Language control in the context of L3 acquisition: the centrality of individual differences

David W. Green

University College London

Chapter for: Angelovska, T. & A. Hahn (ed.). *L3 Syntactic Transfer: Models, New Developments and Implications*. Book Series "Bilingual Processing and Acquisition" (Series Editor: John Schwieter). Amsterdam: John Benjamins.

October 2016

Address for correspondence

Prof David W. Green
Experimental Psychology
Faculty of Brain Sciences
University College London
Gower Street London WC1E 6BT
UK
Email: d.w.green@ucl.ac.uk

Abstract

Current models of L3 syntactic transfer concern what is transferred during the initial stages. Each delineates a different, and singular, trajectory. From the outset though processes involved in co-opting available syntactic forms and pairing these with novel lexical items admit individual variability. Individual variability challenges the presumption of a single trajectory and so this chapter argues that understanding such variability is core to developing necessary and sufficient models of L3 acquisition. The chapter focuses on language control during L3 speech production as an important source of individual variability. Variability in language control affects speech production in L3 throughout the cycle from communicative intention to overt speech. What changes are needed to the processes of language control, and to the representations subject to their control, so that bilingual speakers may converse in an L3? Speakers must adapt their habits of language control so that they can construct and execute sentence plans in L3. Variability in the nature of such control will affect speech output. Current contexts of L3 use will also affect production in the two prior languages. Adaptive changes in language control induced via the acquisition and use of an L3 also impact on the production processes of the two prior languages. Models of L3 acquisition are ultimately models of multilingual processing.

1.0 Introduction

How do speakers acquire and use a third language (L3)? Current models of transfer concern what is transferred. They differ in the source of transfer and whether transfer is solely facilitative but pay less attention to the processes that mediate transfer and the novel use of a pre-existing structure. This chapter considers these processing questions in the context of a model of speech production and comprehension.

Language use is a form of communicative action. It helps us coordinate our actions based on our understanding of states of affairs in the world. From this point of view L3 syntactic transfer and L3 acquisition are to be understood in terms of the cycles of speech production and comprehension that comprise everyday conversations. For bilingual and multilingual speakers these cycles are permeated by processes of language control and it is the theme of this chapter that understanding the variability (i.e., individual differences) in these processes can help develop necessary and sufficient accounts of syntactic transfer, and L3 acquisition more generally.

We guide our exploration of the different kinds of variability using a control process model for speech production and comprehension (see Figure 1 for an illustration, section 4.0 outlines the neural regions). On this model, that extends earlier proposals (Green, 1986; Green, 1998; Green & Wei, 2014), overt speech is the outcome of a number of competitive processes governed by a set of control processes. A communicative intention (generated in the conceptual/intentional system) activates items (syntactic constructions, collocations, words) in language networks that meet the specifications. These items compete to create a speech plan. A speech plan is a parallel representation of the intended output and needs to be serialised to permit speech output (Lashley, 1951). One neurally-plausible solution to this problem involves a competitive queuing (CQ) mechanism that takes as input a parallel representation and outputs one that is serially-ordered. The mechanism comprises two layers: a planning layer and a competitive choice layer (Bohland, Bullock & Guenther, 2009; Grossberg, 1978; Houghton, 1990). Lexical items and constructions have different levels of activation in the planning layer that reflects the intended order of production. The competitive choice layer suppresses all items other than the item with the highest level of activation and releases that item for further processing (e.g., for phonological encoding) at the same time as removing it from the planning layer so that the item with next highest level of activation in the planning layer can be selected via the competitive choice layer. Such a mechanism allows the incremental production of speech in which speech planning is interleaved with speech execution.

What kind of plan is created depends on the speaker's communicative intention. Suppose the speaker wishes to use one language rather than another. Such an intention biases the activation of items (syntactic constructions and words) belonging to the intended language but does not preclude the activation of items from other languages. A control circuit external to the language networks filters competing items for entry into the CQ mechanism. We can think of the filter as a language gate. One gate might, for instance, allow entry for items from one language but not for items from another. The actual state of the filter is set by control signals from a higher level of control – the level of language task schemas. Depending on the communicative intention, these schemas can be configured either competitively or cooperatively. For example, an intention to switch to speaking in L2 rather than continuing to speak in L1 (perhaps because a new person joins the conversation) increases activation of the schema for L2. Its activation suppresses the activation of the L1 schema. In this context, schema configuration is competitive. A schema is effectively a habit of language control orchestrating a set of separable control processes (Green & Abutalebi, 2013). In the competitive case, for instance, the winning schema reduces interference from other languages, primarily by controlling the language gate proactively and, if necessary, by reactively inhibiting interfering items from the other language (see Morales, Gomez-Ariza &

Bajo, 2013, for experimental data on this contrast). Speakers may also code-switch between two of their languages (Muysken, 2000). In this case, the intention to code-switch configures the language task schemas in a cooperative fashion rather than in a competitive one (Green, 1998; Green & Abutalebi, 2013). Different cooperative configurations are optimal for different kinds of code-switching (Green & Wei, 2014; see legend Figure 1 for an example).

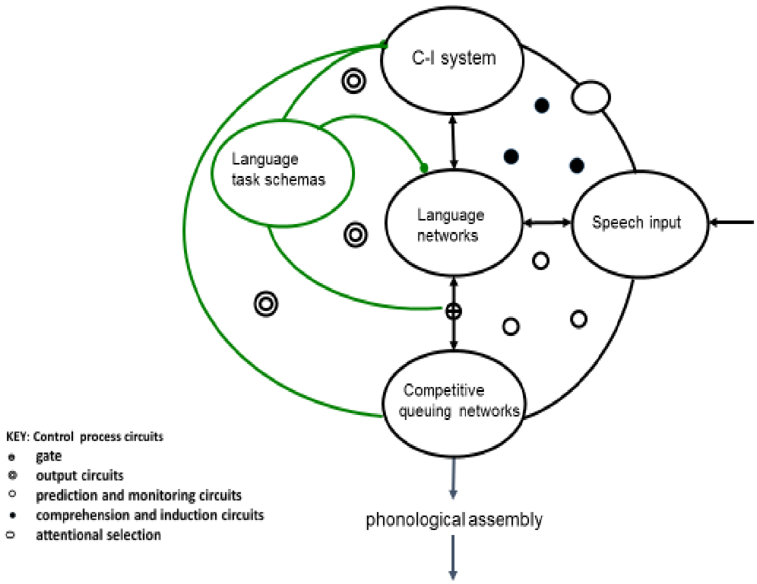

Figure 1. Schematic of the control process model of language control supporting L3 acquisition and use

The figure illustrates the various processing circuits involved in speech production and comprehension. Speech output circuits are captured on the left of the figure. Arrowed lines depict the flow of activation from the conceptual–intentional system (C-I), through the language networks to the competitive queuing (CQ) network that yields a serial output of the activated items. Output from the language network and entry into the CQ network is governed by the coordination of the language task schemas reflecting the communicative intention of the speaker. In the diagram, this is depicted by a line from the conceptual–intentional system to the language task schemas and one from the language task schemas intercepting access to the CQ network and serving to "gate" input into the planning layer (see below). The inhibitory line (filled circle) between CQ network and the conceptual–intentional system indicates that expressed content suppresses its conceptual representation. The inhibitory line linking the language task schemas and the language network indicates reactive inhibition. Such inhibition is triggered when an unwanted item enters the planning layer. The line linking the language task schemas and the CQ networks mediates the identification of such unwanted items.

The processes of speech production are also assumed to drive predictions about incoming speech input (depicted on the lower right quadrant of the figure) as well as providing information for a monitoring circuit to check that actual output matches intention. Speakers also attend to the speech of others in order to comprehend it (upper right quadrant). Such speech also provides an opportunity for inductive processes to identify novel syntactic forms.

Language task schema are habits of control that can be coordinated in different ways to yield different control states. For example, under a competitive control state, one language schema inhibits any other language schema. Under a cooperative control state, by contrast, more than one schema can be active. These different control states govern access to the planning layer and do not directly affect activation of items and constructions within the language networks prior to their activation. We can think of them as controlling different language gates. In the competitive control state one gate is open and the others closed or locked. In such a state, non-target language items are inhibited from release but may through momentary lapses of control enter the planning layer. In the cooperative control state, other forms of language use, such as code-switching, are possible (see Green & Li, 2014). For example, to continue with the analogy, one gate may be open and another "on the latch". In this state, increased appropriateness pushes open the latch which then closes after the relevant items have entered the planning layer permitting insertion of items or expressions from the other another language.

Speakers typically hear their own speech and monitor it for deviations from what they would expect to hear based on predictions generated during speech planning and execution. Of course, speakers also attend to the speech of others allowing speech input to drive the processes of speech comprehension. They also generate predictions about upcoming speech and, where successful, such predictions can speed comprehension (see Silbert, Honey, Simony, Poeppel & Hasson, 2014 for evidence of overlap in the regions involved in sentence production and comprehension). In the case of language learners, the speech of others also provides an opportunity, not only to learn new words (e.g., by reference to particular entities or states of affairs in the world) but to induce novel syntactic structures (by inferring the intended meaning and abstracting the syntactic form). The syntactic forms of heard speech also serve to prime the listener's own speech (Pickering & Garrod, 2013). In Figure 1 prediction and monitoring circuits are identified with the lower right quadrant whereas the comprehension and induction circuits are identified with the upper right quadrant.

Syntactic transfer and L3 acquisition clearly require changes to language networks. They also require change to the way the network is controlled. In order to set the scene for exploring such changes, we overview three prominent models of syntactic transfer. We argue for the inevitability of individual variation during transfer (**section 2.0**). Each model articulates a distinct initial state and a single learning trajectory through the transfer landscape of syntactic forms. But how realistic is the presumption of a single learning trajectory? It is open to challenge because transfer is likely to be a probabilistic process. If there is no single trajectory then exploring individual differences in critical processes offers a way to enrich current models.

We consider processes involved in the process of transfer itself and in using transferred representations in **section 3.0**. Effective transfer requires that structures recruited for L3 use do not interfere catastrophically with their use in the source language. Suitable change in the language networks needs to be complemented by a change in the processes of language control that allow a structure to be selected for use in L3. Habits of control suited to selecting between, or concurrently using, two languages need to adapt to permit selection and use of three languages. We infer that past habits of language control, as well as other individual differences, will affect the ease with individuals initially speak in the L3.

How more specifically might individual variability in language control affect speech production in L3? We consider this question in **section 4.0.** The brain may not operate as a traditional symbol processing system but it does allow a form of variable binding in which there is a separation of form and content. This separation allows the use of transferred structures with novel content. We consider the implications for trilingual speakers and consider the neural bases involved. The crucial point, for present purposes, is that a sentence plan evolves through a competitive process (e.g., alternative words may compete for selection). Given that individuals differ in their ability to exert control, L3 speakers are likely to differ in the stability of sentence plans prior to submission to the CQ mechanism yielding dysfluent L3 speech.

A final section (**section 5.0**) reviews the claim for the centrality of individual differences to the development of necessary and sufficient models of L3 acquisition and stresses the importance of examining how changes in proficiency in L3 affect speech processing in the two prior languages. Adapting the processes of language control reflects the need to manage all languages.

2.0 Transfer as a probabilistic process

How do speakers use their prior languages for L3 acquisition? They may use both as in the cumulative enhancement model, CEM (Flynn, Foley & Vinnitskaya, 2004; see also proposals by Slabakova, 2016 and Westergaard, Mitrofanova, Mykhaylyk & Rodina, 2016) or may use only one. For the typological primacy model (TPM), the source of transfer is the most structurally similar language whether that language is acquired first or second (e.g., Rothman, 2011; 2015; see also Rothman, Bañón, & Alonso, 2015; Gonzalez Alonso & Rothman, 2016). By contrast, for the L2 status factor model the source of transfer depends on the representational form of the source language and that in turn depends on the order of acquisition (e.g., Bardel & Falk, 2007, 2012). Under this model, L3 acquisition uses a declarative representation of grammar and such a representation is viewed as more accessible for L2 than for L1 (cf. Paradis, 2009; Ullman, 2001). Despite their differences each model presumes that the landscape of transfer identifies a single learning trajectory – one identified by the model. In the case of TPM and the L2 status factor model just one language shapes or warps the initial landscape of L3 syntactic forms and populates that landscape with structures from just a single language. For these models, transfer is all-or-none. Accordingly, transfer can be facilitatory or non-facilitatory. For the CEM only facilitatory effects are predicted though the mechanism that permits just such effects is unclear. The presumption of a single initial landscape and trajectory to proficiency is attractive because it renders the models testable and refutable. But how realistic is it? One challenge stems from a logical necessity. If speakers are to become more native-like in their use of L3 then incorrect syntactic forms need to be avoided. In order to do so syntactic structures from the source language must be dissociable – otherwise learning could not be selective. Such dissociability is presumed by the CEM but is also essential for TPM and the L2 status factor model. It follows that the initial L3 syntactic landscape is populated by dissociable syntactic forms.

Syntactic dissociability renders the process of transfer potentially probabilistic. It is likely to be actually probabilistic because individuals will use a given structure in the language that is the source of transfer more or less frequently and differential usage will affects its accessibility for transfer (see Fallah, Jabbari & Fazilatfar, 2016). Further, there is evidence of the mutual influence of one language on another including the syntactic level (see Kroll, Dussias, Bice & Perrotti, 2015 for an excellent review). Language representations are permeable and so a structure that is linguistically in the repertoire of the source language (i.e., part of its formal grammar) may not be available for transfer in practice. The extent of permeability for a given pair of prior languages is an empirical matter dependent on, for example, the typological relationship of the two languages and the patterns of their usage. Permeability certainly does not undermine any claim for all-or-none initial transfer as proposed by the TPM at least. It does mean though that the initial state of the L3 landscape will be variable. Permeability does raise more issues for the L2 status factor model because it undermines any uniqueness for L2 syntactic representation as required by that model (see Kroll *et al*., 2015). Permeability and frequency effects also apply to the CEM: structures from the two source languages will be affected.

On this interpretation, and still consistent with the claim of the TPM and a generous interpretation of the L2 status factor model, a single language source may shape the initial landscape of transfer and populate that landscape probabilistically with syntactic forms from that language. However, for this claim to hold true, the TPM and L2 status factor model require a language control constraint. If this constraint fails to hold then the initial landscape of transfer may be more dynamic than allowed for by the TPM and L2 status factor models. Does it hold? If both languages are active in the mind of the bilingual speaker as they appear to be, L3 input during the initial stages of L3 acquisition will activate any relevant syntactic forms that can account for the input. This input-driven or bottom-up control process is compatible with the CEM. If we allow that accounting for input may assign an incorrect structure to the input then bottom-up control processes can also accommodate non-facilitatory forms (in line with the proposals of Slabakova, 2016 and Westergaard *et al*., 2016) without requiring that any single language initially shapes the syntactic landscape of the L3. The TPM and L2 status factor models, by contrast, after an initial sampling of the input, require a top-down control process that effectively suppresses active, but 'non-source' language syntactic forms allowing only one language to shape the landscape. The TPM and L2 status factor models then operate within one region of a control space, where one dimension refers to bottom-up control and the other to top-down control. These models, where the initial syntactic landscape of L3 is populated by constructions from a single language, require high top-down control and low bottom-up control. The CEM, along with the input-driven proposals of Slabakova and Westergaard et al., occupies a different region – high bottom-up control and low top-down control.

Viewed from a control perspective, current models emphasize one type of control process over another. Certainly, particular contexts of acquisition may well emphasize one or the other. For example, formal instruction will recruit top-down processes of control that help establish correct structures and eliminate incorrect structures (cf. Jessner, 2008). By contrast, bottom-up processes during immersion will lead listeners to induce structures some of which may turn out to be incorrect. Circuits in the upper-right quadrant of Figure 1 play a role in both cases with the driving input for change coming from the language of instruction or from the language of immersion. However, during the actual contexts of acquisition both types of control process surely play a role. For example, the responses of native speakers may lead to the correction of incorrect forms in immersion contexts and require top-down processes of control. Within the contexts of formal instruction, speech input (or written input) will drive the activation of related structures bottom-up.

If we grant this formulation, and add a time dimension, then we can say that initial transfer and subsequent L3 acquisition will be modulated by the individual learner's starting position within this space and that their trajectory through it will reflect the contexts of acquisition (Green, 2016). The precise nature of this trajectory and its effects on representational change and use of L3 will reflect a range of individual difference variables.

3.0 Mechanisms of transfer: representational change and use

Transfer requires that syntactic forms in the source language are active and retrievable in order for them to populate the syntactic landscape of L3. Such forms are then paired with different lexical content. But joint activation of languages appears to be the default (Kroll & Gollan, 2014; Kroll, Bobb & Wodniecka, 2006; Libben & Titone, 2009; Marian & Spivey, 2003; Thierry & Wu, 2007; Van Hell & Dijkstra, 2002) and this state of affairs has implications for both facilitative and non-facilitative transfer. All else being equal, use will induce interference. For facilitative transfer, use will yield interference from lexical content in the source language. Likewise use of the structure in the source language risks concomitant activation of different lexical content in L3. For non-facilitative transfer, an increase in L3 proficiency may involve suppression of these forms in L3 and render them less available for use in the source language. Clearly the process of co-opting forms for use in L3, or restricting their use, should also aim to minimise between-language interference. What mechanisms are involved?

Consider a possible outcome of L3 learning that might appear to minimise between-language interference: based on transferred syntactic forms, learning mechanisms establish a separate L3 language network. This solution would minimise interference at the cost of reduplicating syntactic forms and then only under the strong constraint that the source network is not competing to control output perhaps because it is strongly inhibited. However, experimental data with bilingual speakers provide evidence of cross-linguistic syntactic priming (Hartsuiker, Pickering & Veltkamp, 2004). Cross-linguistic syntactic priming is more consistent with the idea that transfer yields a representation in which a common structure can be used by two languages as in the network model of Hartsuiker et al. (2004). In the network, syntactic forms are represented as combinatorial nodes. If there is an equivalent structure in the two languages then a single combinatorial node is linked to two language nodes, one for L1 and one for L2. Taking a lead from Hartsuiker *et al*. (2004), we suppose that use of a pre-existing syntactic form (whether from L1 or from L2) involves creating an L3 language node and linking the pre-existing structure to it (see De Bot & Jaensch, 2015 for an alternative view). Creating such a link, we propose, involves a top-down process of control but it is an empirical question whether or not mere exposure might in fact be sufficient by implicitly tagging a structure with its context of use.

Co-opting an existing structure generalises its use to a different linguistic context (L3) in which different lexical content can be used. The language node effectively achieves a form of pattern-separation in which facilitatory syntactic forms are deployed in two language contexts (the source language and L3). Individual differences in pattern-separation skills (perhaps for neuroanatomical reasons) will impact on the ability to recruit novel forms and eliminate non-target forms. Such differences impact on the learning of novel vocabulary

(Bellander, Berggren, Mårtensson, Brehmer, Wenger, Li, Bodammer, Shing, Werkle-Bergner & Lövdén, 2016) but remain to be explored in the context of the learning of syntactic forms in L3. In the case of non-facilitatory transfer it is conceivable that any initial link is removed so that the form is deployed in just one context (the source language but not in L3). Alternatively, and perhaps more plausibly, it could be that such forms are activated but are suppressed from output as proficiency increases so that the form is deployed in one context but not another. If so, its presence might be unmasked. For example, under conditions of increased processing load or stress, non-native L3 speakers may produce dysfluent speech associated with that form. Such a prediction remains to be tested.

Pattern-separation is one of two core memory processes (see Hunsaker & Kesner, 2013 for a review). The other complementary process is pattern-completion. In the case of syntactic processing, pattern-completion allows the retrieval of the whole syntactic form given recall of part of it. In speech production, it plays a role in the creation of a sentence plan and in comprehension it may enable top-down processes to predict upcoming morphosyntactic properties. Consistent with this possibility, in relatively proficient bilingual speakers, similarity between the two languages (e.g., in morphosyntactic properties such as gender marking) facilitates the prediction of a target article during L2 comprehension (Foucart, Martin, Moreno & Costa, 2014). Prediction of the associated target noun (or its referent) need not be constrained by language similarity but can be based on the sentence content up to that point (Dijkraaf, Hartsuiker, & Duyck, 2016). On the basis of these bilingual data, there are grounds for expecting both kinds of predictive effects in L3 comprehension as L3 proficiency increases.

Change in the language networks needs to be complemented by a suitable change in the processes of language control that allow that structure to be selected for use in L3. Control process must be able to select structures linked to a given language node. The intention to use a given language needs to be part of the intended message and embedding an L3 tag will help select representations with that tag by biasing their activation. Control processes external to the language network (circuits on the left in Figure 1) enable individuals to use their languages in contextually-appropriate ways and help constrain sentence planning and execution by, for instance, avoiding intrusions. In bilingual speakers, we know that differences in the ability to control inadvertent intrusions correlate highly with tasks tapping into the control of interference, consistent with language control processes external to the language networks (Festman, Rodriguez-Fornells & Münte, 2010). The same pattern is predicted in the case of trilingual speakers. Self-reports certainly illustrate individual susceptibility to intrusions. One German-English bilingual learning French as an L3 (Festman, 2006) reported as follows: "Ich bin blockiert, wenn ich auf Französisch nach Begriffen suche, Flasche, Glas, ich weiß alles auf Englisch, *a bottle*… Ein Blatt Papier auf Französisch? Mir fällt nur *paper* ein. (…) Das Englische blockiert das Französische." [Translation: '*I am blocked when I search for words in French, bottle, glass, I know everything in English, a bottle…. A piece of paper in French? I only recall paper. (…) English blocks French.'*]

Learning and using an L3 involves adapting the control structure (i.e., the configuration of language schemas) suited to selecting amongst two languages (L1 and L2). Less efficient structures early in L3 acquisition may be one possible source of the self-report noted above. So, for example, suppose a bilingual speaker established a control structure prior to learning an L3 that distinguished between their native language (L1) and their non-native language (L2). With this structure, L3 is non-native. Given that L2 is the first non-native language it will likely win out in the competition to provide suitable words, as in the example above, especially when use of L2 requires the strong inhibition of output from L1. Such a control structure could be retained as long as there is further differentiation within the category of non-native languages: effectively creating a control structure with L1 on one branch and L2 and L3 nested under a second, non-native branch. Alternatively, speakers might create a non-hierarchical control structure comprising separate branches for L1, L2 and L3.

The control structure and how it functions may depend on the way in which individuals use their languages– their habits of language control. If so, the trajectory of L3 acquisition will be affected by the individual history of language use. Habits of control depend on the behavioural ecology of language use (Green, 2011). Bilingual speakers may use one language in one context and their second language in a completely disjoint context (e.g., English at work; Mandarin at home). Alternatively, they may switch between languages in conversation with different addressees or code-switch in different ways within a conversational turn. Differences in prior use may lead to adaptive change in component control processes such as sustained attention when using just one language or enhancing the ability to control interference in the case of switching between languages to different addressees (Green & Abutalebi, 2013). If so, prior habits of control will affect the ease of controlling interference from previous languages in the use of L3. Current use of the three languages will also affect the trajectory to proficiency. For example, the three languages may be used in distinct contexts emphasizing control processes that sustain single language use and so potentially restricting interference between three languages. Such usage may be facilitated by a control structure with three distinct branches. In other cases, speakers may code-switch between their first two languages and use their L3 in a distinct context. In this case, a hierarchical structure may be more suitable with L1 and L2 nested under one branch and L3 in another. Nonetheless, with increased proficiency, there may be consequences for speech in L1 and in L2: for example, inhibition of non-target structures during L3 use may restrict code-switching between L1 and L2 involving such structures. Trilinguals, to echo Grosjean (1989) are not three monolinguals in one body.

4.0 Sentence planning and execution in L3

Conversing in L3 requires pairing any transferred structures with novel content. What is involved in creating an L3 sentence plan? As noted above, experimental data indicate that transfer yields the activation of any (perceived) common syntactic structure rather than the creation of an independent language network. Assuming this interpretation is correct, why might representational change take this form? The most likely reason is that sentence formation within a single language works by binding different lexical content to a given syntactic form [e.g., a subject-verb-object structure can be bound to different lexical contents such as “The man kisses the woman” or “The dog chases the cat”]. The essential requirement that permits generativity is to separate form and content. Binding different lexical content from a different language to a common structure preserves this fundamental operational principle [e.g., “The man kisses the woman”; “Der Mann küsst die Frau”]. Traditional symbol processing systems solve this basic problem using variable binding in which constituent parts of sentences (e.g., agent, verb, patient) are treated as variables that are then bound to novel content. There is scant evidence that the brain behaves as a symbolic processor in this fashion (Van Gelder, 1990; Johnson, 2004). However, it clearly allows a form of variable binding in which there is a separation of form and content.

Given the need to distinguish form and content, it is reasonable to suppose that a number of distinct neural regions are involved. Kriete, Noelle, Cohen & O'Reilly (2013) identify three neural regions in their proposal. They suggest that one cortical region represents syntactic roles (e.g., agent, verb, patient). This region connects to a second that represents possible fillers of those roles (e.g., particular lexical concepts, organised in semantic fields perhaps, and associated word forms). Control signals from a subcortical area (the basal ganglia) serve to update, maintain or output the constructed plan. Research on monolingual speakers (Argyropoulos, Tremblay & Small, 2013) indicates that one basal ganglia structure (the caudate) is particularly active during sentence generation compared to sentence repetition suggesting a role in the selection of the sentence plan. Another basal ganglia structure (the putamen) increases its activation over baseline for either kind of speech consistent with a role in outputting the constructed plan (see also Bohland et al., 2009).

The Kriete *et al*. (2013) proposal requires extension to handle the case of multilingual speakers. First, sentence plans evolve through a competitive process and language control signals are needed to select the language for output and to help select amongst competing items. In Figure 1, such signals are mediated by configuring language task schemas that control language gates and entry into the CQ mechanism. Neurally, such mediation involves control signals from the cortical and subcortical regions identified in the Kriete *et al*. proposal (see Abutalebi & Green, 2007: Green & Abutalebi, 2013). Subcortical signals also enable plan execution (Bohland *et al*. 2009). Second, the cerebellum is likely to play a critical role in the cycle of sentence planning and execution. The cerebellum has links to the cortical and subcortical structures identified in the Kriete *et al*. (2013) proposal, and it is also part of the language control network (Green & Abutalebi, 2013). Once treated as primarily concerned with motor control, it is recognized now for its contribution to a wide range of language and cognitive functions (see Tyson, Lantrip & Roth, 2014 for a review). Neuroimaging studies are needed to examine its role in sentence production and comprehension in detail but we already know that a lack of cerebellar activation impairs speech production in bilingual speakers indicating its important contribution to morphosyntactic processing (Marien, Engelborghs, Fabbro & De Deyn, 2001; Silveri, Leggio & Molinari, 1994). Indeed it appears to mediate efficient rule use in non-native speakers of a language (Pliatsikas, Johnstone & Marinis, 2014) and plays an important role in predicting the content of upcoming speech: disrupting its activation delays eye movements to a target object predicted by sentence content (Lesage, Morgan, Olson, Meyer & Miall, 2012). It would be interesting to explore its contribution to the comprehension and production of L3.

Language control processes act over the whole cycle of sentence planning and execution and so processes of language control are needed to help stabilise what is in the plan and so what is entered into the CQ mechanism. Under stress, for example, such stability may be undermined. If so, we can predict increased dysfluency in L3 as speakers attempt to execute an unstable plan. More generally, speakers will need to adapt circuits that include the cerebellum in order to construct and execute L3 sentence plans. On this proposal we can predict that inter-subject anatomical differences in these circuits will contribute to variance in L3 learning and use.

5. Review and Discussion

We noted that initial transfer, however triggered, involves the transfer of dissociable syntactic structures because at some point during L3 acquisition speakers can avoid producing forms that are not part of the L3 grammar. Granting dissociability, transfer may reflect the relative accessibility of syntactic structures from the source language or influences on those forms from the speaker's other language. On this interpretation a single language source may shape the initial landscape of transfer and populate that landscape probabilistically with syntactic forms from that language. Individual variability though would be inherent to initial transfer. However, if both prior languages are active, L3 input during the initial stages of L3 acquisition may activate any relevant syntactic forms that can account for the input. There may be no shaping of the syntactic landscape as a whole for L3 rather its construction may proceed piecemeal (construction by construction). This input-driven or bottom-up control process is consistent with the CEM but this model does not explain negative transfer. However, a bottom-up control process can accommodate such transfer if we allow that there can be incorrect accounting for input, i.e., misanalysis. Proposals by Slabakova (2016) and Westergaard *et al.* (2016) include such a possibility. Further research is needed to explore the factors that determine such incorrect accounting but an approach based on competing cues (MacWhinney, 2005) offers a fruitful line (e.g., Sanz, Park & Lado, 2015) and one consistent with the importance of bottom-up control processes. The TPM and L2 status factor models, by contrast, after an initial sampling of the input, require a top-down control process that effectively suppresses active, but 'non-source' language syntactic forms. If such suppression fails, for whatever reason, then the initial landscape of transfer will be populated by syntactic structures from more than one language.

We sought to capture the contrasts amongst these models by envisaging a control process space. The initial transfer models differ in their positions within this control space where one dimension refers to bottom-up control and the other to top-down control. The TPM and L2 status factor models operate within one region: high top-down control paired with low bottom-up control. By contrast, the CEM, and the proposals of Slabakova and Westergaard *et a*l. occupy a different region: low top-down control paired with high bottom-up control. Realistically though both types of control process are likely to shape the initial landscape of transfer and its development over time.

Does this formulation of the initial landscape of transfer have any merit? It would seem to offer an alternative interpretation of what happens when speakers overcome certain types of negative transfer (Green, 2016). In doing so though it emphasizes the importance of converging methods in understanding the process of L3 acquisition. By way of illustration we consider the work Cabrelli-Amaro, Amaro, and Rothman (2015). These authors examined Subject to Subject (S-to-S) raising over a dative experiencer in Brazilian Portuguese (BP) as an L3. Both English and BP allow such a construction (e.g., "John seems to me to be a nice person"; "O Joao me parece ser uma pessoa excelente"). By contrast, Spanish, does not (* "Juan me parece ser una persona excelente"). On the basis of overall structural similarity Spanish is closer than English to BP and so taking control processes into account, English must be inhibited top-down effectively precluding it from accounting for input via a bottom-up control process. In the first part of the study, Cabrelli-Amaro *et al*. compared the performance of two groups of advanced bilinguals during the initial stages of BP acquisition as an L3. One group had English as their native language and Spanish as L2 and the other Spanish as their native language and English as their L2.   Based on a scalar judgment task of syntactic acceptability, and in line with TPM, both groups rejected the acceptability of BP sentences with S-to-S raising over a dative experiencer. By contrast an advanced and immersed group of L3 learners (native English speakers highly proficient in Spanish) did find such sentences acceptable. They had overcome the negative transfer from Spanish. However, this acceptance came with a cost; they also found the form acceptable in Spanish. Native-likeness in BP occasioned less native-likeness in Spanish. In line with studies of syntactic permeability in bilingual speakers (e.g., Dussias & Sagarra, 2007), a later acquired language affected syntactic preferences in an earlier acquired language. Conceivably, as Cambrelli-Amaro et al. (2015) propose, negative transfer was eliminated by reconfiguring the structure transferred from Spanish. On the assumption that this structure is tagged as Spanish, and as L3, then this proposal offers a neat explanation of the data.

However, the above explanation presumes, in line with TPM, that the initial landscape of transfer was populated solely with Spanish forms. But suppose the English structure was in fact present in the initial landscape because it accounted for input bottom-up. It would be tagged for L3 use. Data from the scalar judgement task of syntactic acceptability appear to rule out this possibility but data from this metalinguistic task may not be decisive. Such a task though may not be sensitive to the dynamic variety of the initial transfer landscape. Other methods are needed to elucidate potential variety. For example, judging a structure unacceptable during the initial stage of L3 learning might dissociate from a more implicit measure such as one that indexes the relative fluency and accuracy of repeating an auditorily-presented L3 sentence with the existing English structure compared to one without it. Neurally, repeating a sentence that uses an existing structure should reduce demand on regions involved in sentence planning and articulation including the basal ganglia structures of the caudate and putamen. Predictive processes in comprehension should also be facilitated. leading to the prediction of an expected word. Given results with bilingual speakers (Foucart, Ruiz-Tada & Costa, 2016) the expected word should be treated as having been actually presented and so falsely recognised in a subsequent recognition test: a type of verbal hallucination.

If acceptability judgements dissociate from other measures then this would be consistent with the presence of the English structure in the initial syntactic landscape of BP as an L3 despite the transfer dominance of Spanish as the typologically closer language that affects initial scalar judgement. In advanced BP learners, use of the English structure would increase the activation of the featural configuration that allows S-to-S raising of a dative experiencer effectively reconfiguring the Spanish structure too. This alternative formulation may be incorrect but it does suggest the importance of using different methods (sentence production tasks, evoked reaction potentials: ERPs, e.g., Rothman et al., 2015; functional neuroimaging or visual world paradigms, e.g., Dijkraaf et al., 2016) to explore the dynamics of initial transfer and how the transfer landscape changes over time.

Depending on their acquisition contexts, and their cognitive proclivities, we expect individuals to vary in their trajectories through the control space of L3 acquisition. Exactly how different trajectories are reflected in speech output is complex. Many other processes entrained by the control processes are relevant to the representation and use of L3. For example, we expect individuals to differ in the ease with which they distinguish and represent novel syntactic patterns. Motivational differences may also play a role because change to the language networks requires a coupling of language regions and regions involved in reward and motivation. Indeed, neuroimaging research corroborates that differences in the integrity of these connections is predictive of the ease with which individuals can learn the meanings of novel words (Ripollés, Marco-Pallarés, Hilescher, Mestres-Missé, Tempelmannn *et al.*, 2014). It seems plausible that such differences will also be predictive of the ease with which individuals can learn novel syntactic forms.

In principle, ERP data provides a sensitive measure for examining longitudinal changes as speakers become more proficient (Duñabeitia, Dimitropoulou, Dowens, Molinaro & Martin, 2016). Different components of the ERP profile appear sensitive to the effects of immersion and proficiency in bilingual speakers (Caffara, Molinaro, Davidson & Carreiras, 2015). The same may be true for trilingual speakers but this is currently unknown. Longitudinal studies are arguably the gold standard as they permit an exploration of a range of potentially relevant individual factors including motivation but they are not without challenges. Tracking ERP changes longitudinally, for instance, also means taking account of individual differences in ERP profiles in the processing of L1 and L2 that are quite variable (Tanner, Inoue & Osterhout, 2014).

Pattern-separation is not only important in the learning of novel forms but also in using language in context. A speaker needs to be able to determine which language is in use and which language to use. Suitable change in the language networks has to be complemented by a change in the processes of language control that allow a given structure to be selected for use in L3. Habits of control suited to selecting between two languages must adapt to permit selection amongst three languages. The precise nature of such change is likely to depend on ecology of language use for a given speaker. For example, some speakers may use their three languages in distinct contexts whereas others may code-switch between their first two languages and use their L3 in a distinct context. Conceivably the use of language in distinct contexts yields adaptive changes that more successfully restricts between-language interference during L3 language use. Any such ecological effects will serve to modulate pre-existing individual differences in cognitive control.

Whilst the intention to speak one language rather than another may bias the selection of syntactic forms and lexical content, current data suggest that it is not sufficient to do so. Accordingly, processes of language control act on outputs from the language network to guide the production of a sentence plan and permit its serial production in speech. This account suggests that with an increase in proficiency speakers overcome non-facilitatory forms not by deleting links in the language networks but by inhibiting entry of the incorrect form into the planning layer. If this is so, then more proficient speakers, having overcome such a form in their overt speech will nonetheless show a transitory increase in regions associated with the control of interference (e.g., the caudate and frontal circuits associated with inhibition).

We supposed that speech production in L3 uses the same mechanism as speech production in L1 and L2. On this view, even if L3 learners make use of declarative representations of syntax, as proposed by the L2 status factor model, these representations drive production procedures yielding convergence in the neural substrate for speech production in different languages (Green, 2003). These production procedures permit a separation of form and content. In line with the idea that language processes co-opt phylogenetically older neural circuits, creating and executing sentence plans recruits circuits involved in constructing and executing plans for action. These implicate subcortical and cortical circuits (Kriete *et al*., 2013) and, in the view expressed here, cerebellar circuits. Adaptive changes in language control must reshape these circuits to allow the selection of syntactic forms that can be bound to L3 lexical content. Whilst exploring the nature of change in these circuits is a task for the future, a relevant behavioural prediction is possible. Over time it is reasonable to expect that syntactic forms common to L3 and one or other of the prior languages will be selected more frequently. It follows that use of a syntactic alternative in L1 or in L2 will decline over time. In such circumstances, acquiring and using an L3, effectively alters the activation landscape of syntactic forms in the speaker's prior languages.

Conclusion

This chapter identified variability in the processes of language control as central to the development of necessary and sufficient models of L3 syntactic transfer and, by extension, to L3 acquisition more generally. It emphasizes the value of a rich characterisation of individual differences in cognitive processes and in the details of multilingual language use.

6.0 References

Abutalebi, J., & Green, D.W. (2007). Bilingual language production: The neurocognition of language representation and control. *Journal of Neurolinguistics, 20*, 242-275.

Argyropoulos, G.P., Tremblay, P., & Small, S.L. (2013). The neostriatum and response selection in overt sentence production: an fMRI study. *NeuroImage, 82*, 53-60.

Bardel, C., & Falk, Y. (2007). The role of the second language in third language acquisition: The case of Germanic syntax. *Second Language Research, 23,* 459−484.

Bardel, C., & Falk, Y. (2012). The L2 status factor and the declarative/procedural distinction. In J. Cabrelli Amaro, S. Flynn & J. Rothman (Eds.). *Third Language Acquisition in Adulthood*. (pp. 61-78). Amsterdam: John Benjamins.

Bellander , M., Berggren, R., Mårtensson, J., Brehmer, Y., Wenger, E., Li, T-Q., Bodammer, N.C., Shing, Y-L., Werkle-Bergner, M., & Lövdén, M. (2016) Behavioral correlates of changes in hippocampal gray matter structure during acquisition of foreign vocabulary. *NeuroImage*, *131*, 205–213.

Bohland, J.W., Bullock, D., & Guenther, F.H. (2009). Neural representations and mechanisms for the performance of simple speech sequences. *Journal of Cognitive Neuroscience*, *22*, 1504-1529.

Cabrelli-Amaro, J., Amaro, F. & Rothman, J. (2015). The relationship between L3 transfer and structural similarity across L3 development: Evidence from subject-to-subject raising over an experiencer. In H. Peukert (Ed.) *Transfer Effects in Multilingual Language Development*. (pp. 21-52) Amsterdam: John Benjamins.

Caffara, S., Monlinaro, N., Davidson, D., & Carreiras, M. (2015). Second language syntactic processing revealed through event-related potentials: an empirical review. *Neuroscience & Biobehavioral Reviews*, *51*, 31-47.

De Bot, K., & Jaensch, C. (2015). What is special about L3 processing? *Bilingualism: Language and Cognition, 18*, 130-144.

Dijkraaf, A., Hartsuiker, R.J., & Duyck, W. (2016). Predicting upcoming information in native-language and non-native-language auditory word recognition. *Bilingualism: Language and Cognition*. doi:10.1017/S1366728916000547.

Duñabeitia, J. A., Dimitropoulou, M., Dowens, M. G., Molinaro, N., & Martin, C. (2016). The electrophysiology of the bilingual brain. In R. R. Heredia, J. Altarriba, & A.B. Cieslicka (Eds.). *Methods in Bilingual Reading Comprehension Research* (pp. 265-312). New York: Springer.

Dussias, P.E. & Sagarra, N. (2007). The effect of exposure on syntactic parsing in Spanish–English bilinguals. *Bilingualism: Language and Cognition*, *10*, 101-116.

Fallah, N., Jabbari, A., & Fazilatfar, A. M. (2016). Source(s) of syntactic CLI: The case of L3 acquisition of English possessives by Mazandarani–Persian bilinguals. *Second Language Research*, *32*, 225–245.

Festman, J. (2006). Trilingual language processing investigated by means of introspective verbalizing during speaking in three Languages. *Journal of Social and Ecological Boundaries*, *2.1*, 117-147.

Festman, J., Rodriguez-Fornells, A., & Münte, T. (2010). Individual differences in control of language interference in late bilinguals are mainly related to general executive abilities. *Behavioral and Brain Functions*, *6:5*.

Flynn, S., Foley, C., & Vinnitskaya, I. (2004). The Cumulative-Enhancement model for language acquisition: Comparing adults' and children's patterns of development in first, second and third language acquisition. *International Journal of Multilingualism, 1*, 3-17.

Foucart, A., Martin, C. D., Moreno, E. M., & Costa, A. (2014). Can bilinguals see it coming? Word anticipation in L2 sentence reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40*, 1461–1469.

Foucart, A., Ruiz-Tada, E., & Costa, A. (2016). Anticipation processes in L2 speech comprehension: evidence from ERPs and lexical recognition task. *Bilingualism: Language and Cognition*, *19*, 213-219.

González Alonso, J., & Rothman, J. (2016). Coming of age in L3 initial stages transfer models: deriving developmental predictions and looking towards the future. *International Journal of Bilingualism*. doi: 10.1177/1367006916649265.

Green, D.W. (1986). Control, activation and resource: a framework and a model for the control of speech in bilinguals. *Brain and Language*, *27*, 210-223.

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language & Cognition*, *1*, 67-81.

Green, D. W. (2003). Neural basis of lexicon and grammar in L2 acquisition: The convergence hypothesis. In R. van Hout, A. Hulk, F. Kuiken, & R. Towell (Eds.), *The interface between syntax and the lexicon in second language* acquisition (pp. 197–208). Amsterdam: John Benjamins.

Green, D.W. (2011). Language control in different contexts: the behavioural ecology of bilingual speakers. *Frontiers in Psychology*, 2: 103.

Green, D.W. (2016). Trajectories to L3 proficiency. *International Journal of Bilingualism.* doi: 10.1177/1367006916637739.

Green, D.W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, *25*, 515–530.

Green, D.W., & Wei, L. (2014). A control process model of code-switching. *Language, Cognition and Neuroscience*, *29*, 499-511.

Grosjean, F. (1998). Studying bilinguals: Methodological and conceptual issues. *Bilingualism: Language and Cognition*, *1*, 131–149.

Grossberg, S. (1978). A theory of human memory: Self-organization and performance of sensory-motor codes, maps, and plans. In R. Rosen & F. Snell (Eds.), *Progress in theoretical biology* (pp. 233–374). New York: Academic Press.

Hartsuiker, R.J., Pickering, M.J., & Veltkamp, E. (2004). Is syntax separate or shared between languages? *Psychological Science*, *15*, 409-414.

Houghton, G. (1990). The problem of serial order: A neural network model of sequence learning and recall. In R .Dale, C.Mellish, & M. Zock (Eds.), *Current research in natural language generation* (pp. 287–319). London: Academic Press.

Hunsaker, M.R., & Kesner, R.P. (2013). The operation of pattern separation and pattern completion processes associated with different attributes or domains of memory. *Neuroscience and Biobehavioral Reviews, 37,* 36-58.

Jessner, U. (2008). A DST model of multilingualism and the role of metalinguistic awareness. *The Modern Languages Journal*, *92*, 270-283.

Johnson, K. (2004). On the systematicity of language and thought. *Journal of Philosophy*, *101*, 111–139.

Kriete, T., Noelle, D.C., Cohen, J.D., & O'Reilly, R. C. (2013). Indirection and symbol-like processing in the prefrontal cortex and basal ganglia. *Proceedings of the National Academy of Sciences U.S.A*, *110*, 16390-16395.

Kroll. J.F. & Gollan, T.H. (2014). Speech planning in two languages: what bilinguals tell us about language production. In V. Ferreira, M. Goldrick, & M. Miozzo (Eds.) *The Oxford Handbook of Language Production* (pp. 165-181). Oxford, UK: Oxford University Press.

Kroll, J.F., Bobb, S.C., & Wodniecka, Z. (2006). Language selectivity is the exception, not the rule: Arguments against a fixed locus of language selection in bilingual speech. *Bilingualism: Language and Cognition, 9,* 119–135.

Kroll, J.F., Dussias, P.E., Bice, K., & Perrotti, L. (2015). Bilingualism, mind & brain. In M. Liberman & B.H. Partee (Eds.), *Annual Review of Linguistics*, *1*, 377-394.

Lashley, K. S. (1951). The problem of serial order in behavior. In L. A. Jeffress (Ed.), Cerebral mechanisms in behavior: The Hixon symposium (pp. 112–136). New York, NY: Wiley.

Lesage, E., Morgan, B.E., Olson, A.C., Meyer, A.S., & Miall, R.C. (2012). Cerebellar rTMS disrupts predictive language processing. *Current Biology, 22*, R794-R795.

Libben, M.R. & Titone, D.A. (2009). Bilingual lexical access in context: evidence from eye movements during reading. *Journal Experimental Psychology: Learning. Memory & Cognition, 35*, 381-390.

MacWhinney, B. (2005). A unified model of language acquisition. In J. F. Kroll & A. M. B. de Groot (Eds.) *Handbook of bilingualism: Psycholinguistic approaches*. (pp. 49–67). Oxford: Oxford University Press.

Marian, V. & Spivey, M. (2003). Competing activation in bilingual language processing: within- and between language competition. *Bilingualism: Language and Cognition*, *6*, 97-115.

Marien, P., Engelborghs, S., Fabbro, F., & De Deyn, P. P. (2001). The lateralized linguistic cerebellum: A review and a new hypothesis. *Brain and Language*, *79*, 580-600.

Morales, J., Gómez-Ariza, C.J., & Bajo, M.T. (2013). Dual mechanisms of cognitive control in bilinguals and monolinguals. *Journal of Cognitive Psychology*, *25*, 531-546

Muysken, P. (2000). Bilingual speech: A typology of codemixing. Cambridge: Cambridge University Press.

Paradis, M. (2009). *Declarative and Procedural Determinants of Second Languages Studies in Bilingualism,* Amsterdam: John Benjamins.

Pickering, M & Garrod, S. (2013). An integrated theory of language production and comprehension. *Behavioral and Brain Sciences, 36*, 329-347.

Pliatsikas, C., Johnstone, T., & Marinis, T. (2014). Grey matter volume in the cerebellum is related to the processing of grammatical rules in a second language: a structural voxel-based morphometry study. *Cerebellum, 13*(1), 55-63.

Ripollés, P., Marco-Pallarés, J., Hielscher, U., Mestres-Missé, Tempelmann, Heinze, H-J., Rodríguez-Fornells, A., & Noesselt, T. (2014). The role of reward in word learning and its implications for language acquisition. *Current Biology*, *24*, 2606-2611.

Rothman, J. (2011). L3 syntactic transfer selectivity and typological determinacy: The Typological Primacy Model. *Second Language Research, 27,* 107–127.

Rothman, J. (2015). Linguistic and cognitive motivations for the Typological Primacy Model of third language (L3) transfer: Timing of acquisition and proficiency considered. *Bilingualism: Language and Cognition, 18*, 179-190.

Rothman, J., Bañón, J.A., & Alonso, J.G. (2015). Neurolinguistic measures of typological effects in multilingual transfer: Introducing an ERP methodology. *Frontiers in Psychology: Language Sciences, 6*: 1087.

Sanz, C, Park, H.I. & Lado, B. (2015). A functional approach to cross-linguistic influence in *ab initio* L3 acquisition. *Bilingualism: Language and Cognition*, *18*, 236–251.

Silbert, L.J., Honey, C.J., Simony, E., Poeppel, D., & Hasson, U. (2014). Coupled neural systems underlie the production and comprehension of naturalistic narrative speech. *Proceedings of the National Academy of Sciences U.S.A*, *111*, E4687-E4696.

Silveri, M. C., Leggio, M. G., & Molinari, M. (1994). The cerebellum contributes to linguistic production: A case of agrammatism of speech following right hemicerebellar lesion. *Neurology, 44,* 2047-2050.

Slabakova, R. (2016). The scalpel model of third language acquisition. *International Journal*

Tanner, D., Inoue, K., & Osterhout, L. (2014). Brain-based individual differences in online L2 grammatical comprehension. *Bilingualism: Language and Cognition*, *17*, 277-293.

Thierry, G. & Wu, Y.J. (2007). Brain potentials reveal unconscious translation during foreign language comprehension. *Proceedings of the National Academy of Sciences USA, 104*, 12530-12535.

Tyson, B., Lantrip, A.C., & Roth, R.M. (2014). Cerebellar contributions to implicit learning and executive function. *Cognitive Sciences*, *9*, 179-217.

Ullman, M. T. (2001). The neural basis of lexicon and grammar in first and second language: the Declarative/Procedural Model. *Bilingualism: Language and Cognition, 4*, 105-22.

Van Gelder, T. (1990). Compositionality: A connectionist variation on a classical theme. *Cognitive Science*, *14*, 355–384.

Van Hell, J.G., & Dijkstra, T. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin and Review*, *9*, 780-789.

Westergaard, M., Mitrofanova, N., Mykhaylyk, R., & Rodina, Y. (2016). Crosslinguistic influence in the acquisition of a third language: the linguistic proximity model. *International Journal of Bilingualism*. doi: 10.1177/1367006916648859.