Doctoral Exam #1

**The role of Cognitive Control and Proficiency**

**in Second Language and Heritage Language Syntactic Disambiguation**

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**Introduction**

With recent advancements in the online measures used to study sentence processing and the psychological components involved in these processes, many questions have emerged, especially questions regarding sentence processing in bilinguals, a group historically understudied in the various interdisciplinary fields involved in sentence processing. Even more grave, a great number of studies conflate different language profiles into the broader ‘bilingual’, even though these distinctions may result in entirely distinct linguistic and cognitive development patterns, suggesting that research explicitly exploring these narrower profiles is in order.

One recent trend in research builds on the association between cognitive control and conflict resolution to determine how the linguistic system engages with conflict. However, how different language profiles engage with conflict, particularly in a second or non-dominant language, remains entirely unclear. In what follows, I will motivate research that considers the role of cognitive control during sentence processing at different proficiencies for the adult second language learner and at different levels of language dominance in the heritage language bilingual. This research will bridge findings from several different fields of cognitive science, particularly second language acquisition, psycholinguistics and neuroscience and neuroimaging.

**Sentence processing**

When participating in a conversation, it’s commonly assumed that it is the content of the conversation that creates difficulty for an interlocutor: the more unfamiliar the content, the more difficult. In some cases, we hear reference to ‘ten-dollar words’, suggesting that a participant in a conversation may also experience difficulty from the unfamiliar lexicon of their partner. The grammatical or syntactic structure of the speech often seems entirely unremarkable. However, sentence processing is a highly complex system, incorporating various levels of coordination. Although this coordination is very rapid and generally very smooth, there are cases in which a syntactic peculiarity is encountered that causes a processing interruption, or ‘boggle’. One particularly frequent example is the famous garden-path below:

1. *The horse raced past the barn fell.*

While this garden-path is unlikely to be encountered in daily communication, linguists often use it to discuss the need for reanalysis that would present itself, were it to be encountered ‘in the wild’. Given the linear nature of spoken (and written) language, the parser must create the syntactic structure online as they are encountered, processing new items and incorporating them into the existing structure according to syntactic rules and restrictions. In (1), the parser would first interpret *raced* as the main verb of the sentence. However, when the listener encounters *fell*, she must abandon her incorrect analysis and re-interpret the sentence in order to acquire the correct interpretation within a grammatically licit structure, such that *raced past the barn* is a reduced relative clause (RC) (i.e. *~~that was~~ raced past the barn*) while *fell* fills the role of main verb.

**Models of Sentence Processing**

The example in (1) presents a case of reanalysis, which has received significant attention in the sentence processing literature and has been used to build several models of parsing, generally divided into universal (two-phase) parsers and Constraint-based (one-phase) parsers. Frazier and colleagues’ Garden Path model (and its later update, Construal Theory) is the predominant two-phase model (Frazier & Fodor, 1978; Frazier & Clifton, 1998). Constraint-based or experience-based models (e.g. Cuetos & Mitchell, 1988; Trueswell, Spivey-Knowlton, Eberhard & Sedivy, 1995; MacDonald Pearlmutter, Seidenburg, 1994) have received more recent focus.

**Two-phase parsers**

In the two-phase models, put forward by Frazier, Fodor and colleagues, the parser’s first pass incorporates new material into the active syntactic structure using a highly restricted system of incorporation limited to the syntax. This is driven by syntactic economy, specifically Frazier’s Minimal Attachment principle, which requires the first pass to create the structure that requires the fewest syntactic nodes while remaining grammatically-permissible, as well as Frazier’s (1978) Late Closure principle, which requires new material be incorporated into the current constituent whenever grammatically possible. Thus, only the lexical items’ subcategorization information (e.g., part of speech) is consulted when constructing the syntactic structure. The parser’s second-phase considers semantic and pragmatic information beyond the syntax, and if a boggle is encountered, the parser rejects the structure and initiates a reanalysis.

Following evidence that identical syntactic structures with differing lexical items may cause differences in ease of recovery or reanalysis based on biases of the lexical items, these researchers updated their two-phase model with the Construal Theory (Frazier & Clifton, 1998). Construal Theory allows lexical information, such as bias or frequency data, to be consulted during the second phase. Compare the following structures, each with temporarily ambiguous structures that require reanalysis:

(2a) *The woman knew the nervous man would leave*. (Ferreira & Henderson, 1998, 6a-b)

(2b) *The woman saw the nervous man would leave.*

Both main verbs can assume either a noun phrase (NP) or a propositional complement (CP). According to Construal Theory, then, *the nervous man* would be incorporated into the structure as a NP in order to minimize the number of nodes used during the first phase. However, upon encountering *would leave*, the parser must reanalyze *the nervous man* as the subject of a CP and reconstruct the structure accordingly. Here, the CP-bias of *know* makes reanalysis simpler than reanalysis of (2b), where *saw* has a NP-bias (Ferreira & Henderson, 1998).

**Constraint-based models**

Despite its update to incorporate lexical biases, the Garden Path/Construal model cannot account for preferences that go beyond lexical biases to cross-linguistic phenomena. Differences in Spanish- and English-speaker preferences related to RC attachment were among the first of these cross-linguistic preferences observed. Specifically, RC attachment preferences in multiple genitive constructions that do not inherently cause boggles (i.e. not ungrammatical but rather fully ambiguous without the appropriate context) cast the two-phase, syntactically-restricted parser into doubt. Consider the following:

(3a) *El periodista entrevistó a la hija del coronel que tuvo el accidente.*

(3b) *The journalist interviewed the daughter of the colonel who had had the accident*[[1]](#footnote-1).

The preference in Spanish is for the high-attachment reading that the daughter had the accident, which contrasts with the English preference that the colonel had the accident (Cuetos & Mitchell, 1998). More importantly for theoretical purposes, it also contrasts with the universal preference that the Late Closure principle would force. In addition, a corpus study showed that exposure to the high-attachment is, in fact, much more frequent in Spanish (Cuetos, Mitchell & Corley, 1996), which suggests that exposure-frequency accounts for cross-linguistic preferences, a finding that has been supported by more recent research.

Most current research in sentence processing recognizes this need for the parser to consider several sources of information simultaneously: frequency, syntax, semantics, and discourse, for example, may all contribute to the resolution of ambiguity during one-pass processing. Evidence shows that parsers do use information beyond the syntax to correctly process during the parse, providing evidence for these Constraint-based models (Tanenhaus et al., 1995; Trueswell, Tanenhaus, & Garnsey, 1994; Novick, Thompson-Schill & Trueswell, 2008; Pozzan & Trueswell, 2015). One example within the research of Trueswell and colleagues is the use of referential context in the visual-world paradigm through controlled definite article use. When there are two competitors in the visual world, the use of a definite article triggers participants to expect the following information to specify which of the two competitors is being referred to, as the use of a definite article is otherwise anomalous.

While the specific models are still underspecified, certain assumptions are characteristic of them all: an ambiguous strain results in multiple alternatives through bottom-up processing, and constraining evidence from several domains is integrated on the first pass to resolve the ambiguity, or rather, to select the most felicitous option. However, the extent to which each domain plays a role varies from model to model (for example, Tanenhaus et al., 1995; MacDonald et al., 1994). These models have been shown to account for phenomena associated with bilingual sentence processing, as well, an area of psycholinguistic research that remains highly understudied.

**Parsing in bilinguals**

Different aspects of the nature of bilingual processing research likely contribute to the many gaps in this research, including the many variables that must be controlled when studying bilingual participants as well as the dearth of a clear understanding of the monolingual parser (Dussias, 2001). However, the bilingual parser is a key component to understanding the human language parser, and as methodological practices and tools improve, bilingual sentence processing research should be a more motivated area of research. This is particularly true provided that the bilingual is the norm in the global context (Linguistic Society of America, 2012).

The first study to investigate processing of the ambiguities such as those discussed above by bilingual speakers worked within a framework of Universal Grammar, supposing that language acquisition is driven by an internal, innate mechanism, and that adult language learners fail to learn a second language (L2) to a native-like level because they use processes, including processing strategies, of their first language (L1) (Fernández, 1995, 1999). Fernández’s study, which included monolingual English speakers and early and late L1-Spanish L2-English bilinguals, found the strongest preference for Late Closure (or low attachment) among the monolinguals (73% preference), followed by the early bilingual group (49%) and late bilingual group (37%), figures which were not significantly different, though finer-grained analyses did show differences between these groups. This suggests that the exposure to English shifts preferences of the native Spanish speakers towards a more English-like bias, though at a greater extent of a shift of preference for earlier bilinguals.

Dussias (2003) tested Spanish-English bilinguals in both languages, investigating preference for RC-attachment. While monolingual control groups showed the previously observed preferences for high- and low-attached RCs (Spanish and English, respectively), both English- and Spanish-dominant bilinguals preferred low attachment. She suggests that amount of exposure may play a role in these preferences. This question was subsequently investigated by Dussias and Sagarra (2007), who forced high attachment or low attachment using noun-adjective agreement and utilized a self-paced reading methodology. They elaborated the question to include exposure, with groups sorted into monolinguals, bilinguals with limited exposure, and bilinguals with extensive exposure. The authors found that extensive exposure to the low-attachment-heavy L2 greatly facilitated total reading times in the L1, diverging from the native monolingual and limited-exposure bilingual data. These findings all suggest that experience plays a major role in bilingual processing, providing further evidence for an exposure-based model of processing.

**Cognitive Control in Disambiguation**

The language ambiguities included above are cases of information conflict. Reconsider the classic example from (1): *The horse raced past the barn fell.* The conflict in this case lies between the lexical items in the input and the syntactic structure constructed during the parse. Much of the early processing literature considers ambiguous sentences, especially RC-attachment in double genitive constructions, such as (3a-b) (e.g. Cuetos & Mitchell, 1988; Cuetos et al., 1996; Dussias, 2003; Fernández, 1995, 1999). More recent research tends to focus on temporarily ambiguous constructions such as (2a-b). Temporary ambiguities are resolved as more information is obtained from the input; in the case of (2a-b), later material forces the parser to reinterpret a noun as the subject of a CP instead of a direct object. Temporary ambiguities can also use gender agreement (e.g., Dussias & Sagarra, 2007), or strong structural preferences in one direction (e.g., subject-first RC word order, Teubner-Rhodes et al., 2016). Consider the following example from Teubner-Rhodes and colleagues, where the subject-first interpretation is much preferred:

(4a) *Este es el general que vigilaba al espía desde la ventana.*

“This is the general that watched the spy from the window.”

(4b) *Este es el general que vigilaba el espía desde la ventana.*

“This is the general that the spy watched from the window.” (Teubner-Rhodes et al., 2016, 1-2)

These temporarily ambiguous structures are used to allow for online data collection, such as eye-tracking, self-paced reading, ERPs or fMRI scans. With these methodologies, researchers can collect data that reveals resolution of the ambiguity and not just preferences for a certain structure (for example, compare Dussias & Sagarra, 2007, and Dussias, 2003).

Cognitive control, the ability to resolve information conflict, is required to correctly interpret all of these garden-paths, temporary or not. I assume the term ‘cognitive control’, as opposed to other terms such as ‘inhibitory control’, following other researchers who reason that conflict can be resolved through *inhibition* of irrelevant information or *promotion* of relevant information, or a combination of both (Botvinick, Braver, Barch, Carter & Cohen, 2001; Teubner-Rhodes et al., 2016). The use of online measures has allowed researchers to isolate the region of the brain involved in cognitive control: data from psycholinguistic, neuropsychological and imaging studies converge to show that linguistic ambiguity resolution and non-linguistic cognitive control processes co-localize within the left ventrolateral prefrontal cortex (specifically the left anterior frontal gyrus, LIFG, and anterior cingular cortex, ACC) (Thompson-Schill, Bedny, & Goldberg, 2005; Novick, Kan, Trueswell & Thompson-Schill, 2009, 2014; January, Trueswell, Thompson-Schill, 2009, Teubner-Rhodes et al., 2016). This region, then, can be considered the center for the correct selection of information during goal-specific tasks, and in the case of sentence processing, it allows the abandonment of an incorrect initial analysis to facilitate correct comprehension (Novick, Trueswell & Thompson-Schill, 2005).

**Cognitive Control: a ‘bilingual advantage’?**

While extensive evidence exists to support a ‘bilingual advantage’ in cognitive control, certain researchers have called into question this advantage. Therefore, the population still affords several questions to psycholinguists regarding exactly *how* a bilingual advantage might transcend into sentence processing, especially provided that much of the work on ‘bilingual advantages’ considers non-linguistic constructs.

**Bilingualism and Cognitive Individual Differences**

Psychological research has revealed that for many populations, the increased use of a certain behavior results in observably improved skills on similar tasks or in observable differences in associated brain structures. For example, architects outperform non-architects on tasks evaluating visuo-spatial ability (Salthouse & Mitchell, 1990), and video game playing has been correlated to heightened modification of perceptual-motor ability (Abutalebi et al., 2012). Just as video-gamers and architects serve as easily identifiable population distinctions, so too is the bilingual. Although ‘architect’ proves to be a much simpler population to isolate, psychologists and psycholinguists have shown that bilinguals differ from their monolingual counterparts in many different facets, both physiologically and behaviorally (Bialystok, 2008).

One reality of the bilingual that distinguishes him from his monolingual peer is the consistent need to suppress one language according to the context. The bilingual does not separate the mental lexicons and grammars, but rather both are active during any language use (Kroll & de Groot, 1997). This perpetual activation was the subject of Green’s (1998) Inhibitory Control (IC) model of bilingual language processing, and has been attested in behavioral studies (e.g. Kroll & Bialystok, 2013; Kroll & Sunderman, 2005); imaging studies (e.g. Abutalebi et al, 2012); and patient data (e.g. Abutalebi, Miozzo & Cappa, 2000).

Within Green’s (1998) IC model, the competitor is suppressed by inhibitory control (or cognitive control). Given two competing forms, the salient but contextually-infelicitous form is suppressed by cognitive control while the desired form is promoted. This model and much of the early research that followed investigated whether this constant activation of cognitive control led to improved performance of bilinguals on nonlinguistic tasks, based on the idea that consistent use of cognitive control would lead to more apt cognitive control (see Bialystok, 2008, for a review). This would become known as the ‘bilingual advantage’. Bilingual advantages have subsequently been attested through neuroimaging and behavioral studies. In neuroimaging, larger gray matter volume has been observed in brain areas that serve executive functioning (Olulade et al., 2015). Likewise, the ACC and the LIFG, both neural structures involved in conflict detection and resolution, the activation of which correlates to poorer performance on conflict tasks, have been observed to be activated more by monolinguals than by bilinguals when performing high-conflict tasks (Abutalebi et al., 2012, Abutalebi, 2008). Likewise, a large effect-size was observed in a meta-analysis conducted by Adesope, Lavin, Thompson and Ungerleider (2010), comparing attentional control of monolingual and bilingual populations, which suggests another bilingual advantage in attentional control. In a high-conflict N-back task, Teubner-Rhodes and colleagues (2016) observe more accurate performance by bilinguals regardless of trial type (lures, targets and fillers), suggesting an advantage that extends beyond conflict resolution to conflict monitoring, a cognitive capacity that becomes especially important in high-conflict contexts when the need for conflict resolution is decided on a moment-to-moment basis. This finding is supported by previous findings (Botvinick et al., 2001; Kerns et al., 2004). However, it should be noted that this advantage has not been found to extend to late bilinguals, i.e. classroom learners, whose performance on a flanker task was compared to that of early bilinguals and monolinguals and found not to differ from the monolingual performance (Luk, De Sa & Bialystok, 2011; but compare Torres & Sanz, 2016, who study heritage language bilinguals and find no difference between late bilinguals and heritage learners, addressed further below).

As far as linguistic development, bilingualism has also been connected to certain ‘disadvantages’, including decreased vocabulary size in one language (e.g. comparing English vocabulary size of monolingual English speakers and bilingual speakers who speak English and another language) (Bialystok, Luk, Peets & Yang, 2009; Bialystok & Luk, 2011); slower lexical access in picture-naming tasks (Gollan, Fennema-Notestine, Montoya, & Jernigan, 2007) and lexical decision tasks (van Hell & Dijkstra, 2002); and decreased verbal fluency in semantic (or categorical) and phonemic (or letter) fluency tasks (e.g. Gollan, Montoya & Werner, 2002; Rosselli et al., 2000). However, when bilinguals are compared to monolinguals of equivalent vocabulary size, bilinguals were shown to perform better in this same task (Bialystok, Craik, & Luk, 2008). These differences, among many observed in the research of Bialystok and colleagues, are attributed to the perpetual activation of both languages during an extended period of time (compare late bilinguals in Luk et al., 2011), thus causing consistent competition and conflict during language use between first- and second language forms.

However, the research has not always so neatly fit within Green’s IC model. Principle among the critiques are Hilchey and Klein (2011), whose extensive review compiled bilingual research and suggested that these ‘advantages’ are not as all-encompassing as the research may suggest. Often, there is a major effect of time, where bilinguals have an initial advantage on non-linguistic cognitive control tasks that dissipates after extensive practice (e.g. Costa, Hernández & Sebastián-Gallés, 2008). Similarly, Paap and Greenberg (2013) found no bilingual advantage in three executive function tasks. In a later review, upon tabulating 76 additional studies that were not considered in Hilchey and Klein’s review, Paap, Johnson and Sawi (2014) found that there was a clear tendency to find bilingual advantages in studies with fewer participants, while null findings were often found regardless of *n*-size. However, the task effect observed by Paap and Greenberg (2013) and the tendency not to find effects in immense studies (Paap et al., 2014) does not necessarily imply that bilingual advantages do not exist. Rather, it leads to a methodological issue: are we asking the right question? While we know that the flanker task requires cognitive control, for example, is the complexity of the task sufficient to observe an extended bilingual advantage in this capacity, if this does exist? A correlational study can only reveal as much as the tools allow, and it may be the case that a flanker task does not simulate sufficiently the complex conflict encountered during language processing.

Another major issue recently observed in bilingual research relates to distinct populations’ representation in the literature (e.g., Torres & Sanz, 2016; Paap & Greenberg, 2013). Given the blurry nature of bilingualism, an umbrella term with many interacting variables, such as biliteracy (see Sanz, 2000; Costa et al., 2008), and which can be used to include diverse populations, ranging from those who use two languages on a daily basis to those who interact with their non-dominant language only very infrequently (Linguistic Society of America, 2012), future research in bilingual sentence processing should include distinct populations to grasp how variables such as literacy, dominance and age of acquisition play a role in processing and how the bilingual advantage may differ between populations. I address the latter question regarding population controls first, followed by the former, methodological question.

**Heritage Speakers and Cognitive Individual Differences**

As Torres and Sanz (2016) address, many studies that consider bilingual speakers may not sufficiently separate distinct language profiles such as heritage language (HL) bilinguals, despite researchers in both camps having asserted that a host of social, economic and other circumstances contribute to linguistic and cognitive development (Hilchey & Klein, 2011; Bialystok, 2008). The bilinguals in some research, such as the Catalonians studied by Costa and colleagues (2008), for example, received bilingual education, thereby possessing an inherently different language profile from HL bilinguals in the US, many of whom have a certain degree of proficiency at an early age and use their HL in their homes but not in school, work or other environments (Polinsky & Kagan, 2007). Even this definition of HL bilinguals is simplistic, though a more detailed definition is beyond the scope of the present project. Torres and Sanz (2016) are the first to bridge and important gap: although much bilingual research likely considers heritage speakers, very few isolate HL bilinguals to investigate the effect of this distinct language profile on cognition; likewise, most research exclusively considering heritage language speakers approaches the population from a perspective that is sociolinguistic (e.g. Goble, 2016), pedagogical (e.g. Polinsky & Kagan, 2007), or developmental (e.g. Benmamoun, Montrul & Polinsky, 2013). Torres and Sanz are the first researchers to isolate this language profile to search for a HL bilingual advantage. The authors find no differences between HL bilinguals and late classroom-emerging bilinguals of Spanish in performance on the Attentional Network Task (ANT), developed to measure cognitive control by (Fan, McCandliss, Sommer, Raz, & Posner, 2002). However, the researchers did note that data trended to show that HL bilinguals resolved conflict easier and at fewer inter-task costs.

While Torres & Sanz (2016) take the important first step to investigate how or whether cognitive differences exist between HL bilinguals and late-L2 bilinguals, differences in the *employment* of executive control during linguistic tasks, such as ambiguity resolution, remain to be investigated. Indeed, the participants of both groups sampled are at the prime age of cognitive control, and so although we don’t see differences in performance on the ANT, a task for which task effects have been observed (see Hilchey & Klein, 2011), temporary ambiguity resolution involves much more coordination. Therefore, a linguistic task modulated by a non-linguistic cognitive control task (i.e. a conflict adaptation paradigm) may raise task difficulty to the point of revealing the subtle differences in young adult bilinguals that we cannot observe in strictly nonlinguistic tasks, as discussed above.

In addition, recent neuroimaging studies suggest that it is *language switching* in particular that may be the key factor for the bilingual advantage (Abutalebi et al., 2012). In this neuroimaging study, bilinguals were required to switch languages during a picture-naming task, a process which showed a hemodynamic response in the same region as conflicting flanker trials. Likewise, in a study in progress, heritage speakers were presented with a subcomponent of the ANT following four separate blocks of linguistic ambiguities (English, Spanish, inter-orational code-switches, and intra-orational code-switches), and reaction time and accuracy following the intra-orational code-switches improved beyond the other three blocks (Adler, in progress). This again suggests that frequent alternation between languages may require more cognitive control resources, regardless of whether bilinguals have more cognitive control resources at their disposal, in the vein of Bialystok and colleagues. As Teubner-Rhodes and colleagues suggest, “bilingualism apparently acts as a form of cognitive control training, bestowing measurable advantages in conflict monitoring – the ability to detect unpredictable conflict and flexibly adjust recruitment of cognitive control resources” (Teubner-Rhodes et al., 2016, p. 227). Therefore, to understand the role of HL bilingualism on cognitive control activation during linguistic tasks, researchers should also consider how frequency of use and dominance contribute to cognitive control demands and use of resources.

**Second Language Acquisition and Cognitive Individual Differences**

Cognitive individual differences in language acquisition have been an area of much research within psycholinguistics (Pozzan & Trueswell, 2015; Kroll & Sunderman, 2005, among many others), neuroimaging and cognitive psychology (Abutalebi, 2008; Abutalebi & Green, 2007; Indefry, 2006, among others), and Second Language Acquisition (Serafini & Sanz, 2016; Linck et al., 2013, among many others). Many of these studies observe a decreased role of cognitive control as language proficiency develops. Consider the behavioral data collected in previous studies, for example. Serafini & Sanz (2016) conducted a longitudinal study with proficiency as an independent variable. They measured the role of cognitive functions in the acquisition process by comparing automaticity of ten different morphological structures in Spanish, two cognitive variables (cognitive control[[2]](#footnote-2) and phonological short term memory), within different proficiency groups (beginning, intermediate and advanced learners). The authors only observed robust correlations between linguistic performance and cognitive variables for beginners, while more advanced learners revealed far fewer significant correlations between linguistic and non-linguistic performance, suggesting a decreased reliance on the ability to encode, store and retrieve information as exposure and proficiency increase in classroom learning. While Serafini and Sanz (2016) are among the very first researchers to specifically compare the role of cognitive functions at various points of L2 proficiency using the same assessment measures, their findings do fit within a long line of previous research supporting the finding of a differential influence of cognitive function at early but not later stages of language learning (compare Linck & Weiss, 2011; Sagarra & Herschensohn, 2010, vs. Grey, Cox, Serafini & Sanz, 2015; however, see Linck et al., 2013 for a review).

These behavioral findings are also supported by neuroimaging data. Collecting neuroimaging data from several fMRI and PET studies of neural structures during bilingual processing, Abutalebi (2008) observed increased activity of the LIFG and other prefrontal structures critical for cognitive control among participants processing a non-native, non-proficient language. The suggestion of this finding is that, as the speaker attains a sufficient level of L2 proficiency, the extra activity fades (Abutalebi & Green, 2007). Bear in mind that the role of cognitive control is to promote relevant information (or suppress irrelevant information), which in the case of bilingual processing can be considered competing forms and linguistic structures, i.e. conflict between languages, and as repeated activation strengthens these networks, the need for cognitive control to intervene decreases (Fedorenko & Thompson-Schill, 2014). Researchers disagree whether this decreased activity is a convergence to the activity involved in L1 activity or if the decreased activity is better understood within the notion of neural organizational efficiency (Indefrey, 2006). However, for our purposes, the observation that there is decreased hemodynamic activity is sufficient to suggest that cognitive control’s influence lessens with increased L2 proficiency.

As Serafini and Sanz (2016) observe, their study is among the first to use the same targets across proficiencies to compare cognitive engagement at different stages of learning, but it considers a range of ten linguistic structures. They motivate the need to isolate fewer specific targets to increase subsequent studies’ power. One target that can serve to fill this gap is syntactic temporary ambiguities, which have been shown to directly engage cognitive control. The authors encourage maintaining a cross-sectional study, which would permit a more detailed understanding of the working memory constructs involved at increasing levels of L2 development. Recent research in child language processing conducted by Pozzan and Trueswell (2015) has also motivated this same cross-sectional study of cognitive control and ambiguity resolution, creating an opportunity for cross-field communication, as will be discussed below.

**L2 Sentence Processing and Ambiguity Resolution**

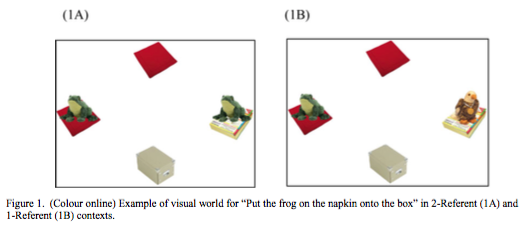
Children present a particular difficulty abandoning an initial interpretation when parsing a temporarily ambiguous sentence Trueswell, Sekerina, Hill & Logrip, 1999). This so-called ‘kindergarten-path effect’ has been associated with immature cognitive control as a result of protracted maturation of prefrontal cortical structures (Choi & Trueswell, 2010; Novick et al., 2005; Woodard, Pozzan, & Trueswell, 2016). Difficulty of the same nature has been observed in patients with impaired cognitive control due to brain damage in these same areas (Novick et al., 2009).

In a recent study, however, Pozzan and Trueswell (2015) question whether the difficulties observed in child processing of syntactic garden-paths are better explained as a L1 learner phenomenon, rather than due to immature cognitive control. In order to investigate this, they study L2 learners’ reanalysis of the same garden-paths used to study child disambiguation. They reason that children will differ from adults (both native and L2 speakers) if these differences relate to immature cognitive control, but that L1 and adult L2 learners will obtain similar results if these difficulties are a learner phenomenon. Importantly, however, a third possibility exists: that L2 processing impinges on cognitive control, which makes learners perform like children during disambiguation. That is, similar results may be obtained, not because the structure is difficult for both sets of learners but because low-proficiency L2 processing occupies cognitive control abilities in adults (Abutalebi, 2008), making comprehension run aground in cases when revision is needed, as is the case in children for whom these same abilities have not yet fully developed.

In their study, native speakers of English and intermediate L2 learners of English (L1 = Italian) participated in a two-by-two study design, allowing researchers to consider the role of syntactic ambiguity (temporarily ambiguous vs. unambiguous) and referential context (though this condition is not pertinent to the current proposal, as L2 adults performed like L1 adults in this aspect). Participants listened to temporarily ambiguous sentences, as in (5a), or unambiguous sentences, as in (5b), while also presented with a coordinating visual world (such as 5c) with a target (*frog on the napkin*), a goal (*box*), a competitor-target (*frog on the phonebook* or *eagle on the phonebook*, depending on referential condition), and a distractor-goal (*napkin*):

5a. *Put the frog on the napkin onto the box*. (Pozzan & Trueswell, 2015)

5b. *Put the frog that’s on the napkin onto the box*.

5c.

During processing of the temporarily ambiguous sentence, the first prepositional phrase encountered tends to be interpreted as the goal rather than the modifier, but upon reaching the disambiguating information, the parser must reinterpret the sentence’s syntactic structure to reach the appropriate interpretation.

L2 adults’ behavioral and eye-movement data reflected increased consideration of the incorrect goal. This is the same patterns observed in children during the abandonment of incorrect parses (Trueswell et al., 1999), while native adults are far superior in reanalyzing the structure at this point. However, as noted, the L2 adults did use referential context while processing, while children do not to the same extent, providing evidence that the mature parser does indeed incorporate more information into the one-pass analysis, which is foundational for visual-world studies (e.g. Trueswell et al., 1999; Tanenhaus et al., 1995). The researchers suggest that the similarity of the parsing difficulties may be attributable to fully engaged cognitive control in the low-proficiency L2 participants. However, due to the limited scope of the study, they cannot make this conclusion beyond speculation. The study aimed to fill a gap in the research on child language processing. In turn, it opened a gap in L2 sentence processing. Because the researchers only included L2 learners of one proficiency level (intermediate, as assessed by the oral comprehension subtest of the Michigan Test of English Language Proficiency), the decreased ability for revision of the garden-paths may be the result of task difficulty for the intermediate learner. Pozzan and Trueswell open the opportunity to study how successful disambiguation of syntactic garden-paths at different stages of L2 proficiency correlates to performance on the ANT, in order to understand the correlation between cognitive control and L2 sentence processing of ambiguities across the learning process. However, as will be motivated below, through a slight modification of the paradigm to modulate conflict engagement, a second study can also make causational claims about cognitive control’s involvement in this process.

**Conflict Detection and Conflict Adaptation**

The detection of conflict, linguistic or otherwise, has been shown to trigger sustained cognitive control; for example, the Stroop effect can be lessened for an incongruent trial if it is immediately preceded by another incongruent trial (Freitas, Bahar, Yang, & Banai, 2007; Kerns et al, 2004). This pattern has also been observed in adults’ performance on cross-task conflict adaptation, where recovery from an incorrect interpretation due to syntactic ambiguity is facilitated when the language-comprehension trial is immediately preceded by a conflict Stroop trial (Hsu & Novick, 2016). The opposite has also been found, where linguistic conflict in a preceding trial can improve performance on non-linguistic conflict resolution tasks, such as the ANT (Adler, in progress).

However, a different pattern has been observed in children: while conflict engagement results have been found within singular task designs for children (e.g. incongruent Stroop trial preceding incongruent Stroop trial), in a cross-task design, recovery from syntactic misanalysis is more difficult following an incongruent Stroop trial (Huang, Gerard, Hsu, Kowalski & Novick, 2016), and again, patients with damage to the prefrontal cortex have shown similar cross-task difficulties (Novick, personal communication, Nov. 3, 2016). The authors suggest this may be due either to the depletion of immature cognitive control resources or to task difficulty fatigue.

Provided the decreased recruitment of cognitive control-related neural structures (e.g. Abutalebi, 2008) and the decreased role of other executive functions (e.g. Serafini & Sanz, 2016) that is associated with higher proficiencies, the conflict adaptation paradigm can serve as a tool to force specific conflict-engagement states, providing causational data reflecting cognitive control’s role in second language syntactic ambiguity recovery. If cognitive control plays a differential role online at different proficiencies, a conflict adaptation paradigm will reveal different responses from different groups: if cognitive control is not engaged to capacity at higher proficiencies, a garden-path preceded by an incongruent trial will reveal faster disambiguation. However, if cognitive control is fully engaged, an incongruent preceding trial will not be able to trigger cognitive control activation beyond capacity, resulting in similar reanalysis abilities in both preceding-trial conditions. Alternatively, L2 learners with all cognitive control resources engaged will obtain slower reanalysis following incongruencies if they too experience the ‘depletion’ hypothesized to cause these findings in children and patients (Huang et al., 2016).

The same task can inform us of engagement of cognitive control by heritage speakers of different levels of language dominance and frequency of use. Although Torres and Sanz (2016) found no difference between heritage speakers and L2 learners on the ANT, more complex linguistic tasks may reveal differences that the ANT cannot reveal. For example, as mentioned above, Adler (in progress) found improved performance on the ANT following intra-orational code-switches, a finding not obtained following the monolingual or inter-orational blocks, which suggests that frequent language switching requires significant cognitive control resources. A conflict adaptation paradigm may be able to contribute more to our understanding of heritage language learners’ cognitive control recruitment during disambiguation. While Adler (in progress) uses a block-by-block adaptation paradigm to study how linguistic conflict triggers a non-linguistic advantage, a trial-by-trial adaptation may reveal how preceding non-linguistic conflict may improve linguistic-conflict resolution and reanalysis. This question is particularly interesting when paired with language use and dominance data, which may correlate to cognitive control engagement, following previous findings (Adler, in progress; Abutalebi et al., 2012)

**Conclusion: Bridging gaps through interdisciplinary research**

This project has outlined several gaps in the psycholinguistic and second language acquisition research. First, there is a dearth of studies that consider the role of cognitive control at different stages of L2 proficiency by using the same linguistic structures or processes. Cognitive control has been shown to be a vital component of sentence processing, especially the resolution of conflict. Therefore, the current project, following Serafini and Sanz (2016) and Pozzan and Trueswell (2015), motivates research on the relationship between these three variables. By conducting two studies of this nature, one correlational and one causational, we may also contribute to the understanding of the conflict adaptation paradigm in psycholinguistic research, a burgeoning methodology.

Meanwhile, while research has shown that language profile differences make an important difference in linguistic and cognitive development (Hilchey & Klein, 2011; Bialystok, 2001), distinct language populations have tended to be conflated in the literature. Torres and Sanz (2016) take the first step to isolate heritage language learners in the ‘bilingual advantage’ literature, but more research is needed, particularly regarding the role of HL bilingualism in linguistic tasks, such as sentence processing and resolution of garden-paths. Beyond the disambiguation of these linguistic conflicts, cognitive control has also been shown to be particularly relevant in language switching for bilinguals, including HL bilinguals. Therefore, the current study motivates the investigation of a cross-task conflict adaptation task to investigate the role of cognitive control and language use in linguistic conflict resolution.

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1. Examples (1a-b), Ceutos & Mitchell (1998). [↑](#footnote-ref-1)
2. The authors call this variable executive function, a term that, like inhibitory control, has been used in the research to refer to the same psychological component (see Novick et al., 2014). Again, for the sake of consistency, I use ‘cognitive control’, given that its role in the current study will be to resolve conflict. [↑](#footnote-ref-2)