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This is a contribution from *Linguistic Approaches to Bilingualism* 5:4 (2015)  
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# Syntactic processing and acquisition

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Phillips and Ehrenhofer (2015; henceforth P&E) provide a welcome new statement on the relationship between sentence processing and syntax acquisition in first (L1) and second (L2) language learners. We agree with a number of statements found in P&E, especially the assertion that processing considerations can and should play a central role in theorizing about language acquisition generally, and syntax acquisition specifically. We also agree that comprehensive accounts of language acquisition need to consider and explain similarities and differences between first and second language acquisition. We further welcome their pushback against the now popular claim that rough-and-ready ('good-enough') parsing of language is what is commonly done to achieve interpretation; contra this view, there is ample evidence that retrieval and use of detailed grammatical information is not only the norm in the comprehension of text and speech, but is necessary for its everyday, commonplace success. Finally, we agree with their general assessment of the three ways in which the study of language processing can be used, and has been used, to understand language acquisition, roughly: (1) documenting how learners process utterances in real-time, with a critical focus on how processing patterns are influenced by experience with the target language and cognitive maturation; (2) re-explaining some acquisition (competence) phenomena as processing (performance) phenomena, and (3) understanding how processing shapes learning and vice versa. We believe that in the coming years, our understanding of the interplay between processing and acquisition is only likely to grow and become a central means for theoretical advancements in the study of language by providing an effective way of explaining L1 and L2 acquisition at the computational and, perhaps, even the neural level.

We do, however, take issue with some aspects of the P&E (2015) piece, which we expand upon here. Firstly, we differ from P&E in some aspects of their

understanding of L2 language processing and acquisition, and especially their assumption that syntactic reanalysis might not pose particular problems for adult L2 learners. Their emphasis was on the differences between how L2 adults and L1 children process language. But in our view, it is the similarities between L1 and L2 processing and acquisition, rather than the differences, that are currently notable and worthy of further comment. Work from our own research group has documented striking similarities between how child and adult learners produce and/or process complex syntactic structures involving *wh*-movement (Pozzan, 2011), gender agreement (Pozzan, Antón Méndez, & Trueswell, 2014; Pozzan & Anton Mendez, submitted) and revision of initial interpretative commitments (Pozzan & Trueswell, 2013). This latter work compared syntactic reanalysis across adult native speakers, child learners and adult second language learners. It examined the eye movements of listeners as they carried out spoken instructions to interact with a referent world. When comparing garden-path sentences to unambiguous control sentences, we found that difficulties revising initial parsing commitments were strikingly similar between adult (L2) and child (L1) learners; specifically, error rates were around 50% for both groups when the target interpretation of a temporarily ambiguous sentence was not supported by referential cues. Our interpretation of these findings is that revision of initial interpretations rests upon a number of shared domain-general cognitive skills that are not fully developed in young children (Zelazo & Frye, 1998) and that might be particularly taxed during the processing of a non-dominant, non-native language in L2 speakers (e.g., Abutalebi, 2008). In line with this hypothesis, we have shown that performance on temporarily ambiguous sentences correlates with measures of executive control in both L1 and L2 child learners (Woodard, Pozzan, & Trueswell, in press; Pozzan, Woodard, & Trueswell, 2014) and can be enhanced by executive function training (Pozzan et al., 2014); for adult native speakers, see Novick et al., 2014.

Secondly, although our theoretical perspective shares much with P&E's insights and general approach, it differs from theirs in ways that will likely lead to further research, debate, and discussion. Our own perspective on the relationship between sentence processing and grammar acquisition is motivated by the theory of syntactic bootstrapping (Gleitman, 1990). Under this view, grammar acquisition is intimately connected to both vocabulary acquisition and sentence processing (see, e.g., Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Pozzan & Trueswell, 2015; Trueswell & Gleitman, 2007). Specifically, at the beginning of the language learning process, a small set of common nouns, acquired (at least in part) from world observation, allows learners to discover some basic facts about the morpho-syntax of their target language (e.g., canonical word ordering); learners' ability to use these newly discovered structural and distributional cues in

turn enables further vocabulary acquisition, as they map the syntactic structure of sentences onto their perceived structure of the referent world (e.g., the structure of events) and thus learn the meaning of abstract morphemes (e.g., verbs, abstract nouns, etc.). Since language-specific knowledge is only partially in place early on in the acquisition process, we and others have suggested that learners' initial structure-to-meaning mappings are guided by a set of unlearned biases, which are gradually accompanied/supplanted by language-specific grammatical knowledge that guides parsing and interpretation more accurately (for L1, see Fisher, 1996; Gertner & Fisher, 2012; Lidz, Gleitman, & Gleitman, 2003; Gleitman et al. 2005; for L2, see Van Patten, 1996).

But crucially, since sentence structure — the input to the syntactic bootstrapping procedure — is the output of the analysis of the human sentence parser, we have recently proposed that both vocabulary and syntax acquisition are shaped by real-time sentence processing considerations. To test this hypothesis, we have begun to explore how sentence-processing limitations, specifically learners' difficulty recovering from syntactic misanalysis, might constrain the acquisition of morpho-syntax in both children and adults (the Level 3 connection described by P&E, see p.411 and Section 5). Our hypothesis was that a learner's transition from universal to language-specific heuristics of interpretation would be shaped not only by the validity and reliability of language-specific cues to structure and meaning (Bates & MacWhinney, 1982; 1989; Slobin & Bever, 1982), but also by the inherent challenges associated with the real-time, incremental nature of sentence processing itself (i.e., garden-path recovery, in L1 and L2, as discussed above). Under this view, a language-specific cue to sentence structure (such as a verbal morpheme or a case marker) should be more difficult to learn if this cue tends to occur late in the sentences of a language, as compared to a cue that tends to appear early. A late-arriving cue to structure would more likely need to be used to revise initial parsing commitments; thus even when a learner has discovered the correct hypothesis about the meaning of a morpheme, it would be difficult for the learner to use that information in the moment, during sentence processing, to accurately structure the input and reinforce a meaning hypothesis.

Two related studies, one from natural child language acquisition (Trueswell, Kaufman, Hafri, & Lidz, 2012) and one from artificial language learning with adult learners (Pozzan & Trueswell, 2015) support this hypothesis. The first study examined the acquisition of verbal morphology in children learning a language (Kannada or Tagalog) in which, due to pervasive argument omission, the number of NPs in a sentence — a cross-linguistically valid cue to argument structure — is not a good predictor of argument structure, while language-specific verbal morphology provides highly reliable cues to argument structure. Children learning Tagalog, a verb-initial (early-cue) language, showed greater sensitivity to causative

morphology compared to children learning Kannada, a verb-final, morphology-final (late-cue) language. This difference in sensitivity to language-specific morphology suggests that in verb-initial languages (such as Tagalog) verbal morphology can be used to guide parsing, while in verb-final languages (such as Kannada), morphology can only be used to confirm or revise initial interpretative commitments. These results were replicated and extended in a laboratory study with adults learning a set of miniature, highly controlled, languages (Pozzan & Trueswell, 2015): our results show that the acquisition of language-specific morphological cues to argument structure was slower and less accurate for learners of languages in which morphological cues consistently appeared at the end (late-cue languages), rather than at the beginning (early-cue languages), of sentences. Crucially, these results held not only for online and offline measures of comprehension but also for production, indicating that parsing limitations affect grammatical acquisition generally, not just real-time parsing commitments.

Based on these findings, we suggest that processing preferences and limitations, which stem from the architecture of the human cognitive system, interact with the properties of the language being learned and similarly affect vocabulary and grammar acquisition in child and adult learners. Through acquisition, processing preferences and limitations might also affect language change and help shape resulting typological tendencies (see also Hawkins, 2012). For this reason, and in line with P&E, we hope that the research agenda in the cognitive science of language will see a growing interest in the systematic comparison of the processing similarities and differences among individuals, both at group level (e.g., comparing L1 acquisition by children with L2 acquisition by children and adults) and at the individual level (e.g., identifying the traits of ‘good’ learners). This research should seek to understand how these similarities and differences relate to general cognitive traits, language acquisition trajectories, and ultimate attainment profiles. We believe that given where we are as a field, it will be only with a unified model of both language learning and language processing that significant progress will continue within these two “separate” topics of study.

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DOI: 10.1111/1467-8721.ep10774761

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