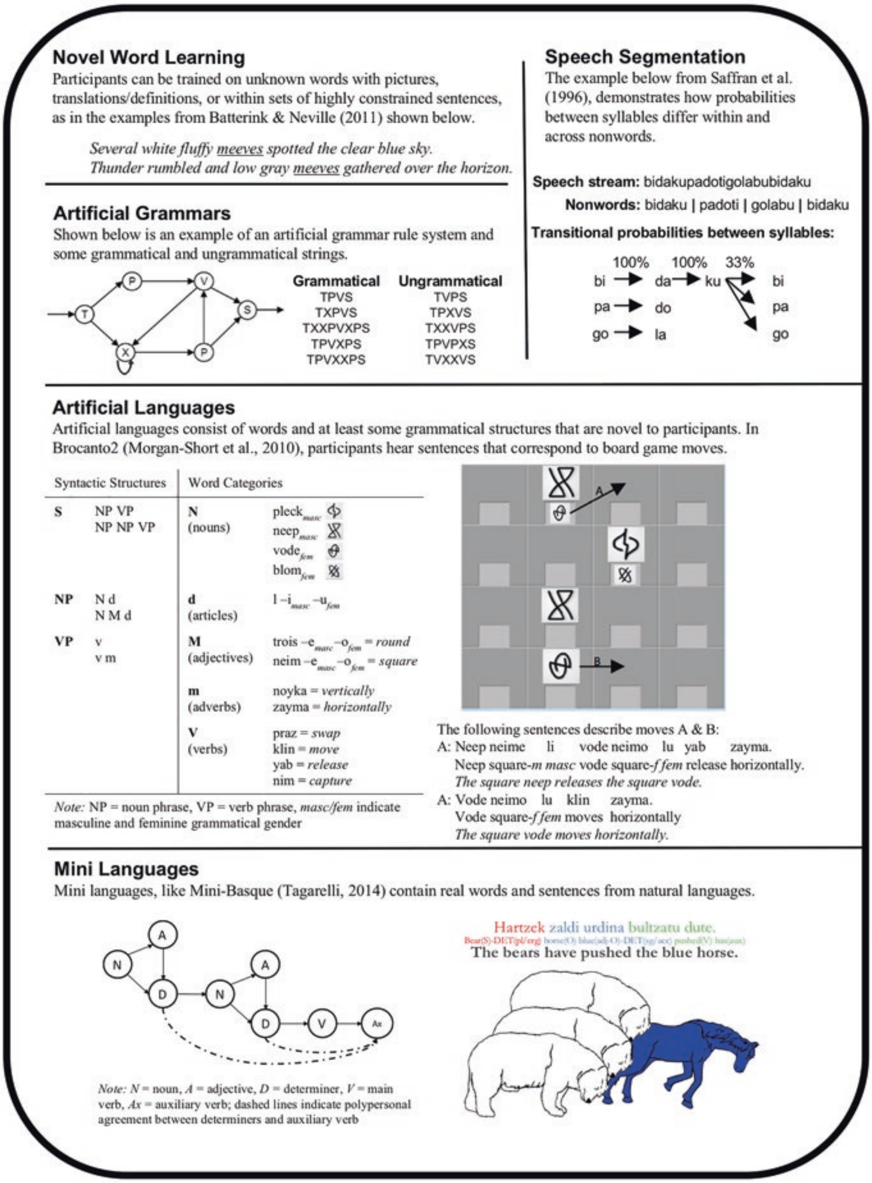

Fig. 14.5 Artificial linguistic systems in language learning paradigms (based on Morgan-Short et al., 2010; Saffran et al., 1996; Tagarelli, 2014). Note: Drawing credit: Kyle Brimacombe

Novel Word Learning

Word learning has been regularly examined in experimental settings since the 1970s, when Carey and Bartlett (1978, p. 17) coined the term "fast mapping." This term refers to the phenomenon by which individuals can learn the meaning of a new word after as little as one exposure to the word with its meaning. Most word learning paradigms involve a short training period in which learners are presented (visually or aurally) with each new word in a set and its meaning, as an image or translation equivalent (e.g., Breitenstein et al., 2007). More active training paradigms include forced-choice matching, whereby participants are presented with a novel word and multiple concepts or translations and must choose the correct match (Tagarelli, 2014). Participants can also be trained on words in sentential contexts, with pictures or in highly constrained sentences (e.g., Batterink & Neville, 2011). These approaches inform lexical-level learning, but language acquisition also involves recognizing word boundaries and learning grammatical structures, which other paradigms can elucidate.

Speech Segmentation

An interesting challenge in language acquisition is that speech is a continuous stream that listeners must break up into words during comprehension—we are not presented with individual words in conversation. Speech segmentation paradigms are designed to investigate how humans parse this noisy speech stream, from infancy (Saffran, Aslin, & Newport, 1996) through adulthood (Karuza et al., 2013). Such paradigms typically present learners with continuous speech composed of randomly placed multisyllabic nonwords (e.g., *pabikugolatudaropitibudo* is a stream of the nonwords *pabiku*, *golatu*, *daropi*, *tibudo*). Transitional probabilities of syllables within a word are high and transitional probabilities across word boundaries are lower because of the random word order. Using the example above, "pa" is followed by "bi" 100% of the time, but "ku" has a 25% chance of being followed by either "pa," "go," "da," or "ti" (see Fig. 14.5). After exposure of as little as two minutes, listeners distinguish words from nonwords or partwords (e.g., *bikugo*) with greater-than-chance ability.

Until recently, speech segmentation paradigms focused on single-language input. However, statistical regularities in speech vary across languages, so bilingual speakers or L2 learners must form two distinct statistical representations in order to successfully segment their two languages. Recent research has begun to explore such issues (Weiss, Poepsel, & Gerfen, 2015), and further research will continue to reveal how bilinguals and L2 speakers learn and represent multiple sets of statistical regularities.

Artificial Grammars

Artificial grammars (Reber, 1967) are structured systems of elements (e.g., letters) whose order is determined by complex rules (see Fig. 14.5). Although artificial grammars look different from natural languages on the surface, the relationships between elements in the grammars tend to rely on structural dependencies similar to those found in natural languages. Indeed, artificial grammar processing has been shown to elicit similar neural responses as natural language syntactic processing (Bahlmann, Gunter, & Friederici, 2006).

Artificial grammar research has demonstrated that complex structural information can be learned under both implicit and explicit training, though there is a longstanding debate regarding whether the acquired knowledge is implicit (Reber, 1990) or explicit (Perruchet & Pacteau, 1990). In reality, it is probably a bit of both. Note also that learning outcomes following implicit training seem to be related to different underlying cognitive abilities for artificial grammar and natural language learning (Robinson, 2005), which has implications for the generalizability of this paradigm to questions in applied linguistics.

Artificial, Semi-Artificial, and Mini-Languages

Word learning and grammar learning paradigms allow researchers to develop detailed knowledge about these aspects of language in isolation, which is impossible to do with natural languages. However, natural language combines lexical semantics and grammar, as well as phonology, prosody, and discourse-level information. For this reason, it is useful to examine how people learn languages using paradigms that more closely approximate natural languages. Over the past 25 years, there has been an explosion of applied linguistics research using paradigms—namely, artificial, semi-artificial, and mini-languages—that do just that (see Fig. 14.5).

Artificial and semi-artificial languages are typically composed of a few grammatical structures that are consistent with natural language structures. Also like natural languages, they can be spoken and understood. Semi-artificial languages contain L1 lexical items and grammatical structures borrowed from another language. For example, the sentence in (3) uses English words with German word-order rules (Rebuschat & Williams, 2012).

(3) When his wife in the afternoon the office left, prepared Jim dinner for the entire family.

Because semi-artificial languages use L1 vocabulary, they are easy to understand, which frees up cognitive resources for grammar learning. However, this design might also be confusing for learners, who need to inhibit what they know about their L1 grammar in the face of a new grammatical system associated with known L1 words. Artificial languages, on the other hand, contain novel words (typically between 10 and 100) in addition to grammatical rules. Learners can be trained on (semi-)artificial languages within hours, allowing researchers to more quickly examine how learners acquire target grammatical structures such as word order (Rebuschat & Williams, 2012), case marking (Grey, Williams, & Rebuschat, 2014), and morphological agreement (Morgan-Short, Sanz, Steinhauer, & Ullman, 2010). Notably, artificial language learning has been shown to correlate with L2 abilities (Ettlinger, Morgan-Short, Faretta-Stutenberg, & Wong, 2016), which adds ecological validity to using artificial languages for informing questions in SLA.

A mini-language is an actual subset of a real, natural language. Mini-languages maintain the grammar, lexicon, and phonotactics of their source languages, and are comprised of sentences that native speakers of the source language would understand. When designing a mini-language, it is important to choose a source language that naturally contains the linguistic features of interest. For example, Mini-Nihongo, a miniature version of Japanese, includes variable word order, case marking, and classifiers. The first two features exist in German, but classifiers do not, so this mini-language allowed the researchers to examine L2 processing of familiar and unfamiliar linguistic targets for L1 German speakers (Mueller, Hahne, Fujii, & Friederici, 2005). In another study, Mini-Basque, derived from Basque, was used to test L2 acquisition of entirely unfamiliar linguistic targets, so it was important that it have a lexicon and grammatical features that were new to the L1 English speakers learning the mini-language (Tagarelli, 2014). Because mini-languages rely heavily on natural languages but focus on small, controlled aspects of those languages, they serve as a way to bridge the gap between artificial and natural languages in SLA research. Indeed, by using ERP (Mueller et al., 2005) and fMRI (Tagarelli, 2014) techniques, research has demonstrated that mini-language learning and processing relies on many of the same neural correlates as L1 and L2 processing.

While these learning paradigms approximate natural languages in many ways, they still employ very small language models that cannot fully generalize to the enormity of natural language learning. Additionally, while there has been extensive evidence of quick learning in a variety of training conditions, studies rarely include untrained controls, which makes it difficult to assess whether high performance is a result of training, or rather a testing effect (for discussion, see Hamrick & Sachs, 2017). Nevertheless, behavioral and neural evidence support their efficacy in informing the processes and outcomes involved in language learning.

Conclusions

In this chapter, we have reviewed a diverse body of psycholinguistic methods that can be utilized to inform work in applied linguistics. We have discussed well-established tasks, measures, and paradigms that provide researchers with detailed information about the underlying psychological (and neural) representations and processes involved in language learning and processing. Throughout, we considered the appeal of these methods to researchers as well as their limitations.

Future research will continue to benefit from methodological bridges across psycholinguistics and applied linguistics. For instance, debates on explicit/implicit L2 learning and knowledge may be elucidated by syntactic priming research in L1 (Fine & Jaeger, 2013), and applied interests regarding L2 learning in the digital age can also be informed by psycholinguistic approaches (Lan, Fang, Legault, & Li, 2015). We hope we have illustrated that merging psycholinguistic methods with interests in applied linguistics opens new avenues of research and offers novel insights into classic questions.

Resources for Further Reading

Luck, S. J. (2014). *An introduction to the event-related potential technique*. Cambridge, MA: MIT Press.

This book provides a thorough foundation in the science behind the ERP technique and important methodological considerations for its use in research. The text is appropriate for novice through advanced ERP researchers and is a critical resource for scholars in applied linguistics who are interested in incorporating electrophysiological methods to answer their research questions.

McDonough, K., & Trofimovich, P. (2009). *Using priming methods in second language research*. New York: Taylor & Francis.

This book provides detailed information on theory, experimental design, and data analysis for priming paradigms in second language processing and acquisition research. It is a comprehensive resource for independent researchers and is also appropriate as a text for courses on research methods, second language acquisition, and psycholinguistics.

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