23 What Language Experience Tells us about Cognition

Variable Input and Interactional Contexts Affect Bilingual Sentence Processing

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1. Introduction

Adult learners often find it difficult to acquire a high level of proficiency in a second language (L2). L2 learners are purportedly unable to learn subtle nuances of the L2 grammar (e.g. Johnson and Newport 1989), they often speak the L2 with an accent (Piske et al. 2001), and they process the L2 differently from first language and/or monolingual (L1) speakers, particularly in the domain of complex syntax (Clahsen and Felser 2006). These general observations are reported even when high levels of L2 proficiency have been attained, and despite many years of study and exposure to the second language. Consequently, a question that has dominated the adult L2 sentence processing literature is why there are apparent constraints on the level of proficiency that adult learners typically reach in their ability to process words and sentences in their second language. Results demonstrating failure to acquire the L2 natively have been widespread (e.g. Clahsen and Muysken 1986, 1989) and have fuelled proposals on the existence of hard constraints on late L2 learning (Bley-Vroman 1990) and L2 processing (Clahsen and Felser 2006). The traditional account has been that individuals who learn a second language past early childhood are unable to fully acquire the L2 syntax (e.g. Clahsen and Muysken 1986) or to process the L2 in an L1-like fashion (e.g. Clahsen and Felser 2006). To explain what L2 learners can do with the L2, the proposal has been that they use compensatory strategies to speak and to process the L2 that are based on semantic and pragmatic information, but that they are not sensitive to complex syntactic operations (e.g. filler-gap dependencies).

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In the past 15 years, a premier method that has been used to examine whether L2 language processing is fundamentally similar to or different from native language processing is electroencephalography (EEG). Time-averaged event-related potentials (ERPs) derived from EEG have served as the benchmark measure to characterize differences and similarities in L2 learners by revealing which processing components approximate the neural signatures of native speakers. The vast majority of neurocognitive studies focusing on the presence or absence of ERP effects in L2 learners have yielded somewhat mixed results. Early electrophysiological studies suggest that L2 speakers are less sensitive than native speakers when processing syntactic violations relative to semantic ones (Hahne 2001; Hahne and Friederici 2001; Weber-Fox and Neville 1996). Recent studies, on the other hand, have shown that some learners manage to successfully achieve L1-like performance in the L2 within the domain of syntactic processing; the evidence has demonstrated that late L2 learners who have become proficient in the L2 show many of the same brain signatures in the L2 that are seen in L1 speakers (e.g. Morgan-Short et al. 2012; Steinhauer et al. 2009). To illustrate, a study by Caffarra et al. (2015) examined the role of L2 factors on three ERP components associated with syntactic processing: early left anterior negativity (eLAN), left anterior negativity (LAN), and P600 (for a discussion of the different ERP components, see Chapter 5, this volume). They report that eLAN effects,[1] which are typically found when L1 speakers process phrase structure violations (e.g. Friederici 1995; Friederici and Weissenborn 2007) are also found in highly proficient L2 speakers. Likewise, LAN effects for morphosyntactic violations have been observed in ERP studies where L2 speakers have had more than five years of immersion in the L2 environment; and P600 effects are observed in relation to the processing of morphosyntactic features, such as grammatical gender and number, in spite of significant syntactic differences between the L1 and L2 grammars (e.g. Dowens et al. 2011).

Despite the documented similarities, an important caveat of the ERP research on L2 sentence processing is that the interpretation of the effects rests on the assumption of homogeneity across individuals, and this is true even when monolingual speakers are the target of study. Notwithstanding, recent evidence suggests that ERP responses are sensitive to individual differences both in the L1 (Pakulak and Neville 2010) and in the L2 (Tanner et al. 2013); it has also been argued that under certain conditions, the modulation and/or absence of an ERP effect may be an artefact of individual processing strategies (e.g. Nieuwland and Van Berkum 2008; Tanner et al. 2014). In other words, it is becoming increasingly clear that individuals display considerable variability in their responses to natural language input (Qi et al. 2017). Given this, an important aspect to consider in the comparison between native and L2 processing is the role of the speakers' linguistic experience and of variation in the input to which they are exposed (see discussion in Boland et al. 2016). The assumption underlying most L2 processing research, and which we would argue should be revised, has been that of an ideal and uniform native language processor. Most research on L2 processing has compared the performance of first and second language speakers, with little consideration of the inherent variability that characterizes speakers' linguistic experience and the input to which speakers are exposed. For example, work investigating the role of individual differences in L1 reading proficiency have shown a tight correlation between letter name and sound knowledge in the L1 and resulting early literacy skills in the L2 (Cárdenas-Hagan et al. 2007). Likewise, L2 proficiency and L1 reading ability interact to predict L2 reading ability (Lee and Schallert 1997). While little, if any, work has been conducted on the variability underlying specific parsing strategies, the finding that the L2 can affect the L1 (Kroll and Dussias 2016) in much the same way that the L1 affects the L2 suggests that variability in the L1 may affect subsequent learning and processing in the L2.

The assumption of a uniform and highly efficient L1 processor has long been challenged and acknowledged in the L1 processing literature, with evidence for individual variation in L1 speakers (e.g. Caplan and Waters 1999; Farmer et al. 2012; Just and Carpenter 1992; Pakulak and Neville 2010; Tanner and Van Hell 2014), and with strategies in L1 language processing that are sometimes 'good enough' (e.g. Ferreira and Patson 2007). While speakers of the same variety tend to converge on the cues and strategies that they employ, there nonetheless exists great heterogeneity and variation in how comprehenders approach sentence processing in their native language (Farmer et al. 2012). Yet, many L2 processing studies that have observed mismatches between L1 and L2 processing routines have not considered the inherent variability that exists in native speaker processing. The aim of this chapter is to discuss recent findings that demonstrate how variability in the linguistic experiences of bilingual speakers and in the ability of bilingual speakers to learn from these experiences, might impact bilingual language processing. The goal is to show that linguistic experience – the input that comprehenders receive – and the interactional contexts in which bilinguals find themselves serve an influential role in L2 speaker language processing. We do this first by briefly discussing several illustrative studies that demonstrate how the first language system of speakers adapts to L2 input. We have chosen to discuss the influence of the L2 on the L1 because it provides a dramatic illustration of the permeability of the language system that challenges the traditional interpretation of critical periods for language learning and language comprehension. We then follow with a discussion of a particular case of bilingual speech – code switching – to illustrate how adaptation to different interactional contexts modulates the processing of codeswitched language. As much as possible, we will present studies that have employed electrophysiological recording methods. We will additionally discuss studies that have used behavioural methods of sentence processing (i.e. reaction time and eye-tracking), especially when neuroscience evidence is not available to illustrate a particular point.

2. The Role of Variable Input in Monolingual Language Processing

It is of little debate in the monolingual sentence processing literature that individual differences affect language processing. The early work examined individual variability in syntactic processing through the lens of verbal working memory, demonstrating that individuals who scored higher on tests of working memory tended to more easily parse difficult syntactic structures compared with those who scored lower (e.g. King and Just 1991). For instance, some studies have found that individuals with higher working memory exhibited faster reading times on object relatives (e.g. 'The reporter that the senator attacked admitted the error') – a difficult English structure to parse – compared with individuals with lower working memory (Just and Carpenter 1992). Recent work suggests, however, that the story does not end here: linguistic experience and the patterns and strategies that speakers use vis-à-vis the input also affect language processing. To take an example from the monolingual processing literature, Wells et al. (2009) directly manipulated input-driven experience in a self-paced reading study of object and subject relatives. They examined two groups of monolingual comprehenders. One group participated in three training sessions in which they were exposed to various complex English structures, but not subject or object relatives. A second group also completed three training sessions, but they saw an equal number of subject and object relatives. Upon testing, the authors found that participants exposed to relative clauses had significantly faster reading times compared with those who were not exposed, suggesting less difficult processing for the exposure group. Importantly, because the two groups were matched on working memory, the results suggest that the individuals' linguistic experience with the particular structure affected processing beyond effects of working memory. Further evidence on the key role of input and experience in monolingual processing comes from studies that incorporate sociolinguistic variation. In a self-paced reading experiment, Squires (2014), for instance, examined participants' processing of different agreement conditions in English: the standard (singular + doesn't) and (plural + don't), the non-standard (singular + don't), attested in African American English Vernacular (Weldon 1994), and an unattested structure (plural + doesn't). Participants varied across various social traits, in particular sex, socioeconomic status, and race. The results showed that while all participants experienced increased processing difficulty when reading the unattested (plural + doesn't) structure, only White participants were disrupted by the non-standard (singular + don't) structure; African American participants, presumably with greater experience to this structure, showed little to no processing costs compared to their processing of the standard structure. The results of this study highlight the key role of linguistic experience in shaping individuals' language processing abilities.

Monolingual speakers' sensitivity to experience is also reported to emerge rapidly. Kim and Gilley (2013) used both ERPs and magnetoencephalography (MEG) to examine how exposure to different patterns of syntactic anomalies affects predictive processing in native speakers. One group was exposed to a consistent anomaly: a doubled preposition where the second preposition was always 'for' (e.g. The thief was caught by for police). A second group saw the same type of anomaly, but the doubled preposition varied between at, of, on, for, from, over, or with. In response to the syntactic anomaly, both groups showed an N170 component, as well as the classic P600 effect. The group which was exposed to the consistent 'for' anomaly, however, also showed an enhanced P1 component; the variable group did not. Because it has been suggested that the P1 is implicated in both attention (Hillyard et al. 1998) and arousal (Vogel and Luck 2000), the authors argued that it reflects participants' sensitivity to the anomaly during the course of the experimental session; that is, its continuing appearance heightened participants' expectation for the same upcoming anomaly.

All three of the studies described above and many others (Fine and Jaeger 2016; Fraundorf and Jaeger 2016; Kleinschmidt and Jaeger 2015) demonstrate the key role of linguistic experience in shaping native language processing. This modulation may be short-term and adaptive in nature (Kim and Gilley 2013) or it may be the result of long-term, community-based norms (Squires 2014). Short-term adaptation may be driven by changes in an individual's expectations or predictions about upcoming input, in turn affecting how participants react to deviations from norms in the moment. Hopp (2016), for example, found that German native speakers stopped using grammatical gender information predictively when gender assignment and agreement errors were present in filler materials (we discuss this in greater detail in Section 3). Long-term exposure-based changes, however, reflect at least some shift in the underlying representations, such that the new or unfamiliar structure becomes entrenched in the individual's linguistic system. This process is similar to 'syntactic satiation' (Snyder 2000; Do and Kaiser 2017), in which the frequent exposure to ungrammatical structures leads to individuals accepting these structures more and processing them more easily. One view, proposed by Pajak et al. (2016) regards the linguistic system 'as a set of language models (or mini-grammars) that encode the hierarchical structure of the listener's linguistic environment and that are continuously being adapted to incoming input' (p. 913). The highest mini-grammar in this system takes precedence, such that small fluctuations in the subsumed mini-grammars (capturing dialectal or environmental variation) need not influence the speaker's own speech. Under a usage-based approach, however, such mini-grammars need not be posited, as this approach connects the linguistic structure to external, social factors, and this system is susceptible to executive processes (attention, suppression, interference resolution, etc.; see Tamminga 2016; see also Hay and Foulkes 2016 for a review and empirical evidence for this approach).

Variability in L1 language processing should thus be considered the norm, rather than the exception. Indeed, the study of individual differences has formed a key component in psycholinguistic work on monolingual sentence processing (King and Just 1991; Tanner and Van Hell 2014). Nonetheless, psycholinguistic work examining the processing of bilingual speech has often upheld the monolingual monolithic comparison, treating bilingualism – in whatever form it takes – as some deviation from this norm (e.g. Montrul 2006). Despite its ubiquity in monolingual sentence processing studies, however, variability in individuals who speak two or more languages has only recently begun to be explored. Rather, most of the literature focusing on L2 processing has sought to compare L1 and L2 processing dichotomously, determining what is similar and what is different. We argue here that an approach that connects L2 language processing with language experience and basic cognitive principles is more compatible with our current knowledge of the architectural underpinnings of the systems responsible for language acquisition and language processing, and a more fruitful approach in future studies of L2 sentence processing.

3. The Role of Variable Input in Bilingual Language Processing

Models of late L2 learning have largely assumed stability of the L1. Yet, recent research on bilingual language processing shows that the L1 changes dynamically in different contexts, for even highly proficient bilinguals. One of the key discoveries is that bilinguals experience coactivation between their two languages in production and comprehension, in both visual and spoken language modalities, and even when the situational context strongly points towards staying in one language alone. This foundational principle is known as non-selectivity (e.g. Dijkstra 2005; Kroll et al. 2006, 2012) and has led to an overwhelming focus on how bilinguals are able to comprehend and produce in one language alone. Because of the overwhelming evidence in favour of non-selectivity, researchers have hypothesized that bilinguals recruit domain-general cognitive mechanisms such as inhibition, increased attentional control, and/or conflict monitoring in order to successfully process in one language (e.g. Green 1998; Hilchey and Klein 2011; Meuter and Allport 1999). The parallel activation of the bilingual's two languages has several consequences, including cross-language activation at all levels of language processing. The availability of both languages affects not only the activation of the two languages, and the resulting mechanisms of cognitive control (Kroll and Bialystok 2013) but also the way in which each of the two languages is processed, suggesting a language system that is highly adaptive. Being bilingual is not only about acquiring and using the L2 but also about the ways that the native or dominant L1 changes in response to the L2. These changes have been observed at every level of language use, from the lexicon to the syntax and phonology, and often are quite subtle. They are unlike the native language transfer phenomena discussed in the context of L2 'interlanguage competence' that began in the 1950s (e.g. Lado 1957) and continues to date (for example, the 2013 workshop in Geneva organized by Julia Herschensohn and Martha Young-Scholten), which often result in obvious deviations of the L2 target that are easily discernible in learners' linguistic productions (see, for example, Choi and Lardiere 2006; Hopp 2010; White 2003), and that have given adult L2 learning its notoriety.

Word recognition studies were the first to have revealed robust effects of the L1 on the L2 (e.g. Dijkstra 2005; Schwartz et al. 2007) and also effects of the L2 on the L1 for proficient bilinguals (e.g. Van Assche et al. 2009; Van Hell and Dijkstra 2002). We now know that effects of L2 on L1 are not restricted to the lexicon. At the morphosyntactic level, Hopp (2016), for example, examined the predictive use of grammatical gender in an intermediate group of English learners of German. Results of an eye-tracking experiment indicated that L2 learners who behaved non-L1-like with respect to L2 gender assignment in an offline task not only made erroneous predictions based on gender in an online comprehension task, but also abandoned gender as a predictive cue altogether. While it may seem that this merely points to the key role of proficiency and its relation to predictive processing in the L2, a second experiment suggested that the story is more nuanced. German L1 speakers completed a similar comprehension task as the L2 learners, but with one additional modulation: half of the speakers received target-like input, where gender features always agreed. The other half, however, was exposed to non-target-like input (through the filler items), where gender features were non-agreeing. Hopp found that the L1 speakers in this treatment group also abandoned gender as a predictive cue, just like the L2 learners in the previous experiment. In this case, it was the L1 speakers who came to exhibit L2-like behaviours.

Equally fast changes to the L1 processing system have been reported when proficient bilinguals are exposed to auditory sentences spoken with L2 accented speech. In one

ERP study, Romero-Rivas et al. (2016) presented Spanish-Catalan bilingual speakers with sentences that ended in three types of words. Highly semantically constrained words, (e.g. underlined in *Lo tenía en la punta de la lengua, pero no conseguía recordar aquella palabra* [He had it on the tip of his tongue, but was unable to remember that word]), words that were semantically related to the target, and semantically unrelated words. Participants heard the sentences in two conditions: in one condition, the sentences were spoken by an L1 speaker of Spanish; in the other, the sentences were spoken by French and Italian speakers with an L2 accent in Spanish. Sentences with the L1 accent produced the expected attenuation of the N400 amplitude for highly semantically constrained words compared to semantically related words; there was also an attenuated N400 amplitude for semantically related words compared with semantically unrelated words. For *word* in the example above, the semantically related condition given the sentence context was *expression* and the unrelated condition was *date*, because it bears no semantic relationship to the most expected item, though it is still a plausible continuation given the sentence context. However, listening to L2 accented speech eliminated the difference previously observed in integrating semantically related and unrelated words.

Changes to the L1 have been found under conditions of immersion in the L2. Recent work on L2 syntactic processing using ERPs has shown that amount of exposure to L2 naturalistic input has been linked to brain signatures that reflect high levels of automaticity in L2 parsing processes, and to neural correlates implicated in the early detection of syntactic mismatch in grammatical features (e.g. Caffarra et al. 2015; Friederici 2002; Mueller 2005). Exposure to the variability present in the input as well as the diverse interactional contexts are presumed to confer high levels of automaticity during syntactic processing in the L2 (Caffarra et al. 2015). If prolonged naturalistic exposure can have profound effects on how a second language is processed by reversing processing strategies that result from transfer of L1 information (Frenck-Mestre 2002) and by causing shifts in L2 processing routines from lexically driven to structurally driven (Pliatsikas and Marinis 2013), an important aspect of the comparison between L2 and L1 speaker performance is to consider how immersion experience might affect L1 processing. One might expect, for example, that experience in a second-language environment should also produce changes in syntactic processing in the native language. Dussias and Sagarra (2007; Fernández, 2003) investigated this hypothesis by examining the effect of intense contact with English on the resolution of syntactically ambiguous relative clauses in Spanish. Native Spanish and native English speakers differ in how they interpret temporarily ambiguous relative clauses like *Alguien disparó al hijo de la actriz que estaba en el balcón* [Someone shot the son of the actress who was on the balcony]. When asked *Quién estaba en el balcón?* [Who was on the balcony?], monolingual Spanish speakers typically respond 'the son' (i.e. high attachment preference), whereas monolingual English speakers respond "the actress' (i.e. low attachment preference) (Carreiras and Clifton 1999). Using eye-tracking methodology while reading, Dussias and Sagarra (2007) found that Spanish-English bilinguals immersed in a Spanish-speaking environment processed the ambiguity using a high attachment strategy. This was an expected finding. The interesting result was that bilinguals living in an English-speaking (i.e. L2) environment strongly favoured the low attachment strategy when reading in Spanish, their first language. That is, for these speakers, exposure to a preponderance of English constructions resolved in favour of low attachment rendered this interpretation more available, resulting in a low attachment preference when reading in their first language. These results highlight how the seemingly stable L1 system is open to influence from the L2 once individuals become proficient in the L2 (e.g. Gollan et al. 2008).

The influence of the L2 on the L1 has also been reported in conditions of L1 immersion. Oliveira et al. (2017) examined whether adult Brazilian Portuguese-English bilinguals differed from monolingual Brazilian Portuguese speakers in their processing of depictive constructions (e.g. *Ele comeu o salmão cru* [He eats the salmon raw], which are shared between the two languages, and of resultative constructions (e.g. He wiped the table clean/**Ele esfregou a mesa limpia*), which are grammatical only in English. Although the surface syntactic word order of resultatives also exists in Brazilian Portuguese, its only licit interpretation is that of a depictive meaning (e.g. He wiped the clean table). The authors found that the two groups of speakers provided similar ratings in an acceptability judgement task; however, the bilingual group showed shorter reaction times in an online sentence processing task for the resultative construction relative to monolinguals, a finding that the authors interpreted as resulting from the influence of the L2 on the L1.

Changes to the L1 have also been observed within a short timescale in the laboratory. These dynamic changes are sensitive to recency of re-exposure to input, and may be partly reversed by it. Above we discussed work by Dussias and colleagues (Dussias and Sagarra 2007) that examined the resolution of structural conflicts when bilinguals read sentences containing syntactically ambiguous relative clauses. A study in progress extends this finding to examine whether changes in the L1 can be triggered in a laboratory setting by exposing bilinguals to particular syntactic structures. In other words, can extensive exposure to particular structures trigger changes 'back' to L1-like parsing preferences as well as movement 'forward' to L2-like parsing preferences, even for bilinguals who have not previously demonstrated L2-like processing preferences? Past findings from the child sentence-processing literature suggest that exposure experience can affect children's sentence-processing routines (e.g. Cuetos et al. 1996). Similar findings have been reported with adult monolingual speakers, demonstrating powerful implicit learning properties that characterize the human language system. As stated earlier, the notorious difficulties that L1 English speakers experience when processing object-extracted relative clauses such as 'The reporter that the senator attacked admitted the error' relative to subject-extracted relative clauses such as 'The reporter that attacked the senator admitted the error' (e.g. Traxler et al. 2002) disappear with increased exposure to object-relatives (Wells et al. 2009). If the parser's configuration is related to language exposure (e.g. Gennari and MacDonald 2009; MacDonald and Seidenberg 2006) and language contact, then bilinguals' processing routines are expected to change as a function of the frequency with which the relevant structure appears in an experimental session. Ongoing experiments on intervention in language exposure provide support for the dynamic nature of parsing. In one study (Carlson et al. in prep), L1 Spanish-L2 English bilinguals identified as being either high attachers or low attachers (via an eye-tracking study) participated in a five-day intervention, during which they read short paragraphs containing relative clauses in which a syntactically ambiguous relative clause was resolved in favour of the opposite attachment site from the one that the bilinguals had previously demonstrated. That is, participants who favoured high attachment received a low attachment treatment, and those who favoured low attachment received a high attachment treatment. In addition, half the participants received the intervention in Spanish and the other half in English. Participants returned to the lab after the intervention to participate in two subsequent eye-tracking studies, one that assessed the immediate effect of the intervention and one that assessed the effect of the intervention a week after it was completed. Ongoing analyses show that those participants who originally preferred high attachment switched to a low attachment preference and participants who originally showed a low attachment strategy switched to a high attachment preference. Like the results on bilingual word recognition alluded to earlier in this section (Dijkstra 2005; Schwartz et al. 2007), these findings suggest that not only does the L1 affect the L2 but that the L2 can come to influence the L1 (for a similar 'reversal effect' in anaphoric processing, see Chamorro et al. 2016). The literature reviewed above suggests that changes in the L1 as a result of L2 experience are driven by both short- and long-term modulations to statistical properties of the input. The finding that experience in one language can affect the other through shared or related structures or strategies suggests that the L1 or native language holds no de facto special status, but merely enjoys greater entrenchment than the L2 – a characteristic readily modulated by both internal (cognitive control, e.g. Segalowitz and Hulstijn 2005) and external (exposure and environment, e.g. Schmid and Köpke 2007) factors.

4. Variability in Bilingual Language Use and its Implications for Language Processing

In our view, the heterogeneity in linguistic exposure that is experienced by bilingual speakers has important implications for language processing. Elsewhere we have discussed that when bilinguals read, listen to speech, or plan utterances in one language, information is also activated in the other language (see Kroll et al. 2012, for a review). One consequence of the parallel activation of the bilinguals' two languages is the ability of highly proficient bilinguals to code switch. Code switching is a structured and creative linguistic behaviour broadly defined as the fluid alternation between languages in discourse (Poplack 1980). The ubiquity with which certain bilingual communities engage in code-switching challenges the strong unilingual perspective prevalent in psycholinguistics research. Instead, it points towards the necessity to maintain heightened coactivation between multiple languages and an ability to flexibly move between the two languages, which requires the seamless and successful integration of two grammars at multiple linguistic levels, i.e. phonology, morphology, syntax, and discourse. Consequently, how bilinguals systematically engage and disengage their languages in real time becomes a new and important avenue of inquiry for understanding bilingual sentence processing and language control (Green and Abutalebi 2013; Kroll et al. 2015).

In the nascent literature on neurolinguistic and psycholinguistic approaches to code switching, two main threads of inquiry have emerged: whether integrating code-switched speech is costlier than unilingual sentence processing, and how bilinguals adapt their parsing strategies to better anticipate upcoming code switches. The first approach pairs code-switched stimuli with unilingual stimuli and tests whether integrating code-switched text or speech is costly relative to non-switched or unilingual speech/text. The underlying logic behind this approach is that it is unusual for humans to engage in behaviour that is more costly or less efficient; therefore, because many bilinguals engage in code-switched speech, processing costs should be minimal, at least under certain linguistic contexts and amongst certain bilingual speakers. Nevertheless, analogous to the switch costs observed in the cued language-switching literature (e.g. Meuter and Allport 1999), code-switched stimuli are often read more slowly (Altarriba et al. 1996), recruit greater neural activity in prefrontal and anterior cingulate brain areas – all areas related to cognitive control (Abutalebi and Green 2008; Abutalebi et al. 2007), and often elicit differential patterns of electrical activity (Kutas et al. 2009) relative to unilingual stimuli. Overall, this literature poses an interesting paradox as to why bilinguals customarily engage in code switching given that it incurs additional processing costs relative to unilingual language. A noteworthy point is that switch costs can be modulated by a number of factors, and this is part of an ongoing discussion as to why behavioural data and ERP measures of switch costs are not always consistent across studies.

Amongst language-related ERP components, the N400 and the late positive complex (LPC) have been associated with processing code switches (see Van Hell et al. 2015, for a review). The LPC has been observed both in meaningful code-switched sentences (Moreno et al. 2002) and in code-switched discourse contexts (Ng et al. 2014). This ERP component is typically sensitive to the processing of an improbable event (Kutas and Hillyard 1980) and is commonly associated to sentence-level integration and reanalysis. The N400 component on the other hand, has been found to be a sensitive measure of the critical word's expectancy (Kutas and Federmeier 2011). Code-switching studies that have observed this component have interpreted it as a processing cost related to lexico-semantic integration (Proverbio et al. 2004).

Emerging experimental evidence indicates that switch costs are modulated by the direction of the code switch (i.e. from the dominant to the weaker language or vice versa) both in behavioural and ERP data. For example, a recent study by Litcofsky and van Hell (2017) tested the influence of language dominance on the processing of intra-sentential code switching, using behavioural (self-paced reading) and ERP techniques. In the behavioural study, reading times were significantly slower for code-switched sentences relative to unilingual sentences. In the ERP study, an LPC was observed at the site where the code switch took place but only when switching from the dominant into the weaker language. Consistent with the latter observation, Bultena et al. (2015) found that switching to the weaker language was more costly than switching to the dominant language using a shadowing task. However, they also found that switch costs decreased with increasing L2 proficiency, suggesting that switch costs may be driven by experience with the L2. Other behavioural studies have found that switch costs appear to be reduced depending on the grammatical structure (Tarlowski et al. 2013) or may be absent altogether in inter-sentential switches (Gullifer et al. 201[illegible]).

Only recently have studies begun to uncover switch costs [illegible]dulations, but their relative contributions and the degree to which they interact remain unclear. Critically, the extant literature lacks reference to the various contexts of language experience to which bilinguals are exposed and the recurrent forms of conversational exchanges in which they engage when communicating in a natural setting. An emerging trend in psycholinguistic research seeks to build a more nuanced view of variation in language processing. For bilinguals, the shift in emphasis towards the everyday conversational use of language is captured by the adaptive control hypothesis (Green and Abutalebi 2013), which postulates that different interactional contexts impose different communicative demands on speakers' language control processes. Indeed, there is growing evidence that individuals learn and attend to distributional variation in the input. However, while such adaptation is a fundamental process of individuals of all language backgrounds, many questions remain concerning the role of experience in guiding online sentence processing. Moreover, understanding the interactional demands of different contexts calls for a systematic assessment of the relationship amongst language processing, language use, and the contexts in which these take place. In this respect, the study of code switching provides a unique lens to examine such interactions underlying processing adaptation and variation. Because code switching emerges in some bilingual communities but not in others, it provides a venue to examine the consequences of exposure and adaptation to variation in code-switched speech and text.

Adamou and Shen (2017) carried out a study examining the processing of code-switched sentences as a function of the frequency of use of specific code-switching patterns. Using a bimodal picture-sentence matching task, they tested whether switching costs were modulated by exposure to specific code-switching patterns from a well-established code-switching community. Stimuli included ecologically valid and ecologically non-valid code switches that were created based on an analysis of code-switching preferences in natural conversations from the community under study. Although participants responded the fastest to unilingual sentences overall, a more fine-grained analysis, based on the statistical frequencies of the switches in natural speech, revealed that switched trials that were based on frequently occurring examples in the corpus were just as fast as unilingual trials. Thus, these findings illustrate the importance of taking the switching preferences of the community into consideration and support an experience-based approach to the study of code switching.

This study also highlights the link to a second approach emerging in the neurolinguistic and psycholinguistic study of code switching, namely, how bilinguals adapt to rapidly integrating code-switched speech. This approach is novel in that it starts from the premise that code switching is ubiquitous and regardless of whether it results in switch costs, bilinguals engage in it. Therefore, bilingual code switchers must adapt their parsing strategies in order to accommodate to this linguistic behaviour. Crucially, this approach builds upon two observations that are well-known from the sociolinguistic study of code switching: not all bilinguals frequently code switch (e.g. Poplack 1988) and different patterns of code-switching structure emerge in different bilingual communities (e.g. insertional, alternational, congruent lexicalization; see Muysken 2000, for detailed explanation).

These two observations have important psycholinguistic implications for language processing: bilinguals who code switch are more sensitive to code-switching structures that are consistent with attested distributional patterns and should therefore demonstrate facilitated processing as compared to unattested code switches. Conversely, bilinguals who do not frequently code switch should not show differential processing to attested vs. unattested code switches, as these code switches are virtually all unattested to bilingual non-code switchers. Indeed, recent research has shown that distributional regularities involving attested code-switching patterns act as cues heightening the probability of upcoming switches (Fricke et al. 2016; Guzzardo Tamargo et al. 2016; Valdés Kroff et al. 2017). Moreover, these observations also predict variability amongst speakers who engage and do not engage in code switching (e.g. Beatty-Martínez and Dussias 2017; Valdés Kroff et al. 2018). To illustrate this approach, Beatty-Martínez and Dussias (2017) conducted a study using two groups of bilinguals who differed in code-switching experience. The goal of the study was to examine the consequences of adaptation to language processing across different communities of speakers. The first experiment analysed ERPs to compare the processing of code switches that were either rarely attested or commonly attested in bilingual corpora from a habitual code-switching community. For code switchers, rarely attested code switches evoked an N400 effect in comparison to common code switches, suggesting greater difficulty with lexical integration. Non-code switchers, on the other hand, processed these two types of code switches similarly. Furthermore, non-code switchers showed greater frontal EEG activity to switching, regardless of switch type, most likely reflecting detection of a language change during early monitoring stages of language processing. The participants additionally completed a map task that elicited naturaly produced speech to assess their code-switching tendencies and behaviours. Code switchers switched more often than non-code switchers, and their code-switching preferences robustly reflected the conditions that were more easily processed in the ERP experiment. Together, the findings underscore how the processing of code-switched language largely depends on bilinguals' language experience, namely on the type of code-switching strategies available in their discourse environment.

5. Conclusion

Language experience is complex and variable, and it is in this view that understanding the sources of variation in language processing can reveal fundamental dynamics of the language system (Boland et al. 2016). In this chapter, we have reviewed the empirical evidence on how comprehenders adapt to and change their processing strategies by tuning into the input they receive, a mechanism that applies to both L1 and L2 processing. The emerging evidence suggests that learning and using two languages changes the language system: the two languages begin to converge, becoming more similar and less monolingual-like (e.g. Ameel et al. 2005). To understand the factors that underlie processing variability, researchers have called for an ecological approach that considers the natural speech of the interactional context in which speakers typically use their language(s) (e.g. Abutalebi and Green 2016; Baum and Titone 2014; MacDonald 2013; Valdés Kroff et al. 2018). In this light, instead of asking if L2 learners process sentences similarly to L1 speakers, we may examine the ways in which L2 learners are sensitive to variability as is the case for L1 speakers.

The fact that L1 speakers and L2 learners may both converge and diverge in terms of language processing is not at all surprising when we take into consideration the inherent variability of language processing itself, and the influential role of linguistic experience. Kaan (2014) argues that the mechanisms that underlie L1 and L2 sentence processing are fundamentally the same. What differs – or rather, what yields differences – are 'several interdependent sets of factors, all of which are subject to individual differences' (p. 261). This includes input-driven factors such as frequency and context (i.e. immersion vs. classroom learning), language-specific factors like competition, and variation in cognitive abilities and resources. The linkage between language experience and processing has several implications for the way psycholinguists design experiments and draw conclusions with respect to issues of language and domain general cognition. We propose here a shift in the way bilingual language processing research moves forward that considers variability in language experience not as a source of noise but rather as a source of evidence.

NOTE

1 We note that the interpretation of the functional significance for the eLAN is unclear; in fact, Steinhauer and Drury (2012) have questioned the reliability and validity of eLAN effects by noting the presence of artefacts.

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