

Julie E Boland\*, Edith Kaan, Jorge Valdés Kroff and Stefanie Wulff

## Psycholinguistics and variation in language processing

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**Abstract:** This Special Collection includes a number of articles published together on the topic of Psycholinguistics and Variation and identified by the keyword “PsychLingVar” The collection reflects our view that variation in language processing is both important and ubiquitous, and that such variation presents challenges that psycholinguists have long ignored. In this article, we provide a brief overview of current psycholinguistic research on variation, including the articles featured in the collection. While quite diverse, this collection of articles is united by the common goal of investigating variation in language processing.

**Keywords:** PsychLingVar, language variation, psycholinguistics

Language variation is ubiquitous. We can observe it in every layer of language, from the variable realization of sounds to choosing one word over another, to competing syntactic frames. This language-internal variation correlates with speaker-individual factors, including, among others, a speaker’s age, sex, educational background, place of birth, and knowledge of other languages, as well as contextual factors such as the discourse setting, what has been said previously, and even what a speaker predicts to be said next. These correlations are never random or incidental, but systematic and robust. They give rise to accents, dialects, genres, registers, and slang, which we in turn use – be it consciously or unconsciously – to create, maintain, and negotiate our own identities just as much as to profile the people we speak with.

In search for a comprehensive definition of variation, we can refer to Halliday’s (1992) theory of Systemic Functional Grammar, which ascribes variation a key role by defining “language as a paradigmatic system, that is, a set of choices for each instance from which a speaker must select one. Such a set of choices is inherently probabilistic, that is to say in each situation, various choices are more or less likely to be selected by a speaker” (McEnery and Wilson 2001: 111–112). Not only did this definition of variation foreshadow advances in statistical machine translation (Manning and Schütze 1999); it furthermore emphasized the need for psycholinguistic models of human language processing to take variation into consideration.

It is somewhat surprising, therefore, that psycholinguistics, the field that seeks to understand how language is processed in and acquired by the human mind, have neglected variation phenomena. For decades, psycholinguists in general—and American psycholinguists in particular—seemed to imagine that the paradigmatic language user was an unrealistically invariant monolingual. This hypothetical prototype acquired a stable, standard English grammar in childhood, along with a lexicon that closely mirrored the Brown corpus (Kucera and Francis 1967); exposure to other dialects and languages had no impact. Of course, the invariant prototype arose from simplifying assumptions that allowed great progress to be made in the subdomains of speech perception, spoken and written word recognition, syntactic processing, and the analogous domains in language production.

Despite impressive progress, these simplifying assumptions raise issues of representativeness on at least two levels. First, the majority of the world’s population is bilingual rather than monolingual. Reflecting this, there has long been a tradition of research on bilingual language acquisition and processing. However, until recently, there was relatively little cross-pollination between bilingualism scholars and mainstream psycholinguists. Happily that has started to change. For example, the 2016 CUNY Sentence processing conference held at University of Florida had a special session entitled “Language variation

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\*Corresponding author: Julie E Boland, University of Michigan, Ann Arbor, MI, USA, E-mail: jeboland@umich.edu

Edith Kaan, Jorge Valdés Kroff, Stefanie Wulff, University of Florida, Gainesville, FL, USA

within and across speakers” that included papers on bilingualism. This collection also reflects the current shift in interest away from the monolingual speaker towards psycholinguistic research that considers bilingual and bidialectal speakers. Second, even those speakers who identify as monolingual encounter, and engage with, language variation at all the other levels outlined above. The potential impact of these sources of variation must be acknowledged in a plausible account of language processing, and have to be controlled for in empirical psycholinguistic studies.

At the level of sound structure, socio-phonetics has embraced variation, but this relatively new subfield stands in contrast to the sparsity of research examining morphological and syntactic variation. Psycholinguists can be inspired by research on socio-phonetic variation, because these investigations have borne substantial fruit— not merely uncovering robust empirical phenomena, but also prompting theoretical developments that reach beyond socio-phonetics, such as exemplar theories (Fink and Goldrick 2015; Goldinger 1998; Johnson 1997, 2007).

The time is ripe for psycholinguists to embrace investigations of variation. The contributions included in this special volume can be broadly grouped into approaches to within- and between-individual variation, studies on bilingualism, and papers discussing new methodological approaches to language variation. Individuals are not static in their language use, but flexibly respond and adapt to variation in the input they receive. We will use the term “within-individual variation” to refer to these dynamic processes. The section “Between-individual variation” deals with differences between language users in terms of differences in exposure and cognitive control, which in turn affect how variation in the language input is dealt with. Bilingualism (broadly construed) represents yet another type of variation within and between individuals in terms of the language(s) that they speak and how the first language changes with increasing exposure to other languages. We devote a separate section to research on bilingualism, which as noted above, is already a well-developed research area. We expect that results from these papers and other empirical findings will lead to theoretical developments that are both productive and broad-reaching.

## 1 Within-individual variation

Some types of variation occur within a single individual, in response to different speakers and situations. At the phonetic level, listeners rapidly accommodate to foreign-accented speech, such that word recognition accuracy increases with each quartile during a transcription task (Bradlow and Bent 2008). At the syntactic level, listeners and readers also adapt to the patterns encountered within the domain of a particular experiment. In a visual world eye-tracking experiment, Kamide (2012) found that listeners’ gaze over language-relevant images reflected the syntactic preferences of individual speakers, once these expectations had been established by patterns of input within the experiment itself. Similarly, Kaschak and Glenberg (2004) found that reading patterns quickly adapted to a novel regional construction when ten tokens of the construction were embedded in 25 sentence stimuli, and Fine et al. (2013) found that garden path effects in reading disappeared across the course of an experiment if the difficult structure was common within the experiment.

Despite strong evidence for adaptation to idiosyncratic input patterns within an experiment, it is not clear how individuals represent linguistic variation in the long term. One possibility is that we represent our own phonetic and syntactic grammar in full detail, but don’t store detailed representations for other speakers and dialects. This would lead to stronger linguistic expectations for in-group speakers, compared with out-group speakers. Alternatively, a given speaker might have multiple sub-grammars representing different dialects and registers, with the ability to generate distinct linguistic expectations depending on the speaker and the situation.

Within the domain of pragmatics and semantics, Van Berkum et al. (2008) found evidence that our linguistic expectations **are** tuned to the age group, gender, and social class of a speaker. They found semantic anomaly effects in the EEG record when, for example, listeners heard a child’s voice saying, “At

bedtime, I like to drink a glass of wine.” In contrast, it appears that our syntactic expectations for out-group speakers are rather coarse-grained, although they are influenced by the speaker’s accent. Hanulíková et al. (2012) exposed native speakers of Dutch to grammatical gender errors in either a Turkish accented voice or a native accented voice; in the EEG record, listeners were less likely to exhibit a syntactic anomaly response for the Turkish-accented voice. Similarly, Seifeldin et al. (2016) found that copula deletion (e. g. “He workin’ today”) elicited syntactic anomaly responses in the EEG record for a white speaker of Standard American English, but not for an African American speaker (copula deletion is grammatical in African American Vernacular English) or an Indian-accented speaker (for whom copula deletion is not grammatical). The latter result suggests that, while syntactic expectations are modified by accent, listeners do not have well-specified expectations about the specific grammar associated with different accents.

The experiments mentioned above all investigated how comprehenders respond to variation in the input. Next we consider within-individual variation from the point of view of the speaker. It is not news that some speakers use short, simple sentences and a reduced vocabulary when speaking with a young child (Newport 1975) or a developmentally disabled adult (DePaulo and Colman 1986). However, researchers have focused mainly on how this “motherese” might benefit first language acquisition, as opposed to investigating what mental representations and processes allow adult speakers to formulate their utterances in the motherese register vs. the default register. The motherese example is related to a broader issue that has been called “audience design” (Clark and Murphy 1982). That is, when and how do speakers adapt their utterance to the needs of the listener? Proponents of audience design maintain that a speaker’s choices in pronunciation, word choice, and syntactic structure match the current knowledge state of the listener; thus, within-speaker variation is theoretically important (e. g., Brennan and Hanna 2009; Bard and Aylett 2005). However, audience design has been highly controversial, with other researchers finding that a speaker’s choices are egocentric, and more likely to reflect their own processing ease (e. g., Keysar et al. 1998). One prominent version of the egocentric approach is Pickering and Garrod’s (2004) automatic interactive alignment theory. Under this account, conversational participants automatically mirror each other through egocentric mechanisms such as phonetic accommodation (Goldinger 1998), lexical repetition priming (Wheeldon and Monsell 1992) and syntactic priming (Bock 1986). Thus, variation is expected, but not driven by communicative goals.

In the current collection, Chun et al. (2016) examined structural priming, the tendency to repeat recently used or recently heard constructions. Structural priming in language production is generally assumed to be driven by abstract syntactic structures, not conceptual or phonetic properties of the input (Bock and Loebell 1990). If so, structural priming from spoken input should be immune to a speaker’s accent, as long as the syntactic content is held constant across speakers. However, Chun et al. found that structural priming **is** influenced by foreign accents, with a larger priming effect for prepositional object datives (e. g., “The policeman gives a helmet to the driver.”) in response to a foreign accented speaker compared with a native accented speaker. This finding—that listeners syntactically align **more** with speakers who are **less** like themselves is similar to Weatherholtz et al.’s (2014) finding of greater priming when the content of the prime phrase was politically dissimilar to the participant’s political views. These similarity effects may be mediated by attention during comprehension of the prime sentence, with more attention being allocated when the speaker is perceived to be dissimilar. In support of such an account, an analogous effect in spoken word recognition is briefly described below in Section 4 (McGowan 2015).

In sum, individuals clearly adapt their comprehension processes to accommodate linguistic variation in the short term. Questions remain, however, about the long term representations about linguistic variation that are brought to bear during language comprehension. Likewise on the production side, there is clear evidence that we adapt our speech to the current situation under some circumstances. However, it is an open question whether this is guided by beliefs about the cognitive ability and/or knowledge state of the listener, versus our own ease of processing.

## 2 Between-individual variation

The processing of language variation is also modulated by factors that differ between individuals. First, individuals differ in their language exposure. The frequencies with which words, structures, and their combinations are encountered in language greatly influence processing strategies and preferences (e. g., Cuetos and Mitchell 1988; MacDonald et al. 1994). For instance, English-immersed native Spanish speakers shift their preference for relative clause attachment from the pattern that is frequently attested in Spanish (high attachment) to the pattern that is frequent in English (low attachment) even when reading Spanish (Dussias and Sagarra 2007). Individual differences in exposure affect processing preferences in functionally monolingual speakers as well. For instance, language users who are more exposed to written language as measured by the Author Recognition Task (Acheson et al. 2008; Stanovich and West 1989), show a stronger processing preference for patterns that are commonly attested in written language, such as a low-attachment preference for English relative clauses (Payne et al. 2014) or a first-mention bias for pronoun interpretation (Strangmann et al. 2016).

In this collection, Lev-Ari (2016) extends the notion of exposure by investigating effects of social networks, that is, the number and kind of people one interacts with regularly. In sociolinguistics, social networks have been used to describe patterns of usage (e. g. Milroy and Milroy 1992). In her paper, Lev-Ari discusses evidence that people with larger social networks are better at recognizing speech in noise, and better at semantically evaluating adjectives in context. Simulation studies suggest that a larger network provides exposure to many observations that differ very slightly from each other, leading to a smooth rather than a more clustered distribution of relevant properties. Especially in the case of many-to-many mappings of sounds to phonemes, or of meaning nuances to adjectives, a larger social network therefore allows one to better and more flexibly match new input onto what one has encountered before. Differences in language exposure in terms of the number and kind of people one interacts with, can thus affect how language variation is handled.

In addition to language exposure, individuals differ in internal factors that influence how they understand and produce language. In the current collection, Zerkle and Arnold (2016) investigated a speaker's choice of how to refer to a visually present object, either with a full noun phrase or a pronoun. This is a topic that has also been investigated in dialogue paradigms, to test audience design vs. egocentric approaches to language production. However, Zerkle and Arnold investigated this phenomenon in a monologue context. In their eye-tracking experiment, the speakers who spent more time fixating objects during the first mention were more likely to use a pronoun to refer back to the objects, presumably because the additional visual attention devoted to an object rendered it more salient in the speaker's mind. Why should speakers differ on this dimension? The authors speculate that differences in working memory or print exposure might underlie this difference in linguistic production.

One internal difference among individuals that is known to impact language processing is cognitive control. Like differences in exposure (discussed above), differences in cognitive control may affect how within-language alternations are managed. We will interpret the term "cognitive control" loosely here, taking it to include functions such as working memory, inhibition, and monitoring (see for a model Miyake and Friedman 2012). We discuss cognitive control separately from exposure, but acknowledge that cognitive functions and language exposure are related, and that there is a substantial debate concerning the specifics of this relation (e. g., MacDonald and Christiansen 2002; and the literature on bilingualism and cognitive control, e. g. Kroll and Bialystok 2013; Hilchey and Klein 2011).

Cognitive control has been shown to affect how language users deal with linguistic ambiguities. For sentences such as *The soldiers warned about the dangers...*, readers with a high working memory span keep both preferred (soldiers warning others) and non-preferred readings (soldiers who were warned) activated for a while, whereas low span readers quickly revert to the preferred reading only (MacDonald et al. 1992). When the sentence is disambiguated towards the non-preferred reading, language users with weaker inhibitory or updating skills are worse at rejecting the initially preferred

interpretation of the ambiguity, and may consider both the initial and the intended interpretation (Pozzan et al. 2016; Vuong and Martin 2014; see for overviews Novick et al. 2010; Mazuka et al. 2009). Cognitive control can therefore affect the simultaneous activation of different representations; this can in turn affect how language variation is dealt with. Lev-Ari and Peperkamp (2014) report that native French speakers with weaker inhibitory skills were more likely than speakers with stronger inhibitory skills to accept word stimuli in which the voice onset time of a voiced consonant was shorter than usual (e.g., *code* in which the VOT of ‘d’ was shortened), provided that there was an unvoiced competitor word (*cote*). This suggests that people who are worse at inhibiting information in general are worse at inhibiting lexical neighbors, which in turn affects their perception of variation in speech sounds. Building on this research, Berry (2016) in this collection proposes that the different weighing of pro-active and re-active control affects the processing of language variation. Pro-active control modulates one’s reliance on the preceding context, and re-active control modulates how unexpected input is managed. Language users with stronger re-active control will treat the new input as a variation of existing categories, whereas language users with weaker re-active control will prefer to analyze the different input as a new category.

Dealing with language variation involves (implicitly) recognizing that the input is different from what is typically expected or encountered, and adjusting one’s knowledge and future expectations on the basis of that input, either by accommodating the new input into existing categories, or by classifying the input into a new category, which the language user can consider a valid or invalid alternate given the context. Exposure, cognitive control, and cognitive style are only a few of the many environmental and internal factors that are likely to modulate these processes and affect how an individual deals with language variation.

### 3 Bilingualism as a window into language variation

A central insight from bilingualism research is that the bilingual mind is not the simple amalgamation of two monolingual minds (Grosjean 1989). Instead, even when speaking or listening in one language, the other language continues to be co-active to varying degrees, an observation known as *non-selectivity* (e.g., Kroll et al. 2006). Thus, in order to speak or comprehend in one language alone, researchers have hypothesized the use of domain-general cognitive processes that may involve inhibition, conflict monitoring, and/or increased attention (e.g., Bialystok et al. 2009). There remains considerable debate on whether the use of domain-general cognitive processes in bilingual language use confers a bilingual cognitive advantage over monolingual individuals (e.g. Paap et al. 2015); nevertheless, the overarching perspective is that a bilingual’s experience essentially involves the constant mental juggling between languages (Kroll et al. 2012).

Due to this navigation between languages, research on bilingualism stands at the nexus in investigating within- and between-speaker variation. Following common practice in psycholinguistic studies of bilingualism, we define bilingualism broadly to indicate speakers who engage with more than one language, including those who may traditionally be referred to as second language speakers. This broad definition is, in part, recognition of the myriad paths that speakers take in becoming bilingual. Some are born into multilingual settings or immigrate to regions in which another language is the norm compared to the home language, while others learn a second language later in life, whether in a formal classroom or through immigration. Additionally, the way in which bilingual speakers use their languages differs broadly. At one extreme, bilingual individuals who effectively cease to use one of their languages may experience language attrition (e.g. Schmid 2010). On the other hand, certain bilingual communities frequently and fluidly switch between their languages even within the same conversation setting (i.e., *code-switching*, Gardner-Chloros 2009).

Taken together, these different modes of acquisition and language use lead to an extremely heterogeneous group of speakers, which challenges the traditional tactic of categorically comparing native and non-native groups. The traditional focus has been on whether late bilinguals (i. e., non-native, second language, or L2 speakers) are able to process their second language in a native-like fashion (e. g., Frenck-Mestre and Pynte 1997; Johnson and Newport 1989; Weber-Fox and Neville 1996). This line of inquiry is due to the well-documented phenomenon of transfer: the influence of the first language on the second language. Regardless, an emerging picture within the last decade is that both linguistic systems are subject to dynamic changes as a result of the bilingual experience. Thus, even at early stages of second language acquisition, the second language can have an effect on first language processing (e. g., Dussias and Sagarra, 2007; Marian and Spivey, 2003).

Both bilingual contributions to our special collection fall within this recent line of work. First, Caffera et al. (2016) explore grammatical gender processing in early Basque-Spanish bilinguals. Basque, an agglutinative language, lacks grammatical gender whereas Spanish, an inflectional language, obligatorily encodes grammatical gender on nouns. This study manipulates two features of the Spanish grammatical gender system: whether the noun ending is transparent to grammatical gender (i. e., *-o* highly correlates with masculine; *-a* highly correlates with feminine) and whether this gender feature is separable as a morpheme (e. g., *tí-o/a*, “uncle/aunt” v. *gusano* “worm”). Caffera et al. found that the degree of language use in Basque, influenced reaction times on a Spanish gender judgment task such that greater Basque usage led to faster reaction times on gender transparent nouns. Caffera et al. interpreted this finding as suggesting that the bilingual’s experience with Basque as an agglutinative language changes how they access gender features in their other language. This study demonstrates how the effects of processing in one language influencing processing in the other, even on a grammatical feature that is absent in the non-target language.

Also in this collection, Shoji et al. (2016c) analyze the consequences of immersion (measured as age of arrival) on reading times on the Repeated Name Penalty (Gordon et al. 1993) and Overt Pronoun Penalty (Gelormini-Lezama and Almor 2011). These penalties occur when readers are slower to read repeated name anaphors and overt pronoun anaphors (in pro-drop languages like Spanish) than subject pronoun anaphors and null subject pronoun anaphors, respectively. Japanese further distinguishes between topic and non-topic subjects (i. e. *-wa* and *-ga*). Shoji et al.’s previous studies presented conflicting results. In one paper, they reported that a Japanese group immersed in an English-speaking country showed no differences relative to topicality (Shoji et al. 2016a). However they reported in another paper that a monolingual Japanese group exhibited an interaction with topicality, such that the penalties only arose with anaphors marked by *-ga* (Shoji et al. 2016b). The current paper reanalyzes the original immersed group data set and finds that the early age of arrival (AOA) group shows processing patterns similar to the monolingual group, whereas the late AOA group does not show sensitivity to the topicality manipulation. Shoji et al. hypothesize that early AOA bilinguals represent different languages separately, while late AOA bilinguals tend to rely on a single unified language system. Importantly, Shoji et al. underscore a sound warning in making broad generalizations on sentence processing without taking into account the linguistic experience of the sample group.

With the demographic reality that most people around the world are multilingual speakers, the field of psycholinguistics is moving in a new direction that places variation at the forefront of how humans parse language, whether this variation stems from cross-language influence or degree of language use. Due to the inherently variable nature of working with bilingual populations, bilingualism research has been confronting these issues for many years. Thus, bilingualism can and should contribute to our knowledge of the bounds of dynamicity and flexibility in production and comprehension in all speakers, both within a single language and in navigating between languages.

## 4 Adapting paradigms from other subfields

In the research described above, new factors designed to reflect linguistic variation were added to experimental paradigms that were already in use within psycholinguistics. This approach takes

advantage of decades of research in cognitive psychology and cognitive neuroscience to develop paradigms such as eye-tracking and ERP, which tap cognitive processing as it unfolds. In addition, psycholinguists have begun to supplement this approach by adapting paradigms from the subfields of linguistics that specifically focus on variation. For example, the matched guise paradigm (Lambert et al. 1960) has been used extensively in sociolinguistics to measure language attitudes, usually via questionnaire: Listeners hear recordings of the same speaker producing the same sentences in two or more guises. A between-participants design can be used, so that listeners are unaware of the guises. Sometimes the same speaker uses different languages or accents and sometimes the speech itself is held constant, and only the description of the speaker varies. The latter version of the matched guise paradigm has recently been used to measure word recognition accuracy, as a function of socially-based expectations (McGowan 2015). McGowan found that speech transcription by American college students was more accurate when told that the speaker was Chinese than when told the speaker was American, even though the speech itself was held constant in a between-participants design. As noted above, McGowan concluded that listeners attended more deeply to the presumed out-group speaker.

In the current collection, Tamminga et al. (2016) describes how generalized additive mixed models (GAMMs) can be used to examine within-speaker variation during sociolinguistic interviews, where it is important to distinguish short-term priming from style-shifting. Similar issues arise in psycholinguistic experiments that examine language production in naturalistic conversations. For example, there are multiple mechanisms that might lead to repeated production of a linguistic constituent (syntactic, lexical, or phonetic) including activation-based priming and deliberate attempts to be clear and understandable. GAMMs provide a means to disentangle mechanisms that have differing inherent time-courses.

The study of language change across time and geography is another subdomain of linguistics in which variation is important. Although some research has examined how speech perception is affected during vowel mergers (e. g., Hay et al. 2006; Koops et al. 2008), Rodina et al. (2016) may be the first to investigate how a morphosyntactic merger affects linguistic predictions. She considers the merger of masculine and feminine gender in Norwegian, comparing participants who still use the feminine morphology with those who do not. In a visual world eye-tracking experiment, both types of participants had fewer anticipatory looks following masculine and feminine articles, compared with neuter articles, suggesting that the merger influenced comprehension even when it was not apparent in production patterns.

Together, these papers illustrate how paradigms that have predominately been used in other subfields of linguistics can be adapted for investigating the cognitive mechanisms that underlie variation in language processing.

## 5 Conclusions

The new research reported in this special collection represents an emerging interest in experimental investigations of variation in language processing, among psycholinguists. As summarized above, the new research reported here builds upon pioneering research of other scholars, both in linguistics and psychology. By learning from research in socio-phonetics and bilingualism, two subdomains that have explicitly confronted issues of language variation and by adapting new research tools from variationist research, psycholinguists will be well positioned to make rapid progress on understanding how language variation is dealt with in language comprehension, production and acquisition.

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