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Authors

Fricke, Melinda

Zirnstein, Megan

Navarro-Torres, Christian

et al.

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Bilingualism reveals fundamental variation in language processing

Melinda Fricke[1], **Megan Zirnstein**[2], **Christian Navarro-Torres**[2], and **Judith F. Kroll**[2,3]

[1]Department of Linguistics, University of Pittsburgh

[2]Department of Psychology, University of California, Riverside

[3]Department of Psychology, Pennsylvania State University

Abstract

Although variation in the ways individuals process language has long been a topic of interest and discussion in the psycholinguistic literature, only recently have studies of bilingualism and its cognitive consequences begun to reveal the fundamental dynamics between language and cognition. We argue that the active use of two languages provides a lens through which the interactions between language use, language processing, and the contexts in which these take place can be fully understood. Far from bilingualism being considered a special case, it may provide the common basis upon which the principles of language learning and use can be modeled.

Keywords

Bilingualism; individual differences in language processing; cognitive control

A recent trend in the language sciences has been to pursue a more nuanced understanding of individual differences in language processing. Armed with increasingly sophisticated tools for statistical modeling and data collection, researchers have turned their attention to the systematicity hidden within the “noise” of processing behavior. In this paper, we argue that, while this shift has been occurring slowly but surely over the past few decades, relatively little explicit consideration has been given to the implicit assumptions motivating this endeavor, namely, that variation in language processing is a fundamental aspect of language as a cognitive system, and that a better understanding of the sources of this variation will reveal the architecture of the system itself. In this respect, studies of language processing in bilingual speakers have made an important contribution. The use of two or more languages is perhaps the most common characterization of language use in the world today. Combined with the rapid development of neuroscientific methods, bilingualism can act as a lens to illuminate the relations between language and its cognitive and neural underpinnings (e.g., De Groot, 2011; Kroll, Dussias, Bice, & Perrotti, 2015).[1]

Address for Correspondence: Melinda Fricke, Department of Linguistics, 2822 Cathedral of Learning, University of Pittsburgh, Pittsburgh, PA 15260 USA, melinda.fricke@pitt.edu.

This paper is not intended as a comprehensive review of the current literature on bilingualism, nor of individual difference approaches to language processing. Rather, we intend to illustrate how research on bilingualism has contributed to the current reorientation toward and reinterpretation of variation in language processing. We define "variation" as the way in which individuals differ in how they employ cognitive and linguistic skills. We first consider what has been learned about the acquisition and use of two languages that reflects the inherent variability of the language system, and we then discuss recent findings that reveal the contextual and cognitive factors that modulate the dynamics of this variation. Finally, we point to recent discussion about the cognitive consequences of bilingualism (e.g., García-Pentón, Fernández García, Costello, Duñabeitia, & Carreiras, 2016; Valian, 2015) as an example of how language science may benefit by considering the ways that individual variability gives rise to stable patterns of results across seemingly disparate studies.

1. Variation in second language (L2) acquisition reveals a dynamic system

Not all bilinguals are the same and not all contexts of language use incur the same cognitive demands (Luk & Bialystok, 2013). Recent proposals (e.g., Green & Abutalebi, 2013) underscore the idea that some language contexts may engage cognitive resources differentially, with distinct consequences for bilinguals whose cognition has been "tuned" by a respectively demanding environment. Although lifelong bilinguals are likely to adapt to such demands, adults who have acquired the L2 later in life are also impacted by differences in the context of language learning and use, and various proposals have been offered to account for the variation seen in learners' mastery and use of the L2 (Flege, 2007; Flege & Eefting, 1987; Hawkins & Chan, 1997; Franceschina, 2001, 2005). Traditionally, two assumptions have been made about the trajectory of L2 acquisition: (1) that the native or first language (L1) remains stable throughout the lifespan; and (2) that the L2 is biologically constrained. Under these assumptions, adult L2 learners must attempt the seemingly insurmountable feat of constructing a new language system, with transfer from L1 that may be only partly successful (e.g., Clahsen & Felser, 2006; but see MacWhinney, 2005). Historically, this framing left little room for a nuanced discussion of individual variation, as successful L2 learning was assumed to decline with increasing age (Johnson & Newport, 1989; Flege, Munro, & MacKay, 1995). However, recent neuroscience research shows that late L2 learning is highly dynamic (McLaughlin, Tanner, Frenck-Mestre, Valentine, & Osterhout, 2010), can result in native-like grammatical processing (Morgan-Short, Steinhauer, Sanz, & Ullman, 2012), and can have consequences for both brain structure and function (Li, Legault, & Litcofsky, 2014). Below, we highlight the discoveries that illustrate how the study of individual differences allows us to further our understanding of the path that L2 learners take to becoming proficient language users.

1.1 The L1 is affected by L2 learning

Successful language learning has been argued to depend on the degree of overlap between the L1 and L2 (Flege & Davidian, 1984; Hancin-Bhatt, 1994; Hatzidaki et al., 2011;

[1]For the purpose of this discussion we consider bilingualism broadly to include all speakers who actively use two or more languages, regardless of age of acquisition. The consequences of the form of bilingualism and level of proficiency and dominance in each language have been reviewed elsewhere (e.g., Luk & Bialystok, 2013).

Sabourin et al., 2006; Sabourin & Stowe, 2008), with the underlying assumptions that the native L1 should be relatively static and the primary direction of transfer should be from the L1 to the L2. These assumptions have been questioned by studies showing that the L1 is subject to influence from the L2, not only for learners (Baus, Costa & Carreiras, 2013; Chang, 2012, 2013; Linck, Kroll & Sunderman, 2009; Namjoshi et al., 2015) and highly proficient bilinguals (Dussias & Sagarra 2007; Valdés-Kroff, 2012; Dussias et al., 2014; Van Hell & Dijkstra, 2002), but even for monolinguals immersed in another language environment (Caramazza & Yeni-Komshian, 1974). While L2 immersion enhances the influence of L2 on L1, this relationship can also be observed for students learning L2 in the classroom (e.g., Herd, Walden, Knight, & Alexander, 2015, Huffman & Schuhmann, 2015, & Schuhmann & Huffman, 2015). Crucially, in some instances, these effects are detectable only if a sensitive measure is used (e.g., Event Related Potentials; ERPs) and if individual differences are considered (Bice & Kroll, 2015). The emerging evidence suggests that the influence of L2 learning on L1 may vary depending on the individual and context under consideration, and further, that pursuing a more complete understanding of the L1-L2 relationship may be informative with respect to issues of language and domain general cognition, as well as neuroplasticity across the lifespan (Baum & Titone, 2014).

1.2 L2 and L1 processing are highly variable

Achieving native-like processing ability in the L2 is considered difficult for late learners (Clahsen & Felser, 2006; Ullman, 2005), and data on age of acquisition has been used to argue this point. Recent work has taken a different approach by using measures of proficiency, lexical knowledge, and executive function to track whether particular learners will be sensitive to aspects of L2 syntax (Hopp, 2014; 2016; Steinhauer, 2014). These studies indicate that L2 learners with higher working memory capacity are capable of parsing complex structures like relative clauses in a manner similar to native speakers, and that individual differences in working memory are correlated with qualitatively similar parsing strategies across both groups (Hopp, 2014; see also Kim, 2010). Moreover, monolingual performance may not serve as the best benchmark for successful L2 attainment; while some monolinguals use efficient parsing strategies to revise syntactic ambiguities, others simply do not (Ferreira, 2003; Townsend & Bever, 2001). There is much still to be learned about how syntactic processing ability changes over the course of L2 acquisition. What we know is that monolinguals and L2 learners can show comparable performance, suggesting that L1 and L2 processing share some fundamental properties. Only by examining the factors that underlie processing variability in both native and nonnative speakers (Pakulak & Neville, 2010; Tanner, Inoue, & Osterhout, 2014) have these commonalities have been brought to light.

2. Differences in L1-L2 competition show how the language system adapts

When bilinguals read or speak a word, they must select among competing alternatives in the L1 and L2. The ability to manage this competition has been highlighted as a potential factor underlying the consequences of bilingual language use for cognition. When this immediate competition is absent, as is the case for bimodal bilinguals who are not required to select a single lexical form, the effects on cognition and the brain can be quite different (Emmorey,

Luk, Pyers, & Bialystok, 2008; Olulade, Jamal, Koo, Perfetti, LaSasso, & Eden, 2016). We next consider some ways in which cross-language competition during lexical access can influence language processing across individuals and language contexts.

2.1 Language production

Multiple factors affect the extent to which dual-language activation impacts language production. The relative proficiency or dominance of a bilingual's two languages undoubtedly plays a role. For example, Costa and Santesteban (2004) demonstrated an asymmetrical cost when switching from naming pictures in the L2 into the L1 for lower proficiency speakers, but a symmetrical switching cost for higher proficiency speakers. This result was taken to mean that the stronger L1 must be suppressed in order to gain access to a weaker L2, and then subsequently de-regulated in order to allow L1 naming to occur. Other studies suggest that proficiency may affect only some components of inhibitory control and that even highly proficient bilinguals inhibit the L1 to plan speech in the L2 (Misra, Guo, Bobb, & Kroll, 2012; Van Assche, Duyck, & Gollan, 2013). These regulatory mechanisms may be differentially impacted by the context in which language use takes place (see Kroll, Bobb, & Wodniecka, 2006). To illustrate, Jacobs, Fricke, and Kroll (2016) demonstrated that the cross-language activation that L2 learners experience in production could be influenced by the language immersion context. Independent of L2 proficiency, learners immersed in the L1 showed cross-language influence in their phonetic production, while those immersed in the L2 did not. While greater L2 proficiency and the ability to appropriately regulate the L1 typically go hand in hand, these factors appear to be dissociable under certain circumstances. Different stages of speech planning may also be differentially affected by patterns of activation and inhibition, as cross-language activation in this study was shown to influence naming times across groups, but not necessarily qualitative aspects of articulation. Other aspects of the production context also play a role; Olson (2013) found that the proportion of other-language trials impacted the degree of cross-language phonological influence on picture naming, and Gustafson, Engstler, and Goldrick (2013) reported greater cross-language phonological influence during picture naming as compared to verbal shadowing.

Even within the same production context, bilinguals' ability to flexibly recruit cognitive resources is important. Simply encouraging different lexical selection strategies during a picture-naming task, for example, may affect the magnitude of language switching costs (Kleinman & Gollan, 2016). Festman, Rodriguez-Fornells, and Münte (2010) reported that young adult, late bilinguals who performed relatively poorly on a range of domain-general cognitive tasks also tended to produce more unintended language intrusions. This suggests a relationship between domain-general cognitive function and efficient lexical selection, and raises the possibility that variation in language task demands may be associated with long-term, adaptive changes to the cognitive system (Green & Abutalebi, 2013). However, more work is needed to fully appreciate how L1 dominance and regulatory ability impact the manifestation of cross-language activation during speech planning.

2.2. Language comprehension

Effective language comprehension relies on the ability to support relevant information in prior context and suppress irrelevant information (Gernsbacher & Faust, 1991; Gernsbacher,

Varner, & Faust, 1990). When individuals experience more difficulty suppressing, interference can occur, making efficient processing and successful comprehension more effortful. In spoken discourse comprehension, Boudewyn, Long, and Swaab (2012) found that individual performance on a Stroop interference task predicted whether monolingual listeners were able to suppress competing and less relevant information in local discourse (within the same sentence) in order to maintain more relevant information over time (from prior sentences in the discourse). Cognitive control has also been shown to support the comprehension of sentences containing syntactic ambiguities. Novick, Hussey, Teubner-Rhodes, Harbison, and Bunting (2014) trained participants on the N-back task to improve their ability to resolve non-linguistic conflict. Participants who gained the most from N-back training also saw the greatest gains in resolving syntactic ambiguities from pre- to post-training.

Studies of non-native bilingual comprehension support the claim that there is a relationship between language processing and cognitive control. Teubner-Rhodes et al. (2016), for example, found that the degree of improvement in a high conflict N-back task was significantly correlated with improvement in sentence comprehension for bilinguals as well as monolinguals. Moreover, bilingual readers performed better than monolinguals overall on the high conflict N-back and in their comprehension of syntactically ambiguous sentences, suggesting that previous experience in negotiating conflict due to cross-language activation can be applied to other cognitive training contexts, as well as to language comprehension itself.

Cross-language influence from the unintended language has repeatedly been demonstrated to play a role in bilingual language comprehension (Kroll, Gullifer, & Zirnstein, 2016; Van Hell & Tanner, 2013), meaning that language regulation ability may be critical for successful comprehension. Similarly to language production, results suggest that individual differences both in cognitive resources and sensitivity to contextual constraints help to predict the circumstances under which bilinguals will evince greater cross-language modulation. Whitford and Titone (2012) showed that individual differences in the degree of L2 exposure itself has consequences for the accessibility of words in each language, with a decline in L1 accessibility as L2 exposure increases (and see Whitford & Titone, 2015). Pivneva, Mercier, and Titone (2014) found that when bilingual readers encountered interlingual homographs, which share form but not meaning across languages (e.g., *chat*, which means “cat” in French), inhibitory control ability attenuated the amount of interference observed, irrespective of L2 proficiency. The findings with respect to contextual influences are somewhat mixed, with some studies showing that language-specific constraining information can reduce cross-language activation (Chambers & Cooke, 2009; Fricke, Kroll, & Dussias, 2016; Schwartz & Kroll, 2006), while others show no such effects (Gullifer, Kroll, & Dussias, 2013; Van Assche et al., 2011), although individual variability in this area is not yet well understood (see Gullifer, 2015, for evidence concerning syntactic constraints and cognitive control). Further research may reveal interactions between language- and task-specific constraining information, on the one hand, and individual differences in cognitive control ability on the other.

3. How individual variation can inform current debates

We have argued that accounting for a wide array of language use is key to understanding the fundamental dynamics of the language system. What we have yet to address is how this type of approach can impact the field more broadly. A potentially critical application concerns the recent debate on the impact of bilingual language use on cognition. Some research has suggested that the effort required to appropriately switch languages, between speakers and contexts, can change or tune the neural networks that support this complex behavior (see Green & Abutalebi, 2013, on the Adaptive Control Hypothesis) and provide protection against cognitive decline during aging and in the face of pathology (Alladi et al., 2015). In particular, multiple studies show that bilinguals tend to outperform matched monolingual controls on tasks of executive function (e.g., Bak, Vega-Mendoza, & Sorace, 2014; Gold et al., 2013). However, advantages for bilinguals tend to be more robust in early childhood and older adulthood (Baum & Titone, 2014; Bialystok, 2017; Kroll & Bialystok, 2013). In young adults, these consequences for cognition are not always found, and some argue that this level of inconsistency calls into question all cognitive consequences attributed to bilingualism (de Bruin, Treccani, & Della Sala, 2015; García-Pentón, et al., 2016; Valian, 2015; but see Bialystok, 2017 and Bialystok, Kroll, Green, MacWhinney, & Craik, 2015). Notably, there is variation not only across the lifespan, but also for different indices of processing, with some evidence suggesting that measures of brain activity may be more likely to detect the consequences of bilingualism than behavior alone (Kousaie & Phillips, 2017). How can we place these varied findings in a larger context in the literature?

3.1 Individual differences in language processing: the bigger picture

When investigating the potential cognitive consequences of bilingualism, it is important not only to take individual variability into account, as we have argued, but also to acknowledge that the hypothesized interaction between language and cognition has been the focus of research on individual differences in monolingual language use for decades (see Boudewyn, 2015, Long, Johns, & Morris, 2007; and Prat, 2011 for reviews). This includes a range of research that has reported multiple influences of individual-level skill on language processing, including word-decoding (e.g., the Lexical Quality Hypothesis; Perfetti, 2007), working memory (Daneman & Carpenter, 1980; Just & Carpenter, 1992), inhibition/suppression (e.g., the Structure-Building framework; Gernsbacher, 1996, 1997), speed of processing (Traxler et al., 2012), experience (Ericsson & Kintsch, 1995; as measured by vocabulary and print exposure, e.g., Braze et al., 2007), susceptibility to memory interference (Van Dyke & Johns, 2012), and complex interactions between these skills (Hamilton, Freed, & Long, 2013). Together, this work indicates not only variability but also malleability in language processing. Rather than interpreting this complex relationship as an impediment to “parsimonious” explanations for language performance, we propose that the principled investigation of inter-individual variation in bilingual language processing can provide a creative solution to what appear to be discrepant findings across populations and laboratories.

Even if one is highly skeptical of the impact that bilingualism might have on domain-general cognition, it is not unreasonable to suspect that individual-level variability could play a large

role in determining performance on tasks of executive function. As a repercussion, differences between and within bilinguals may often be masked by group-level analyses. As Baum and Titone (2014) suggest, research on bilingualism, in particular, could benefit from considering both types of variance.

4. Summary and conclusions: Opportunistic processors and creatures of habit

Language processing is inherently variable, and the contexts in which bilinguals acquire and use language afford unique opportunities to observe the consequences of this variability. Bilingualism has the potential to reveal the fundamental breadth and underlying nature of variation in language processing (for a similar approach to language development see Pierce, Genesee, Delcenserie, & Morgan, 2017). We have briefly discussed research that suggests that bilingual language processing is, at its core, plastic: proficient speakers, listeners, readers, and learners all appear capable of exploiting multiple strategies to regulate their languages, flexibility that may benefit cognition more generally. Recent proposals hypothesize a link between a speaker's history of language regulation and the adaptation of cognitive control processes to the linguistic contexts in which they have most commonly been engaged (Green & Abutalebi, 2013; Green & Li, 2014). Future research promises to elucidate the ways in which accumulated experience with specific modes of language control may impact both linguistic and cognitive processing. In this sense, bilinguals are model subjects of study for those interested in the dynamics between language and cognition and their neural bases.

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