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# What can artificial languages reveal about morphosyntactic processing in bilinguals?

Sarah Grey

Department of Modern Languages and Literatures, Fordham University

**Review Article**

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**Address for correspondence:**
Sarah Grey,
E-mail: sgrey4@fordham.edu

**Abstract**

This article reviews work that has employed artificial languages to investigate the learning and processing of additional language grammar in bilinguals, with a focus on morphosyntactic processing in sentence contexts. The article first discusses research that has utilized artificial languages to elucidate two central issues in research on bilingual third language learning and processing: the role of prior language-learning experience and cross-linguistic transfer from the native and second languages to the third. Then, research that has compared bilingual third language to monolingual second language grammar processing is discussed, with specific consideration of hypothesized bilingual advantages at language learning. Finally, future directions in artificial language learning research on bilingual morphosyntactic processing are considered.

Within the last 25 years, artificial languages have been increasingly used to study language grammar learning and processing, predominantly in child first language and adult second language research (for reviews, see Folia, Uddén, De Vries, Forkstam & Petersson, 2010; Morgan-Short, 2014). Such work has generally focused on the learning of new morphosyntactic structures and/or syntactic constraints in functionally monolingual participants (e.g., Amato & MacDonald, 2010; Ferman & Karni, 2010; Morgan-Short, Sanz, Steinhauer & Ullman, 2010; Rebuschat & Williams, 2012). In much of the adult work, artificial languages are employed as an approximation of natural adult second language (L2) learning. Indeed, the neural correlates of artificial language processing are similar to those of natural languages (e.g., Friederici, Steinhauer & Pfeifer, 2002; Morgan-Short et al., 2010) and artificial language learning correlates positively with natural L2 learning (Ettlinger, Morgan-Short, Faretta-Stutenberg & Wong, 2016). Thus, artificial languages are a reliable tool for investigating questions about grammar learning and processing.

In this paper, the term 'artificial language' is used to refer to three related artificial linguistic systems: artificial languages, semi-artificial languages, and mini-languages. All three reflect small-scale linguistic systems that are composed of a few grammar structures which are consistent with natural language structures. Additionally, they integrate lexical-semantics and grammar and can be fully spoken and understood (unlike artificial grammars; for further discussion, see Grey, Sanz, Morgan-Short & Ullman, 2018; Grey & Tagarelli, 2018). The systems differ mainly with respect to their lexical inventories[1]. Semi-artificial languages contain native language (L1) lexical items combined with the grammar of a different language (e.g., English L1 words combined with German syntax; Rebuschat & Williams, 2012) whereas the lexical inventories of artificial languages and mini-languages are composed of novel words (see e.g., mini-French, Batterink & Neville, 2013; the Brocanto2 artificial language, Morgan-Short et al., 2010).

These artificial language paradigms offer methodological advantages that enable researchers to investigate questions about grammar learning and processing that would be highly difficult or impossible to reliably test in natural language settings. Such advantages include high experimental control over the types of language structures being tested, (dis)similarity to participants' known language(s), and control over the amount and type of language exposure. Additionally, artificial languages show fast-learning, i.e., they can be learned to high proficiency in hours to days, whereas high proficiency in natural languages requires many years of study/exposure.

With these experimental advantages, artificial language paradigms are highly useful for bilingualism research. Given that the majority of the world speaks more than one language

[1]The three systems may vary in other respects. All three can be comprehended and produced and integrate lexical-semantics with grammar so, in those aspects, meaningfulness is equivalent among them. However, whether participants would view them as meaningfully similar in other ways is unknown. Additionally, because artificial language studies have investigated distinct research questions, used different tasks, and tested different learners, it is not clear whether results for learning are overall similar among the three sub-types. It would be interesting for research to compare the three sub-types to evaluate these and other points of comparison, and I thank an anonymous reviewer for highlighting them.

(Marian & Shook, 2012), bilingual populations comprise the bulk of additional language learners worldwide. In this global multilingual reality, a sophisticated understanding of how new languages are learned and processed in bilingual populations is necessary. Artificial language paradigms help to further such understanding.

The present article provides a review of work that has employed artificial languages to investigate the learning and processing of additional language grammar in bilingual learner participants, with a focus on morphosyntactic processing in sentence contexts[2]. The article first discusses research that has employed artificial languages to investigate issues related to bilingual third language[3] (L3) learning and processing. Then, I discuss related work that has compared bilingual L3 to monolingual L2 learning/processing. Finally, future directions are considered.

## Third language learning and processing

In both bilingualism and second language acquisition research, prior language-learning experience has been found to significantly benefit subsequent language learning (e.g., Cenoz, 2013; Cenoz & Valencia, 1994). Theoretical explanations for this benefit of language-learning experience include increased metalinguistic awareness and the availability of a broader linguistic repertoire (e.g., Cenoz, 2013; Dillon, 2009) as well as discussions of the role of cross-linguistic L3 transfer (e.g., Alonso & Rothman, 2017). Artificial languages are useful for closely examining these topics and, indeed, some researchers have taken an artificial language approach in L3 research. Table 1 provides summary information on the studies discussed in this review.

### *Prior language-learning experience*

Stafford, Sanz, and Bowden (2010) investigated whether Spanish L1 bilinguals' age of arrival to the U.S. (early arrival $M_{age} = 8.3$ years vs. late arrival $M_{age} = 25.1$ years) affects potential bilingual benefits for L3 learning/processing. Spanish L1–English L2 participants were tested within The Latin Project, which was designed to examine interactions among bilingualism and instructional factors (e.g., explicitness of feedback and instruction) in L2 and L3 learning (Lado, Bowden, Stafford & Sanz, 2017; Stafford, Bowden & Sanz, 2012). In this framework, a miniature version of Latin is used to help control for prior knowledge; the lexicon contains 35 animate nouns and 11 verbs and the target of grammar learning is agent/patient thematic role assignment. In Latin, the most reliable grammatical cue for determining agent/patient roles is case-marking, followed by subject-verb agreement, then syntactic word order.

In the study, L3 training consisted of metalinguistic grammar explanations and practice with metalinguistic feedback. The results showed that both early-arrival and late-arrival bilinguals moved from non-optimal reliance on word order during sentence processing to more reliable L3 cues of subject-verb agreement and case-marking, and the bilinguals with a later age of arrival maintained case-marking strategies up to three weeks post-training. Thus, the bilingual benefits of prior language experience on L3 learning/processing do not seem to be restricted to early bilingualism.

Grey, Williams, and Rebuschat (2014) also investigated the role of prior language experience. In the study, they compared advanced and beginning English L1–Spanish L2 participants on their L3 learning of the artificial language Japlish, developed by Williams and Kuribara (2008). Japlish combines English words with Japanese case-marking and syntactic word order. Japlish processing was assessed immediately following 20 minutes of incidental Japlish exposure and two weeks later. The results showed that both groups demonstrated grammatical sensitivity to Japlish syntactic word order immediately after exposure and following the two-week delay; neither word order nor case-marking processing were different between the groups. However, total semesters of prior language-learning experience (in Spanish as well as other languages) was found to correlate positively with performance following the two-week delay, suggesting a generally beneficial role for prior experience in the maintenance of L3 syntactic processing.

The finding that prior experience benefits longer-term maintenance of L3 processing was also observed in a study by Lado et al. (2017). The study employed an artificial language approach within The Latin Project and, like Grey et al. (2014), tested English L1 participants with different levels of Spanish L2 language-learning experience. Participants were at beginning, intermediate, advanced, and very advanced L2 levels, and in two experiments were trained on L3 Latin. Experiment 1 provided metalinguistic feedback during L3 practice whereas participants in Experiment 2 received only right/wrong feedback during practice. The results showed that when metalinguistic feedback was provided, as little as intermediate-level experience yielded benefits for L3 morphosyntactic processing. However, only participants with very advanced L2 experience maintained this behavior in the longer-term (four weeks) and very advanced experience was necessary for *any* benefits to L3 morphosyntactic processing in Experiment 2 (which provided only yes/no feedback), indicating a key role for increasing levels of L2 experience for L3 processing.

### *Cross-linguistic transfer*

Another important issue in bilingual L3 research concerns cross-linguistic transfer. For bilingual L3 learners, there are at least two sources of transfer: L1 and L2. This sets L3 learning/processing apart from second language acquisition, which has only the L1 as a transfer source. The unique cross-linguistic transfer context for bilingual L3 learning has received increasing attention in the last decade and is a source of expanding theoretical rigor (e.g., Bardel & Falk, 2012; Berkes & Flynn, 2012; Flynn, Foley & Vinnitskaya, 2004; Rothman, 2011, 2015; Slabakova, 2017). Artificial languages are very well-suited for investigating bilingual L3 transfer questions and informing these theoretical perspectives, as researchers can manipulate how the L3 (artificial language) relates structurally and typologically to the L1 and L2.

In line with this perspective, Sanz et al. (Sanz, Park & Lado, 2015) employed an artificial language (within The Latin Project) in a study that tested English L1–Spanish L2 and English L1–Japanese L2 participants. In the study, all participants shared an L1 that relies on syntactic word order to determine agent/patient relationships whereas, in the L3 Latin, case-marking is the most reliable cue, followed by subject-verb agreement. Importantly, participants' L2s differed in how linguistic cues are

[2]'Morphosyntax' is used to refer to aspects of syntax as well as morphologically marked features such as case-marking and grammatical gender. The reviewed research reflects, to the author's knowledge, the current extent of published work using artificial languagess to study sentence-level morphosyntactic processing in bilinguals, based on literature searches conducted in Google Scholar, Linguistics and Language Behavior Abstracts, and PsychINFO between November 2018 and January 2019.

[3]'L3' refers to any language acquired after the first and second; it does not exclusively refer to the third sequential language acquired by study participants.

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**Table 1.** Artificial language studies of bilingual morphosyntactic learning and processing

| Study | L3 area | Participants | Artificial language | Morphosyntactic targets | Language training/exposure | Assessments |
|---|---|---|---|---|---|---|
| Cox (2017) | Bilingual vs. monolingual learning | 22 Spanish L1-English L2 intermediate-advanced bilinguals<br>23 English monolinguals | Mini-language, Latin | Agent/patient roles via:<br>• Case-marking<br>• Subject-verb agreement<br>• Syntactic word order | +/– Metalinguistic grammar explanation | 1. Written interpretation<br>2. Aural interpretation<br>3. Grammaticality judgment<br>4. Written production |
| Grey, Sanz, Morgan-Short, & Ullman (2018) | Bilingual vs. monolingual learning | 13 Chinese L1-English L2 high proficiency bilinguals<br>16 English monolinguals | Artificial, Brocanto2 | • Syntactic word order | Metalinguistic grammar explanation | 1. Grammaticality judgment<br>2. ERPs |
| Grey, Williams, & Rebuschat (2014) | Prior experience | English L1-Spanish L2 learners<br>• 15 beginning<br>• 21 advanced | Semi-artificial, Japlish | • Case-marking<br>• Syntactic word order | Incidental exposure | 1. Grammaticality judgment<br>2. Picture-matching |
| Lado, Bowden, Stafford, & Sanz (2017) | Prior experience | Exp. 1: English L1-Spanish L2 learners<br>• 10 beginning<br>• 13 intermediate<br>• 26 advanced<br>• 9 very advanced<br><br>Exp. 2: English L1-Spanish L2 learners<br>• 10 beginning<br>• 25 intermediate<br>• 23 advanced<br>• 12 very advanced | Mini-language, Latin | Agent/patient roles via:<br>• Case-marking<br>• Subject-verb agreement<br>• Syntactic word order | Exp. 1: Practice with metalinguistic feedback<br>Exp. 2: Practice with yes/no feedback | 1. Aural interpretation |
| Nayak, Hansen, Krueger, & McLaughlin (1990) | Bilingual vs. monolingual learning | 24 multilinguals (various languages)<br>24 English monolinguals | Artificial (no name) | • Syntactic word order | Memorize sentence or discover word order rule | 1. Grammaticality judgment<br>2. Vocabulary test |
| Sanz, Park, & Lado (2015) | Cross-linguistic transfer | 10 English L1-Japanese L2 intermediate-advanced learners<br>15 English L1-Spanish L2 intermediate-advanced learners | Mini-language, Latin | Agent/patient roles via:<br>• Case-marking<br>• Subject-verb agreement<br>• Syntactic word order | Practice with yes/no feedback | 1. Written interpretation<br>2. Aural interpretation |
| Stafford, Sanz, & Bowden (2010) | Prior experience | 15 early AoA<br>Spanish L1-English L2 high proficiency bilinguals<br>18 late AoA<br>Spanish L1-English L2 high proficiency bilinguals | Mini-language, Latin | Agent/patient roles via:<br>• Case-marking<br>• Subject-verb agreement<br>• Syntactic word order | Metalinguistic grammar explanation & practice with metalinguistic feedback | 1. Written interpretation<br>2. Aural interpretation<br>3. Written production |

*Note*. AoA = age of arrival to the U.S.

used: Spanish relies more on subject-verb agreement whereas Japanese relies on case-marking. Therefore, the well-controlled artificial language approach enabled the study to reveal dynamic information on cross-linguistic transfer in L3 processing. The findings showed that, upon first encountering the L3, both groups demonstrated comparable L1-based sentence processing strategies, indicating their L1 English was the locus of transfer at this initial stage. This pattern persisted over the longer-term trajectory of the study (four weeks): participants showed slightly decreased reliance on L1-based word order during L3 sentence processing, but still preferred this processing strategy over either subject-verb agreement or case. Thus, the differential L2 sentence processing strategies (Spanish, Japanese) did not transfer to the L3, even though L3 processing would have benefited from such transfer since L1-based word order was not reliable.

In summary, the artificial languages used in these studies reveal the following with respect to prior language-learning experience and cross-linguistic transfer in bilingual L3 morphosyntactic processing. First, benefits of prior experience on L3 are not exclusive to early bilingualism (Stafford et al., 2010) – in fact, benefits can be observed even in late, intermediate L2 bilinguals (Lado et al., 2017). Additionally, with increasing levels of L2 experience, L3 morphosyntactic processing benefits are more likely to be maintained in the longer-term (Grey et al., 2014; Lado et al., 2017). Regarding L3 transfer, initial-stage and longer-term L3 sentence processing is influenced by L1 preferences, even when L2-based preferences would be optimal (Sanz et al., 2015), which is informative for distinguishing among L3 transfer models.

## Comparing morphosyntactic processing in bilinguals and monolinguals

As demonstrated in the preceding section, artificial languages are useful for investigating questions that are specific to bilingual L3 processing. Artificial languages have also proven very useful in elucidating differences in morphosyntactic learning/processing between bilinguals (or multilinguals) and monolinguals. This strand of research contributes to work on hypothesized bilingual advantages at additional language learning, compared to monolinguals. Although a bilingual learning advantage has been observed for some aspects of language, such as novel word learning (e.g., Antoniou, Liang, Ettlinger & Wong, 2015; Escudero, Mulak, Fu & Singh, 2016; Kaushanskaya, 2012; Poepsel & Weiss, 2016), much less work has examined potential advantages for additional language grammar learning, which includes the learning of morphosyntactic structures. (For discussions of bilingual advantages in other domains, including executive function, see e.g., Bialystok, 2015; Blanco-Elorrieta & Pylkkänen, 2018; Kempe, Kirk & Brooks, 2015; Lehtonen M., Soveri A., Laine A., Järvenpää J., de Bruin A., & Antfolk, 2018; Paap, Anders-Jefferson, Mason, Alvarado & Zimiga, 2018). Because artificial languages can be learned to high levels of proficiency over a short period of time, they provide researchers with an excellent framework for examining potential bilingual/monolingual differences in additional language grammar learning/processing.

In an early study comparing monolinguals and multilinguals, Nayak, Hansen, Krueger, and McLaughlin (1990) employed an artificial language composed of 40 visually-presented sentences, with novel words mapped to specific geometric figures. Because the authors were also interested in how language exposure influences learning/processing, the groups were trained under one of two conditions: 'memory' (instructed to memorize sentences) and 'rule-discovery' (instructed to discover the set of word order rules). Although the results showed no monolingual/multilingual group differences for word learning under either condition, in the rule-discovery condition the multilinguals outperformed the monolinguals in syntactic processing. This indicated that knowing more than one language may be advantageous for subsequent learning of new language grammar, particularly under more explicit, grammar rule-focused exposure conditions (see also Nation & McLaughlin, 1986).

In a study conducted within The Latin Project, Cox (2017) compared additional language learning in English L1–Spanish L2 bilinguals and English monolinguals. In the study, all participants were older adults (>60 years old) and, like Nayak et al. (1990), were trained under different conditions: an 'explicit instruction' condition that provided metalinguistic grammar explanations, or a condition that was less explicit in that it did not provide metalinguistic explanations. The results showed that regardless of training condition bilinguals outperformed monolinguals on sentence interpretation, which depended on accurate case-assignment. The study also hinted at an interaction with bilingualism and training condition, with a trend for the bilinguals who received explicit instruction to outperform monolinguals who did not.

Because both Nayak et al. (1990) and Cox (2017) employed artificial language paradigms they were able to carefully manipulate the explicitness of language training. This is important for determining whether bilingual language learning advantages are contingent upon certain learning conditions. Considering the two sets of findings together, it seems that explicit, metalinguistic language exposure may be a learning context in which bilingual advantages at morphosyntactic learning/processing are more likely to emerge. This aligns well with the perspective that bilingual advantages at language learning stem from greater metalinguistic awareness (Dillon, 2009; Jessner, 2008). However, since these are just two studies, further work is needed.

Recently, the hypothesized bilingual advantage at additional language learning was examined with an artificial language paradigm coupled with the event-related potential (ERP) technique. ERPs reflect real-time brain activity elicited in response to an external time-locked event, such as a word in a sentence, and their excellent temporal precision enables researchers to elucidate aspects of language processing in fine-grained detail. Grey et al. (2018) compared Chinese L1–English L2 bilinguals and English monolinguals on their learning of Brocanto2, an artificial language developed by Morgan-Short and colleagues (following Brocanto; Friederici et al., 2002). Brocanto2 is composed of a lexicon of nouns, adjectives, verbs, and adverbs and Brocanto2 grammar includes word order rules and grammatical gender agreement. Grey et al. (2018) focused on Brocanto2 syntactic word order. In the study, all participants were trained under an explicit, metalinguistic condition. Following training, participants practiced comprehension and production, and judged Brocanto2 sentence grammaticality at low and high Brocanto2 proficiency while ERPs were recorded (proficiency was determined by accuracy and completion of comprehension and production practice over the course of the study). The behavioral results indicated no differences between bilinguals and monolinguals regarding sensitivity to Brocanto2 syntax at low or high proficiency.

The ERPs revealed more detailed information. At low proficiency, only the bilinguals showed a P600 ERP response. The P600 is a well-studied ERP component elicited during morphosyntactic processing (e.g., Osterhout & Holcomb, 1992). P600

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responses are considered to reflect the processing of a stimulus in conflict with the expected linguistic representation and an attempt to resolve or reanalyze the conflict. They are often elicited in native speakers of languages and rarely elicited at low proficiency in monolingual L2 learners (for reviews, see e.g., Morgan-Short, 2014; Van Hell & Tokowicz, 2010). The P600 observed in the bilingual group indicates that, even at low proficiency, bilinguals are capable of employing neural mechanisms associated with native language syntactic processing. The authors suggest that this may be linked to bilinguals being better at managing cross-language syntactic competition which, in turn, manifests as being better at engaging P600-related processing mechanisms early in learning. At high proficiency, both bilinguals and monolinguals showed P600s. However, the monolinguals additionally showed an anterior positivity, which is not a typical ERP effect observed during syntactic processing and has been linked with increased reliance on attentional mechanisms (see e.g., Bowden, Steinhauer, Sanz & Ullman, 2013). This finding suggests that even when both bilinguals and monolinguals engage in P600-related processes during additional language sentence comprehension, only monolinguals need to recruit additional attentional mechanisms.

The use of an artificial language in Grey et al. (2018) enabled the study to reveal information about the trajectory of learning/processing from low to high proficiency in bilinguals compared to monolinguals, and it was along this trajectory that syntactic processing differences between the two groups were observed. With natural languages, investigating such a trajectory would take many years and be confounded by numerous factors, such as the amount and types of language exposure and practice. By using an artificial language, Grey et al. (2018) were able to account for these and other factors between the bilingual and monolingual groups, similar to Nayak et al. (1990) and Cox (2017).

Overall, this small set of studies shed new light on bilingual advantages at additional language learning, which has been examined more extensively for novel word learning than language grammar learning. The artificial language approach is an ideal foundation for this strand of research and the studies reviewed here set the stage for future research on bilingual language grammar learning, including extensions to natural language contexts.

## Conclusion and future directions

This article reviewed research that has utilized artificial languages to investigate bilingual morphosyntactic learning and processing. This research highlights the knowledge gained within the well-controlled linguistic contexts of artificial languages. In particular it has revealed novel information on the role of prior language-learning experience, contributed insight on cross-linguistic L3 transfer, and provided compelling evidence for bilingual advantages at additional language morphosyntactic processing. Bilingual L3 research is only just beginning to employ artificial language paradigms to investigate morphosyntactic processing. Thus, many insights are yet to be gained and there are a number of interesting ways to move forward.

For example, it would be worthwhile to manipulate cross-linguistic L3 (artificial language) characteristics, as in Sanz et al. (2015), and include measurement of ERPs during L3 morphosyntactic processing, as in Grey et al. (2018; see Rothman, Alemán Bañón & González Alonso, 2015 for a sample methodology). This will reveal information at the neurocognitive level that can help to distinguish among different L3 transfer models. Additionally, although the small amount of work on bilingual advantages at additional language grammar learning indicates that explicit, metalinguistic learning conditions are a particularly favorable context for bilinguals, future artificial language learning studies should investigate other types of learning conditions to help elucidate the full extent of potential advantages. Relatedly, it will be important to integrate individual differences research with artificial language approaches in order to capture the effects of inter-individual variation on bilingual L3 morphosyntactic processing. Finally, this review focused on adult bilingual morphosyntactic processing, and the artificial language approaches highlighted herein will also be valuable for investigating similar topics related to child bilingual L3 processing (for a review on artificial language work in child L2 research, see Pili-Moss, 2017).

In sum, the research and insights discussed in this review are but a starting point. The cutting-edge work that can be done by applying artificial language methods to pertinent theoretical and empirical issues in bilingual morphosyntactic processing will continue to advance knowledge and reveal nuanced perspectives.

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