So since bilinguals show an advantage in certain tasks based on distribution/percentage of conflict, but there aren’t many studies that show how there’s a linguistic advantage, it becomes necessary to incorporate research to show how cognitive control (a) plays a role in linguistic tasks (b) plays a role at different levels of the learning process (c)

1. Language processing is complex
   1. Linear nature of sentence processing
   2. Therefore, complex Specifically because of garden paths, boggles and ambiguities
      1. Theories of sentence processing and reanalysis (terminology – late closure, etc)
      2. Theories for bilinguals
2. Disambiguation requires cognitive control
   1. What is cognitive control?
   2. Why does it play a role in disambiguation?
   3. Should it play a role in general language comprehension?
      1. Probably because of suppression of highly active competitors, but once those networks are solid, probably not, (search: cognitive control can be applied uniformly)
   4. How has it been studied?
3. Role of cognitive control in bilinguals
   1. probably decreases across proficiency
   2. bilinguals have increased cognitive control
   3. heritage learners likely have higher cognitive control too, but who knows? Reading?
      1. Language use likely plays a role in how much higher bilinguals’ cognitive control is

Summaries

1. Introduction to sentence processing
   1. More difficult than you think
   2. Garden-paths and introduction to garden-paths
      1. Relative clause and reduced relative clause garden paths, which require reanalysis
   3. Models of parsing
      1. Garden path model (De Vincenzi, 1991; Frazier, 1978; Frazier & Clifton (from Ferreira & Henderson, chapter 3 of Fodor and Ferreira book, p 74)
         1. Adhere to principle of syntactic economy: simplest structure 1st
            1. Parser incorporates new material into the ongoing syntactic structure using as few syntactic nodes as possible
            2. Frazier’s minimal attachment principle is followed even when semantic and discourse-level information seem to indicate that a nonminimal interpretation is likely to be correct (Ferreira & Clifton, 1986; Mitchell et al., 1992; Rayner et al., 1983; Rayner et al., 1992)

However Altmann & Steedman, 1988; Pearlmutter & MacDonald, 1995; Sedivy & Spivey-Knowlton, 1994; Spivey-Knowlton & Sedivy, 1995; Taraban & McClelland, 1989).

*Mary knew Susan would leave*: Susan interpreted as subject of propositional clause instead of as object

My study will have to take certain contextual information (discourse-level) due to the nature of the visual world paradigm

See study referenced in Pozzan and Trueswell about use of referential cues

Thus only strict information is consulted: lexical information; subcategorization, PROSODY

But easy of recovery is influenced by the availability of the alternative structures and by how committed the parser is to the incorrect initial SYNTACTIC and THEMATIC analysis

That is, both syntax ( VERB (OBJ) 🡪 VERB (PROP)) and themes (Susan = theme 🡪 Susan = subject of verb of embedded clause) have to be reanalyzed.

Therefore, in this model, we could really think about *Mary knows Susan* *would leave* as a garden-path as much as *The horse raced past the barn fell*, but one has significantly more ease of recovery due to higher availability of the other structure

However, see length of ambiguous region as an additional source of garden-pathing (Ferreira & Henderson, Ch. 3 of Fodor and Ferreira, specifically section 3.1)

* + - * 1. Then reanalyze when you encounter an unconformable structure
    1. Linguistic Tuning (Ceutos & Mitchell, 1988)
       1. Supported by corpus data that show that Spanish and English do have different preferences for RC attachment
    2. Construal (Frazier & Clifton, 1996)
       1. Counters Linguistic Tuning, returning to a development of the Garden-path model, by considering Norman vs Saxon genitives
    3. Constraint-satisfaction models (using frequency) (MacDonald Pearlmutter, Seidenburg, 1994; Trueswell & Tanenhaus, 1994, MacWhinney & Bates, 1989; See note above i.1.b.i (Altmann & Steedman, 1988; Pearlmutter & MacDonald, 1995; Sedivy & Spivey-Knowlton, 1994; Spivey-Knowlton & Sedivy, 1995; Taraban & McClelland, 1989).
       1. Ambiguity and resolution is guided by lexical information and frequency of use of ambiguous or homophonous tokens
    4. Parsing strategies in bilinguals:
       1. Fernandez (1995) – first to study; framed within UG
          1. Processing strategies of L1 impede full native-like L2 attainment because L1 processes are not optimal in L2
          2. Compared adjuncts to complements
          3. Monolinguals preferred low attachment, then early bilinguals than L2 bilingauls (73% > 49% = 37%)

However, subjects who reported their Spanish language proficiency higher reported higher attachment preferences

* + - 1. Late bilinguals process L2 input by using strategies typical of their L1 (Fernandez, 1995; Dussias, 1998; Dussias, ch 8: Nicol, *One Mind, Two languages*)
         1. However, some conflicting data: some speakers use same strategy regardless of the lang of the input (Fernandez, 1995); Dussias (1998) reached same conclusing with questionnaire and online data.

These results difficult to explain with the construal model.

There’s no way to explain why L1 Spanish bilinguals reading Spanish would show a preference for low attachment which is what the above studies found (Dussias, Fernandez)

Dussias (ch 8 of Nicol) says that this also leads to problems for constraint-satisfaction because if actress had more “modifier-attracting” properties, we’d expect high attachment if actress were higher and low attachment if actress were lower.

However, the consideration here is more for verbs like *know* vs verbs like *saw*. That is, words that *assign* theta-roles.

Best explained by Linguistic Tuning

Reflect construction frequencies in the environment (the Spanish bilinguals live in an English-speaking country, etc.)

* 1. Introduction to temporary garden-paths
     1. Frazier’s Late Closure Principle (incorporate material into the current constituent)
        1. This was challenged as a universal Cuetos & Mitchell with their repeated prep. phrase self-paced reading tasks that showed difference between Spanish and English (Span prefers high attachment)
           1. This leads to competing model for Garden-path model, *Linguistic Tuning* (parser looks to linguistic experience)
     2. In Early Closure sentences (that is, garden-paths), lengthening the ambiguous region of the EC sentence causes comprehension difficulty (Ferreira & Henderson, 1991a – Recovery from misanalysis of garden paths)
        1. However, lengthening LC (that is, non-garden-paths is also costly for comprehension at a significant level, but not so costly (compare LC: 82%-64% to EC: 69%-18%)
        2. However, what is it about lengthening?
           1. Syntactic complexity? No.

*If the clerk forgets the customer (that likes Bobby/with turquoise shoes) typically yells.*

63%--> 35% vs 35% adding 3 words with differing syntactic nodes: more added for *shoes* example

* + - * 1. Increased distance between the head of the ambiguous phrase and the disambiguating word of the sentence? Yes

*While the boy scratched the dog that Sally hates yawned loudly* (24%)

*While the boy scratched the big and hairy dog yawned loudly* (51%)

(head of ambiguous region and disambiguating word adjacent)

1. What causes difficulty?
   1. Repair vs reparse
      1. Repair: must have some way to make the decision of *which* structural changes to make
         1. Thus, repairs’ costs depend on the repair being made
            1. *Know*(DP) vs *Know*(CP) are not such a repair as a PP vs reduced relative clause
         2. 1.c.ii --- it makes sense to talk about frequency models here, even though this comes from Fodor and Inoue Ch. 4 of Fodor and Ferreira, specifically the background
   2. Principles:
      1. Attach – incorporate new word in such a way that it is syntactically well-formed but perhaps incomplete at right edge
      2. First analysis constraint (Frazier & Rayner (1988), Frazier & Fodor, 1978) – if there is more than one way of creating a new well-formed structure, use the fastest
         1. Simplest attachment wins the race – Minimal Everything principle
            1. Minimal attachment
            2. Right association or Late Closure
      3. Attach Anyway – having established that there is no legitimate attachment site in the CPPM (current structure) for the current input word, attach anyway wherever it *least severely* violates the grammar
         1. This should could really be framed as an optimality theory principle, collapsing all of the above into one system with constraints of minimal attachment, right association, etc.
            1. The sick sheep cannot find food for themselves in the winter

Attach anyway forces attachment of *themselves* even though *sheep* is interpreted and modeled by the parser as singular, but then the parser goes back and looks for a plural referent and finds that sheep can be re-interpreted

* + 1. Adjust – when a grammatical conflict has been created, eliminate the problem by altering minimally whichever of X and Y *was less recently acted on* without regard for grammatical conflicts thereby created between that node and other elements in the structure
    2. Revision as a last resort (Fodor & Frazier 1980)
  1. Length (Frazier & Clifton, Ch 5, from Fodor and Ferreira)
     1. Length increases revision cost unless the disambiguation occurs in the ambiguous phrase itself
        1. John will explain to the kids that their grandfather died *tomorrow*
        2. John will explain to the kids that their grandfather died *after the operation they need*.
  2. Semantic reasons (Frazier & Clifton, Ch 5, from Fodor and Ferreira)
     1. Animacy
     2. Anomaly
        1. While Mary was cooking the sky turned grey and dark
        2. While Mary was cooking the soup turned grey and dark

1. ERP data (Friederici, chapter 6, from Fodor and Ferreira)
   1. Subject- vs object-first sentences
2. It may be the case that L2 participants’ parsers use a different reanalysis strategy than that of L1
   1. See Chapter 8, Richard L Lewis on 4 different models (including limited repair, which may for example be a better way to imagine L2 reanalysis)
      1. Backtracking (p.263)
         1. Overt – forward, backward or selective (see refs.)
         2. Covert forward, backward, backward-reuse of well-formed subphrases, selective-limited memory, selective-reuse of well-formed subphrases
      2. Parallel parsing
         1. All paths parsing
         2. Ranked limited path parsing
         3. Multi path parsing with limited memory
      3. Minimal commitment parsing
         1. Lookahead/delay
         2. Under-specified representations
         3. Under-specifiied representations, language-specific control knowledge
      4. Repair parsing
         1. Limited mechanism
         2. Limited control knowledge
      5. (Parsing as incremental restructuring – chapter 10, Suzanne Stevenson, from Fodor and Ferreira)

The effects of bilingualism on conflict monitoring, cognitive control, and garden-path recovery

Susan E. Teubner-Rhodes a,b,⇑, Alan Mishler c, Ryan Corbett c, Llorenç Andreu d, Monica Sanz-Torrent e, John C. Trueswell f, Jared M. Novick b,c,g

Balanced bilinguals—people who are equally proficient in two languages—seem to experience a host of cognitive advantages over monolinguals. This so-called ‘‘bilingual advantage” is evident across the lifespan: young bilingual children outperform monolinguals on executive function tasks requiring inhibition and focused attention (Bialystok, 1999; Bialystok & Martin, 2004; Kovács & Mehler, 2009; Martin-Rhee & Bialystok, 2008); healthy adult bilinguals are faster than monolinguals on cognitive control tasks (Bialystok, 2006; Costa, Hernández, Costa-Faidella, & Sebastián-G allés, 2009); and older adult bilinguals exhibit less cognitive decline due to aging than monolinguals (Bialystok, Craik, Klein, & Viswanathan, 2004; Schweizer, Ware, Fischer, Craik, & Bialystok, 2012).

xist broad, domain-general effects of bilingualism on different tasks involving cognitive control—the ability to regulate mental activity to resolve information-conflict during processing. Here, we use the term cognitive control instead of inhibitory control (or inhibition) to describe this process, because conflict could be successfully resolved by inhibiting irrelevant information, by promoting relevant information, or both (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Despite some evidence supporting a bilingual advantage in cognitive control (Bialystok, 2010; Bialystok, Craik, Green, & Gollan, 2009; Bialystok et al., 2004; Costa et al., 2009; Martin-Rhee & Bialystok, 2008; but see also Hilchey & Klein, 2011; Paap & Greenberg, 2013), there are still several unanswered questions regarding its nature, specificity, and extent.

It is striking that the bilingual advantage is observed on nonlinguistic cognitive control tasks: bilinguals exhibit faster response times (RTs) on (1) the Simon task (Bialystok et al., 2004), in which participants identify a non-spatial attribute of a visual stimulus presented on the same (congruent) or opposite (incongruent) side as the correct response; (2) the Flanker task (Costa et al., 2009), in which participants indicate the direction of an arrow that is flanked by task-irrelevant arrows pointing in the same (congruent) or opposite (incongruent) direction; and (3) the spatial Stroop task (Bialystok, 2006), in which participants indicate the direction of a single arrow that appears on the same (congruent) or opposite (incongruent) side as the correct response. Despite overt dissimilarities, these tasks all involve occasional ‘‘conflict trials,” where task-irrelevant stimulus features provide misleading information; thus, they all require cognitive control to resolve competition between different sources of information.

In his seminal work, Green (1998) proposed the inhibitory control (IC) model of bilingual language processing, which theorized that a central inhibitory-control mechanism played an important role in bilingual language use by suppressing items from the lexicon not currently in use. For instance, bilinguals might inhibit words from their native language (L1) when speaking their second language (L2). Under this model, bilingualism could strengthen domain-general inhibitory control via extensive practice (Abutalebi & Green, 2008; Bialystok et al., 2009), and bilinguals could then apply their improved control to non-verbal tasks.

However, the IC model does not fully account for the diverse empirical evidence supporting an effect of bilingualism on cognitive control. If bilinguals are better specifically at inhibiting irrelevant information, then they should outperform monolinguals selectively on conflict trials where such inhibition is required. Yet in many studies, bilinguals outperform monolinguals on both congruent and incongruent trials (for review, see Hilchey & Klein, 2011). Indeed, in their meta-analysis of bilingual cognitive control studies, Hilchey and Klein (2011) found limited evidence that bilinguals had smaller interference effects than monolinguals, but showed that across studies, bilinguals appeared to enjoy a general advantage as long as the task involved conflict processing. On the basis of such evidence, Costa et al. (2009) proposed that bilinguals have superior ‘‘conflict monitoring”: the ability to detect information conflict and reactively increase cognitive control recruitment (Botvinick et al., 2001). During conflict monitoring, people continuously evaluate input to determine if it contains conflicting sources of information. If so, then cognitive control is recruited to help resolve the competing evidence by inhibiting routine responses or irrelevant information, and/or by promoting correct responses or goal-relevant information; otherwise, cognitive control need not deploy (Botvinick et al., 2001). Cognitive control is thus a sub-component of conflict monitoring that is downstream from monitoring for and detecting conflict (Kerns et al., 2004). Conflict-monitoring demands are high when the input frequently switches between stimuli with and without conflict; people must therefore flexibly recruit cognitive control on a moment-by-moment basis. In such contexts, monitoring facilitates the detection of conflict and subsequent engagement of cognitive control, but it also helps to detect the absence of conflict—monitoring occurs continuously because the individual cannot know a priori if a given stimulus will contain conflict. By contrast, in environments where conflict is always or nearly always present, monitoring demands are low because cognitive control can be applied uniformly (Botvinick et al., 2001; Costa et al., 2009).

Consistent with this account, Costa et al. (2009) found that the magnitude of the bilingual advantage was larger on Flanker task versions with approximately equal proportions of conflict and non-conflict trials than versions with relatively unequal proportions. When congruent and incongruent trials occurred equally often, imposing heavy monitoring demands, bilinguals were significantly faster at both trial types. Yet bilinguals performed no differently from monolinguals when the vast majority of trials (92%) were incongruent (Costa et al., 2009); their advantage disappeared when conflict-monitoring demands were low, despite high cognitive control demands. Moreover, brain-imaging research finds that language switching trials and incongruent Flanker trials co-activate overlapping voxels in the anterior cingulate cortex (ACC), a medial-frontal region thought to be involved in monitoring for conflict and signaling adjustments in control (Abutalebi et al., 2012; see Botvinick et al., 2001). This idea is supported by evidence that conflict-related activity in the ACC is reduced when conflict is expected (Carter et al., 2000) and that the ACC responds to cues indicating the conflict-status of an upcoming trial, regardless of whether that status is congruent or incongruent (Aarts, Roelofs, & van Turennout, 2008). Thus, bilinguals’ experience of language switching may engage and strengthen the domain-general conflict monitoring system.

Despite this evidence, inconsistencies across the bilingualism literature question the robustness of an effect of bilingualism on conflict monitoring and cognitive control. One problem is that monolinguals often ‘catch up’ to bilinguals with a small amount of practice (see e.g., Bialystok et al., 2004; Costa et al., 2009). If one session of practice on the Simon or Flanker task is equivalent to a lifetime of bilingual language experience, then the effect of bilingualism on conflict monitoring and cognitive control seems rather weak—perhaps bilinguals reach a functional limit and are unable to improve further. Yet characteristic cognitive control tasks (e.g., Simon, Flanker) typically yield high performance and bilinguals may already be performing at a task ceiling (e.g., accuracy greater than 97% with reaction times faster than 400 ms across several task blocks; Bialystok et al., 2004); thus it may be impossible to observe continued improvements. The current study examines whether monolinguals and bilinguals benefit differentially from cognitive control practice by administering tasks with initially low performance, allowing for greater practice-related changes, potentially even in bilinguals.

A final issue is that a bilingual advantage is observed in some experiments but not in others, with no apparent pattern to its (non-)occurrence (Hilchey & Klein, 2011; Paap & Greenberg, 2013). Indeed, Paap and Greenberg (2013) assessed the stability of bilingual benefits by administering within-subjects a variety of executive function tasks (Simon, Flanker, Antisaccade, Ravens …

As often as not, bilinguals exhibited a nominal disadvantage relative to monolinguals. The authors acknowledged, however, that correlations among these different tasks are rather weak; thus, the inconsistency in bilingual performance may have been because the tasks largely assessed different components of executive function. A current challenge for bilingual research therefore is to demonstrate that a bilingual advantage occurs consistently across tasks that tap a common cognitive control mechanism. To this end, we test whether bilingual benefits manifest in sentence processing when conflict-monitoring demands are high, and if this performance can be tied to conflict-monitoring abilities in a non-syntactic domain.

3. Do the effects of bilingualism cascade into on-line sentence processing?

Most investigations of bilingualism’s effects on conflict monitoring and cognitive control have been limited to non-linguistic tasks. Yet, if controlled use of two languages enhances conflict monitoring and cognitive control, then bilingualism must impact performance on linguistic tasks involving cognitive control as well. One difficulty with testing this is that bilinguals exhibit slower lexical access in each of their languages (Gollan, Montoya, Cera, & Sandoval, 2008; Ivanova & Costa, 2008; Sandoval, Gollan, Ferreira, & Salmon, 2010), perhaps reflecting increased competition across two constituent lexicons (Spivey & Marian, 1999). Yet little is known about the effects of bilingualism on sentence processing after lexical access has occurred. If bilingualism improves conflict monitoring and cognitive control, then we believe that—despite their apparent disadvantages in lexical access—bilinguals should enjoy a sentence processing advantage when behavior must be adjusted—namely, when the environment necessitates monitoring for syntactic conflict and potentially frequent misinterpretation.

This prediction stems directly from evidence that general-purpose cognitive control functions deploy under language processing conditions involving ambiguity (Hsu & Novick, in press; January, Trueswell, & Thompson-Schill, 2009; Novick, Kan, Trueswell, & Thompson-Schill, 2009; Novick, Trueswell, & Thompson-Schill, 2005; Ye & Zhou, 2009). Ambiguity arises frequently in natural language processing: the combinatorial nature of language means that typical utterances can have tens to hundreds of different possible parses (Wasow, Perfors, & Beaver, 2005). In particular, during sentence processing, readers and listeners may recruit cognitive control to revise misinterpretations that arise when multiple, conflicting evidential sources lead them to an incorrect syntactic analysis (Novick et al., 2005). According to constraint-based models of parsing, as readers and listeners perceive input, they rapidly consult multiple, probabilistic sources of information (e.g., lexico-syntactic cues and visual context) to make real-time predictions about sentence meaning (MacDonald, Pearlmutter, & Seidenberg, 1994; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995; Trueswell, Tanenhaus, & Garnsey, 1994). For most sentences, evidential sources converge, and initially favored parses ultimately turn out to be correct. Such sentences should not require conflict resolution even if other parses were initially available, but disfavored. Sometimes, however, an early interpretation of a sentence conflicts with evidence that arrives later in the sentence, which can result in processing difficulty (known as the ‘‘garden-path effect”). This forces readers and listeners to revise their incorrect analysis. For example, consider the following sentence from the Washington Post’s Afternoon Buzz e-mail newsletter, ‘‘The new hunting season opens today, with more hunters and more bears allowed to be killed”. Th reader may initially believe that both hunters and bears can be killed in greater numbers this season. However, as this is implausible, the reader must override this misinterpretation and realize that there are more hunters this season, and these hunters are allowed to kill more bears. Under such conditions, cognitive control may serve to rein-in initial misinterpretations and recover the intended meaning (Novick et al., 2005; Ye & Zhou, 2009). Accordingly, if bilingualism enhances conflict monitoring and cognitive control processes, then it should also improve performance on sentence processing tasks involving syntactic ambiguity.

But how exactly should the effects of bilingualism manifest in syntactic ambiguity resolution? We consider this question in view of the hypothesis that bilinguals have conflict monitoring advantages on non-linguistic tasks (Costa et al., 2009; Hilchey & Klein, 2011). Typical language contexts often contain ambiguous and unambiguous sentences, so readers and listeners must monitor for contradictions between their initial interpretation and subsequent input as they cannot know in advance when their initial parse will turn out to be wrong. If bilinguals are better at conflict monitoring, then they should be better at detecting ambiguities and recruiting cognitive control to revise misinterpretations, but also at using converging information sources to efficiently arrive at the correct interpretation even in unambiguous sentences. In other words, good conflict monitors are prepared either to resolve conflict or easily recognize the absence of conflict. Thus, bilinguals should outperform monolinguals on ambiguous and unambiguous sentences in linguistic environments that contain both—that is, under conditions when they have to monitor for potential misinterpretations.

Relatively few studies have examined the effects of bilingualism on sentence processing. An important exception, however, is an investigation of auditory sentence comprehension, which found that bilinguals had higher comprehension accuracy than monolinguals on ‘‘target” sentences with atypical word orders, but only when they had to ignore simultaneously-presented ‘‘distracter” sentences (Filippi, Leech, Thomas, Green, & Dick, 2012). This result suggests that bilinguals are better at suppressing interfering linguistic information than monolinguals. However, the bilinguals in that study had primarily acquired their second language after age 10—it is plausible then that they became fluent in a second language because they possessed superior linguistic (or cognitive control) abilities. It remains uncertain then whether bilingualism actually improves parsing abilities. In the present study, parsing abilities are tested in early bilinguals who acquired both languages prior to age 10. It is unlikely that such people become bilingual as a result of superior cognitive control, because, by and large, they learn two languages not by choice, but because their particular environment involves simultaneous (or nearly simultaneous) input of two language systems.

…The bilingual advantage manifested in a similar pattern across both tasks, emerging on both conflict trials and non-conflict trials. Because the bilingual advantage consistently extended beyond those trials requiring conflict resolution, our results support the conflict monitoring theory (Costa et al., 2009; Hilchey & Klein, 2011), which characterizes the bilingual advantage as a superior ability to detect conflict and flexibly adjust recruitment of cognitive control. According to this account, the bilingual advantage emerges because the presence of conflict during routine language use heightens monitoring demands, thereby increasing the readiness of cognitive control functions to deploy when necessary. The tasks in the present study may have particularly required good conflict detection, because the external cue for conflict is weak. Specifically, conflict arose in both tasks because the participants’ mental representation (familiarity for a word on N-back and bias towards a subject-first interpretation during sentence processing) conflicted with the bottom-up input (actual serial position on N-back and object-first syntactic construction). Contrast this situation with prototypical cognitive control tasks like Stroop and Flanker, where the stimulus itself contains conflicting information. Bilinguals seem to be more adept than monolinguals at detecting that conflict exists and engaging cognitive control appropriately.

We note, however, that the bilingual advantage seems to hinge on the presence of conflict, or irrelevant information that needs to be ignored. When such conflict is removed, as in the no-conflict N-back task, bilinguals and monolinguals perform equivalently. This suggests that information processing conflict is the critical factor underlying the bilingual advantage in conflict monitoring and cognitive control.

Betancort, Carreiras & Sturt (2009) The processing of subject and object relative clauses in Spanish/ An eye-tracking study

The results show that Spanish readers follow a subject relative preference, but this preference is modulated by animacy, in a pattern resembling data from other languages. The cost for object relatives was greater when both the antecedent NP and the RC-internal NP were animate (the A-A conditions) than when the antecedent NP was inanimate, and the RC-internal NP was animate (the I-A conditions). This aspect of the results resembles the Dutch findings reported by Mak et al. (2002). However, one difference is that while Mak et al. (2002) found no evidence of difficulty at all for object relatives in the I-A conditions, we did find such evidence. In our study, total times were longer for I-A object relatives than for I-A subject relatives, both in the critical region and in the final region. Moreover, there were more regressions out of the final region for I-A object relatives than for I-A subject relatives. Our results could be explained if, at least on some trials, people initially adopt a subject relative preference despite encountering an inanimate antecedent NP. However, the results are not compatible with a model in which the parser delays their choice of relative clause structure until the RC-internal NP has been found in the input. Under an extreme version of such a model, where delays occur regardless of the animacy of the antecedent NP, we would not expect to find any detectable preference at all. The data are also not compatible with a less extreme model, in which the delay only occurs

for the inanimate antecedent NPs, because even in the I-A conditions, we did find some evidence of a subject relative preference. This aspect of our results differs from the Dutch data reported by Mak et al. (2006).

There are at least two possible explanations of our results. The first is that the parser initially adopts a subject relative analysis regardless of animacy (for example, due to the minimal chain principle or active filler hypothesis). Processing difficulty subsequently occurs in cases where the sentence is disambiguated as an object relative, due to the need to recover the correct analysis. It is this difficulty that is modulated by the animacy of the two relevant NPs: Recovery is more difficult when both NPs are animate, due to the confusability of the relative clause arguments. Such an account was proposed by Traxler et al. (2002), who report an English eye-tracking experiment where first-pass reading times showed an object relative cost irrespective of animacy, but other measures such as total time showed that this preference interacted with animacy. Although such an account is compatible with our data, recent work puts into question the idea that the parser invariably adopts an initial subject relative analysis. For example, when the RC-internal NP is a personal pronoun or a discourse topic, an object relative preference can be observed in Dutch (see Mak et al., 2008). Moreover, as pointed out by Mak et al. (2006), the word order differences in English relative clauses might have contributed to some component of the object relative cost observed by Traxler et al. (2002).

A second possible account is the adapted version of Mak et al.’s (2006) topicality hypothesis suggested in the introduction of the present paper. According to this account, instead of delaying until the RC-internal NP is read, the processor has to commit to a choice of relative clause analysis at least at the point of the relative verb. In our Spanish verb-initial relative clauses, this means that the processor has to make a choice based only on the antecedent NP and the verb, and it may be that faced with this limited information, the processor always chooses the subject relative analysis. If so, the interaction with animacy

**The effect of exposure on syntactic parsing in Spanish–English bilinguals**∗

PAOLA E. DUSSIAS NURIA SAGARRA *Penn State University*

***Linguistic tuning***

To explain the cross-linguistic findings, Mitchell and Cuetos (1991; see also Mitchell and Cuetos, 1991; Brysbaert and Mitchell, 1996; Cuetos et al., 1996) raised the possibility that the sentence parser is experience-based, and that initial parsing choices are made on the basis of the experience that the individual reader or listener has with the environment. LINGUISTIC TUNING states that in the course of comprehension, the parser’s initial analysis of an ambiguous structure is influenced by the reader’s (or listener’s) previous encounters with ambiguities of the same kind. Every time a person resolves an ambiguous sentence in a given direction successfully, the comprehension system adjusts itself to keep track of the chosen resolution. The result is that on subsequent encounters of comparable ambiguities, the syntactic processor will be more likely to choose that same resolution (Cuetos et al., 1996).

Naturally, the adequacy of this explanation depends, in part, on evidence showing that there is a direct relationship between parsing preferences and linguistic input. If NP2 attachment is a prevalent parsing routine in English, one should be able to find some correspondence between behavioral data and corpus data in English. Mitchell, Cuetos and Corley (1992) report results suggesting that this is the case. A small-scale corpus study of modifier attachment preferences in English, using the million-word Lancaster-Oslo/Bergen (LOB) corpus, found that 62% of the (resolvable) relative-clause attachment constructions were linked to the second noun. Convergent findings are also reported in Gibson and Pearlmutter (1994), who analyzed all occurrences found in the Brown corpus of constructions where a relative clause attached to one of three sites (i.e. NP1, NP2 or NP3) and found that the NP3 was the preferred attachment site. However, as will become evident later, the Tuning account has been criticized on the grounds that it cannot successfully handle a number of recent monolingual findings.

***Construal***

A second interpretation of the cross-linguistic variation put forth in the monolingual literature is the CONSTRUAL THEORY (Frazier and Clifton, 1996). The theory suggests that comprehension preferences concerning relative-clause modifiers are affected by universal discourse principles as well as by the existence of language specific syntactic options to express genitive relationships. To begin with, Construal suggests that the relative clause in (3) is associated with the last thematic domain. Roughly speaking, because NP2 is not theta marked by the preceding preposition “of”, the last thematic domain contains both the NP1 AND the NP2 (for evidence suggesting that NP2 is the thematic domain in sentences in which the preposition assigns a thematic role, see Frazier and Clifton, 1996 and references therein; Frenck-Mestre and Pynte, 2000b). As a result of discourse-based influences (i.e. the principle of Relativized Relevance), NP1 will be the last discourse entity in focus. Hence, all languages should display a broad preference to construe NP1 as the host of the relative clause. This is, precisely, what we observe in Spanish. However, this preference is overridden and a tendency for attachment to the second noun prevails if the language has at its disposition two or more syntactic constructions to express possessive relationships, one of which unambiguously conveys the intended attachment to the first noun. This is the case in English, which has two genitive forms, the so-called Saxon genitive (e.g. the actor’s sister), which can be used to unambiguously modify the first noun in the complex NP, and the Norman genitive (e.g. the sister of the actor). According to the Construal theory, a speaker of English intending association of the relative clause to the first NP would choose the Saxon genitive over the Norman genitive, because it is the grammatical option that best conveys the intended meaning. It follows that if the Norman genitive is used instead, it is because the reader/listener intended an interpretation where the relative-clause modifies the second NP. This explains the NP2 preference found in English for this type of construction.

To summarize the Construal account, in English and Spanish, a relative-clause modifier preceded by complex head will associate with the entire NP, in cases where the second noun is an argument of the first. The parser’s final choice to attach the relative clause high or low will depend on semantic and interpretative considerations. It will also depend on whether the grammar of the language has a grammatical option to block one of the two available interpretations. In English, but not in Spanish, the parser chooses the lower host in a complex NP as the attachment site because English offers a grammatically unambiguous option to convey interpretation to the first NP.

It is important to note that both the Construal theory and the Tuning hypothesis have been questioned on the grounds that they are unable to satisfactorily account for a number of recent experimental findings from the monolingual literature. For instance, Brysbaert and Mitchell (1996; see also Mitchell and Brysbaert, 1998) discuss evidence from Dutch which is damaging to the construal account. These authors explain that Dutch is similar to English in that the Norman genitive co-exists with two other genitive forms: the Saxon form (comparable to English) and a possessive pronoun form (e.g. *vader zijn hoed*, translated as “father his hat”). As in English, the use of the Norman genitive results in an ambiguous sentence, but the use of the two other forms forces attachment of the relative clause to the second NP. Following the arguments presented above to explain the

NP2 bias found in English, Dutch readers should interpret the speakers’ choice of the Norman form as a sign that the relative clause is intended to modify the second NP. However, as it turns out, Dutch shows a preference for NP1 attachment (Brysbaert and Mitchell, 1996). In a similar vein, Mitchell et al. (2000) provide evidence from Afrikaans against the proposal, developed in the Construal theory, that the presence of an unambiguous alternative genitive structure is responsible for the cross-linguistic difference. An analysis of questionnaire data in Afrikaans, which like English has a frequently used Saxon genitive form, revealed a reliable NP1 preference for sentences in which a complex noun phrase was followed by a relative clause. Taken together, the results of both studies indicate that speakers do not capitalize on the presence of more than one genitive form to resolve relative clause modifier ambiguity (see Kamide, 1998, for similar evidence from Japanese).

There are also some exceptions to the correspondence between corpus statistics and parsing data that are not expected if the Tuning hypothesis is correct. For example, Gibson et al. (1999; see also Gibson, Schu ̈tze and Salomon, 1996) showed that for stimuli involving two or three potential attachment sites, Spanish readers had a preference for NP1 attachment when only two sites were present. However, low (NP2) attachment was preferred over high (NP1) attachment, which was in turn preferred over middle attachment, when three sites were present. This suggests, contrary to the claim made by Cuetos and Mitchell (1988), that attachment preferences are determined in part by a preference to attach recently.

Along these same lines, Gibson et al. (1996) examined conjunctions of noun phrases to complex heads that contained three noun phrases (e.g. *The salesman ignored a customer with a child with a dirty face and a wet diaper* (low attachment); *The salesman ignored a customer with a child with a dirty face and one with a wet diaper* (middle attachment); *The salesman ignored a customer with a child with a dirty face and one with a baby with a wet diaper* (high attachment)). Analyses of corpus searches revealed that middle-attached examples were more frequent than high-attached examples. However, results of a survey showed that low attachments were rated as least complex, followed by high attachments, with middle attachments rated as most difficult. This finding contrasts with the prediction of the Tuning hypothesis that middle attachments should have been rated as easier to process because they were more frequent in the corpus. Finally, Mitchell and Brysbaert (1998) also discuss evidence from Dutch which shows that NP2 attachment of relative clauses is more frequent in corpora, whereas NP1 attachment prevails in on-line data, a finding that is problematic for the Tuning hypothesis.

Notwithstanding the notable differences between corpus frequencies and parsing data, recent findings reported in Desmet, Brysbaert and De Baecke (2002) provide some indication that the differences in the literature between corpus materials and comprehension data can be accounted for when considering variables that had been previously overlooked. For example, Desmet and his colleagues found that the overall NP2 attachment preference in the Dutch corpus was due to a mismatch between the types of complex NPs that prevail in corpus data and the ones often used in reading experiments. Specifically, in reading experiments, the complex noun phrase always consists of two human nouns (e.g. servant of the actor), but complex NPs of this type turn out to be very rare in Dutch corpus materials. Moreover, Desmet et al. showed when NP1 did not refer to a human entity, the preference in the Dutch corpus was for NP2 attachment. However, this preference was reversed, and an NP1 attachment preference emerged, when the first noun in the complex noun phrase referred to a human. Thus, this variable not considered in previous corpus studies accounts for the apparent contradiction between corpus data and sentence comprehension results, at least in the Dutch cases.

In spite of the large number of cross-linguistic studies that have examined relative-clause-attachment preferences, there is still considerable debate about what this structure really tells us about models of the architecture of the human sentence processing mechanism. Although some models are able to afford the kinds of tests that allow researchers to discriminate between opposing accounts of ambiguity resolution, it is often difficult to distinguish between competing proposals because the available methodological tools do not unequivocally allow researchers to distinguish the sources of information that influence initial parsing decisions from those that become available during subsequent stages of reanalysis. In addition, to conduct experiments that investigate parsing preferences in reading, researchers need to construct materials that have been carefully controlled to allow for an adequate comparison between the different experimental conditions. In the case of RC ambiguity resolution, this has resulted in the majority of studies being based on sentences with complex NPs containing two human entities, partly because this allowed researchers to disambiguate the relative clause on the basis of the semantic gender of the nouns (Desmet et al., 2002). However, as mentioned earlier, this has also led to distorted conclusions about the processes underlying relative-clause attachment.

In this respect, bilingual sentence parsing research becomes particularly revealing. Thus, for example, a prediction that stems from the Construal theory is that knowledge of the existence of the Saxon genitive in English should impinge on how Spanish L2 learners of English parse English relative clauses preceded by complex NPs. If L2 speakers are like native speakers in that they use the same discourse information (i.e. interpretive and discourse principles) and language-specific information (i.e. knowledge of different genitive constructions in the languages involved) when parsing sentences containing a complex genitive NP followed by an RC, then we expect Spanish-dominant bilinguals reading in Spanish and in English to show language dependent parsing preferences. That is, the bilinguals should favor NP1 attachment when reading Spanish and NP2 attachment when reading English (so long as they are sufficiently proficient in English to know of the existence of alternative genitive constructions). Experimental findings congruent with these predictions would provide evidence in favor of the Construal proposal.

To illustrate further how research on bilingual sentence parsing provides an important tool for revealing constraints within the cognitive architecture (Frenck-Mestre, 2005; Kroll and de Groot, 2005), a model such as Linguistic Tuning predicts that parsing preferences should change if, during an extended period of time, speakers are exposed to large amounts of one particular attachment resolution over the other. As Cuetos et al. (1996) discuss, testing this hypothesis with monolingual speakers can prove to be difficult. This is because outside of an experimental setting, monolingual participants continue to be exposed to the attachment biases that exist in their environment. Hence, the lack of a change in parsing preferences cannot be interpreted as disfavoring the Tuning hypothesis. This obstacle can potentially be overcome with bilingual research, because depending on the language background and the discourse community that bilingual speakers come into contact with most frequently, they may be naturally exposed to different types of biases. The goal of the present paper is precisely to test the impact that immersion in the second language environment has on syntactic parsing. Before launching into a description of the present study, however, it is useful to provide a review of the studies that have investigated ambiguity resolution of relative clause modifiers in bilinguals.

On referential context:

KOHLSTEDT, T. and MANI, N. (2016) ‘The influence of increasing discourse context on L1 and L2 spoken language processing’, *Bilingualism: Language and Cognition*, , pp. 1–16. doi: 10.1017/S1366728916001139.

<https://www.cambridge.org/core/journals/bilingualism-language-and-cognition/article/div-classtitlethe-influence-of-increasing-discourse-context-on-l1-and-l2-spoken-language-processinga-hrefafn1-ref-typefnadiv/932B5108EB81779908C788BF1B17A9A6/core-reader>

We won’t use referential context because the two languages have the same referential contextual clues.

NP1 of NP2 RC structures

Cognitive control tasks? What are they? What do they mean? Why?

Cognitive controls’ different roles: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4009428/>

ANT

Stroop

Cognitive control (1) conflict resolution and (2) monitoring system

which evaluates the need to engage the conflict resolution mechanism (Bialystok et al., [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B12); Costa et al., [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)). According to Costa et al. ([2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)), if the task at hand engages the monitoring system to a large extent, the advantage for bilinguals on overall RTs emerges.

Costa et al. ([2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)) proposed two alternative ways in which the interplay between conflict resolution and monitoring processes might be explained. According to the first hypothesis, bilingualism may independently influence **both monitoring and conflict resolution** processes. According to the second hypothesis, the monitoring system may account for the observed bilingual advantage on both overall RT and conflict cost. The fact that the bilingual benefit in conflict resolution in most of the previous studies co-occurs with the overall RT benefit seems to support the latter claim (cf. Costa et al., [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)).

The bilinguals tested in the two previous studies by Costa et al. ([2008](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B26), [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)) were highly proficient and balanced early bilinguals. Since the bilingual advantage in overall RTs observed in those studies was not always accompanied by the reduced cost of conflict resolution, authors concluded that bilingualism primarily influences the monitoring system rather than the conflict resolution processes. In the present study, the bilingual advantage on overall RTs was observed only in combination with a reduced conflict cost for early bilinguals, whose L1 proficiency was rather limited. Although bilinguals from the studies by Costa et al. ([2008](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B26), [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)) and the early bilinguals from the current study differed from each other in many aspects of language experience, they shared one common characteristic – the early age of acquisition.

Conflict adaptation

Despite the incredible rate at which language is presented, language users interpret language incrementally as it is presented to them, as opposed to packaging the input as a unit after it has been communicated and interpreting it as a whole. However, there arise cases in which an initial interpretation needs to be re-interpreted, as new information is encountered in the input. For example, as a listener hears the structure in 1, they may initially interpret it as a prepositional phrase expressing the goal of the movement. However, further information, i.e. the remainder of the sentence, informs the listener to re-structure the initial information such that [on the plate] is interpreted as a reduced relative clause providing information distinguishing the target dumpling from other dumplings, as shown in 2.

1. Put the dumpling on the plate…

2. Put the dumpling on the plate into the wok.

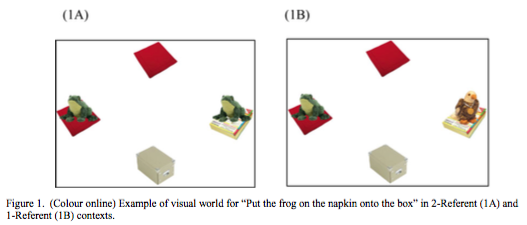
Correlational and causation research paradigms have shown that this re-interpretation is related to domain-general cognitive control. Cognitive control (CC) is a set of behavioral adjustments that detect and resolve conflict during information processing (Botvinick, Braver, Barca, Carter & Cohen, 2001), including in the context of linguistic mis- or re-analysis, as described in 1-2 (Novick, Trueswell & Thompson-Schill, 2005). The importance of CC in the reanalysis has also been observed in patients with prefontal damage associated with CC deficits, who present difficulty or failure to reanalyze upon reaching the subsequent information that typically leads to reanalysis (Novick, Kan, Trueswell, & Thompson-Schill, 2009; **Vuong & Martin, 2011**), and imaging studies have shown overlapping activity when adults interpret such **ambiguities** and when they complete tasks such as the Stroop or Flanker tasks (Fedorenko, 2014; January, Trueswell & Thompson-Schill, 2009; Ye & Zhou, 2009), which suggests that the linguistic and nonlinguistic tasks share resources. Beyond this, Hsu & Novice (2016) investigated whether CC engagement facilitates reinterpretation, building a research paradigm around the important observation that conflict detection triggers the sustained activation of CC, thus reducing the cost of subsequent conflict resolution (Gratton, Coles, & Donchin, 1992; Ullsperger, Bylsma & Botvinick, 2005; Freitas, Bahar, Yang & Banai, 2007; Kerns, Cohen, MacDonald, Cho, Stenger & Carter, 2004), what they call conflict adaptation. By interleaving tasks (Stroop and an online language-comprehension task involving syntactic ambiguity), the researchers observed that participants made significantly fewer mistakes in the behavioral analysis of their data when the the preceding trial was an incongruent Stroop trial (thus activating cognitive control), and the researchers observed more accurate online processing following incongruent Stroop trials in their eye-tracking data. In other words, the researchers demonstrated through a cause-effect paradigm that comprehension difficulty, such as temporary ambiguities, recruit CC mechanisms to resolve the conflict.

**L2 Conflict Adaptation**

Many sources of information must be coordinated and processed during the online interpretation of sentences by a healthy adult in his or her first language (L1), a process that only becomes more difficult in other populations that must coordinate this information while dealing with certain handicaps, such as impaired cognitive skills as a result of brain damage (in the case of patients) or immature cognitive skill development (in the case of children).

Several studies that have found decreased performance by children on language processing experiments have attributed it to their immature domain-general cognitive skills (Choi and Trueswell, 2010; Novick et al., 2005; Woodard et al., 2016). However, the issue arises that children are developing their linguistic system while their cognitive skills develop. Recent research attempting to tease apart results associated with their emerging language skills from those associated with protracted maturation of prefrontal cortical has led to questions concerning the interaction of these two systems. Following a rich strand of research that utilizes the visual world paradigm to understand language processing through participant behavior and eye movements, Pozzan and Trueswell (2015) question whether the differences seen in child processing of syntactic garden-paths is better explained as a L1 learner phenomenon or as a result of this incomplete prefrontal development observed in children. They reason that L1 and adult L2 learners will obtain similar results if these differences are a learner phenomenon, while children will differ from adults (both native and L2 speakers) if these differences relate to immature cognitive skills.

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 (1-referent vs 2-referent visual world). In this incarnation of the visual world, each scene presented to the participant was divided into four quadrants, each quadrant containing either the target referent, a nontarget competitor referent, the correct goal, or an incorrect goal (see Fig. 1)



*Figure 1. From Pozzan and Trueswell (2015). Example of visual world for "Put the frog on the napkin onto the box" in 2-Referent (1A) and 1-Referent (1B) contexts.*

Participants were presented with a temporarily ambiguous sentence, as in (1), or an unambiguous sentence, as in (2):

1. Put the frog on the napkin onto the box.

2. Put the frog that’s on the napkin onto the box.

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. To aid in reaching this appropriate interpretation, participants can use referential cues that Pozzan and Trueswell incorporated into their design. In the case of the 1-referent condition (i.e. 1B), the use of the definite article is effectively required and so does not provide any clues to disambiguation, but in the case of the 2-referent condition (i.e. 1A), the definite article is atypical (in both Italian and English) unless followed by modifying information, so the definite article can serve as a hint that the subsequent information will modify the noun, not serve as a goal.

The results obtained were mixed: L2 adults’ act-out and eye-movement data reflected increased consideration of the incorrect goal, the same patterns observed in children in terms of the difficulty they presented in the abandonment of incorrect parses in temporarily ambiguous sentences once the disambiguating information became available (Trueswell et al., 1999), while the native adults are far superior in reanalyzing the structure at this point. However, L2 adults used the referential context to aid their processing, similar to native adults and “in sharp contrast with the pattern observed for children” (Pozzan and Trueswell, 2015, p. 7). The use of referential context to aid interpretation in the 2-referent conditions may relate to L1-transfer, given that in both English and Italian the use of a definite article (“Put the frog…”) would be anomalous without modifying information to indicate a specific target, but it may also relate to increased sensitivity to contextual information that children do not utilize (Pan & Felser, 2011), a question that remains for future research.

Although the researchers found that adult L2 learners behaved like children in terms of their increased consideration of the incorrect goal, and therefore, their ability to abandon initial interpretations upon reaching the disambiguating information, the study only involves one proficiency level: intermediate (as assessed by the oral comprehension subtest of the Michigan Test of English Language Proficiency). Therefore, this decreased ability for revision at one particular stage of L2 development may be the result of task difficulty for the intermediate learner. The authors suggest an alternate possible explanation by relating their findings to neuroimaging data from Abutalebi (2008), who found increased activity of the LIFG and other prefrontal structures involved in cognitive control during processing of a non-native, non-proficient language, which could suggest that the L2 speakers involved in Pozzan and Trueswell’s study may have shown revision difficulties similar to populations with immature or impaired cognitive skills because their own cognitive skills may have been engaged to the point of depletion, resulting from processing a non-highly proficient L2. A differential role of other cognitive functions has been observed in behavioral studies, as well. For example, the facilitative effects of executive function and phonological short term memory on the automatization of L2 grammatical structures have been shown to diminish as proficiency level increases (Serafini & Sanz, 2015)

Conflict detection has been shown to trigger sustained cognitive control; for example, the Stroop effect can be lessened for an incongruent trial if it is is preceded by another conflict trial as opposed to a congruent/nonconflict trial (Freitas, Bahar, Yang, and Banai, 2007; Kerns, Cohen, MacDonald, III, Cho, Stenger, and Carter, 2004). This pattern has also been observed in adults’ performance on cross-task conflict adaptation tasks, where recovery from an incorrect interpretation due to syntactic ambiguity is facilitated when the language-comprehension trial is preceded by a conflict Stroop trial (Hsu and Novick, 2016). A different pattern has been observed in children: while conflict adaptation has been found within cognitive control tasks (e.g. incongruent Stroop trial preceding incongruent Stroop trial), in a cross-task design, recovery from syntactic misanalysis is less likely following an incongruent Stroop trial (Huang, Gerard, Hsu, Kowalski, and Novick, 2016). The authors suggest this may be due either to the depletion of immature cognitive control resources or to task difficulty fatigue.

The current study develops out of these findings that cognitive-control engagement can be manipulated by altering the type of conflict of a preceding trial. By introducing varying proficiency levels and a cross-task conflict adaptation paradigm, we can determine whether conflict-control engagement can account for the non-native-like findings observed in Pozzan and Trueswell (2015). Given that the LIFG and other prefrontal structures are significantly less engaged during highly proficient L2 processing than during non-highly proficient L2 processing (Abutalebi, 2008), the conflict adaptation paradigm should result in a triggering of sustained cognitive control for near-natives, resulting in improved performance on a language-comprehension trial that follows an incongruent Stroop trial. Meanwhile, if cognitive control is already engaged for beginner and intermediate learners, performance should not improve to the same extent following incongruent trials, and in fact, may decrease following these trials due to depletion of resources or fatigue, as observed in children in Huang et al. (2016). However, if the differences observed between native and intermediate L2 speakers in Pozzan and Truewswell (2015) relate exclusively to proficiency-related task difficulty, all groups should behave similarly when exposed to the cross-task conflict adaptation.

In another recent study, Poarch and Van Hell ([2012b](http://link.springer.com/article/10.1007%2Fs11618-014-0491-8#CR40)) compared the performance of second-language learners who were in the process of becoming bilingual to children who were bilingual or trilingual as well as a group of monolinguals. Thus, groups of 6- to 8-year old children who were English-German dual-immersion students, German-English bilinguals, German-Language X-English trilinguals, or monolinguals were given two measures of executive control, the Simon Task and the flanker task. All of the children in the three multilingual groups outperformed monolingual children on the Simon Task, although the difference only became statistically significant for the bilinguals and trilinguals, and the bilinguals and trilinguals outperformed the second-language learners in the flanker task. Thus, for some aspects of executive control, there may be a threshold of bilingual experience before the cognitive advantages become apparent.

**Differences between monolinguals and bilinguals**

Psychological research has revealed that for many populations, the increased use of a certain behavior results in improved skills on similar tasks or associated brain structure differences. For example, **Taxi drivers required to pass strict examinations of the streets of London** possess more development in the region of the hippocampus associated with spatial navigation (Maguire, Gadian, Johnsrude, Good, Ashburner, Frackowiak, & Frith, 2000). In behavioral studies, architects outperform non-architects on tasks evaluating visuo-spatial ability (Salthouse & Mitchell, 1990), and video game playing was correlated to heightened modification of perceptual-motor ability (Green and Bavelier, 2008). Likewise, bilingual populations have been shown to differ from monolingual counterparts in many different facets, both physiologically and behaviorally.

In linguistic development, bilingualism has been connected to decreased vocabulary size in specific languages (e.g. comparing English vocabulary size of monolingual English speakers and bilingual speakers who speak English and another language) (Bialystok, Luk, Peets, & Yang, 2010; Bialystok & Luk, 2012); slower lexical access in picture-naming tasks (Gollan, Fennema-Nostestine, 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, Ardila, Araujo, Weeks, Caracciolo, Padilla, Ostroski-Solis, 2000; however, compare Bialystok, Craik & Luk, 2008, who matched monolinguals and bilinguals for vocabulary size and observed bilinguals outperform monolinguals).

These linguistic differences likely relate to the perpetual activation of both languages, thus causing competition between first- and second-language forms in a picture-naming task, for example. This activation has been attested in behavioral (Kroll & DeGroot, 1997; Francis, 1999), imaging (Martin, During, Thomas & Thierry, 2009); and patient data (Abutalebi, Miozzo & Cappa, 2000; Fabbro, Skrap & Aglioti, 2000).

COGNITIVE EFFECTS OF BILINGUALISM

<http://link.springer.com/article/10.1007%2Fs11618-014-0491-8>

**Cognitive Control in bilinguals**

One reality of bilingualism is the consistent need to suppress one language according to the context. It’s been shown that a bilingual does not separate the mental lexicons and grammars, but rather that both are active during any language use (Kroll & Bialystok, 2013; Kroll & Sunderman, 2003). Within Green’s (1998) Inhibitory Control Model, the competitor is suppressed by executive control (or cognitive control). That is to say, given two competing forms, the salient but contextually-infelicitous form is suppressed by CC while the desired form is promoted. This model and the much of the early research that followed (see Bialystok, 2007, 2009, for reviews) investigated whether this constant activation of CC led to improved performance of bilinguals on nonlinguistic tasks (that is, did consistent use of cognitive control lead to more apt cognitive control), what would become known as the bilingual advantage (Bialystok, **2009**). The bilingual advantage has subsequently been attested through neuroimaging studies and behavioral studies. In neuroimaging, larger gray matter volume has been observed in brain areas that serve executive functioning (Olulade, Jamal, Too, Perfetti, LaSasso and Eden, 2015). Likewise, the anterior cingulate cortex, a neural structure involved in conflict resolution, the activation of which correlates to poorer performance on conflict tasks, has been observed to be activated more by monolinguals performing such tasks (Abutalebi et al., 2012), and this decreased network activation was replicated by Gold et al. (2013). Likewise, a large effect size was observed in a meta-analysis conducted by Adesope, Levin, Thompson, and Ungerledier, 2010, comparing attentional control of monolingual and bilingual populations, which likewise would suggest a bilingual advantage

However, some questions have arisen in the research, such as the extent to which the bilingual advantage is demonstrated by distinct populations of bilinguals (e.g., Torres & Sanz, 2015; Colzato, Bajo, Wildenberg, Poaolieri, Nieuwenhuis, La Heij, & Hommel, 2009; Paap & Greenberg, 2013).

Both approaches seem to be of great importance since the relationship between bilingualism and executive functions appears to be more complex than initially claimed (Tao et al., 2011)

which evaluates the need to engage the conflict resolution mechanism (Bialystok et al., [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B12); Costa et al., [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)). According to Costa et al. ([2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)), if the task at hand engages the monitoring system to a large extent, the advantage for bilinguals on overall RTs emerges.

Costa et al. ([2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)) proposed two alternative ways in which the interplay between conflict resolution and monitoring processes might be explained. According to the first hypothesis, bilingualism may independently influence **both monitoring and conflict resolution** processes. According to the second hypothesis, the monitoring system may account for the observed bilingual advantage on both overall RT and conflict cost. The fact that the bilingual benefit in conflict resolution in most of the previous studies co-occurs with the overall RT benefit seems to support the latter claim (cf. Costa et al., [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)).

The bilinguals tested in the two previous studies by Costa et al. ([2008](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B26), [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)) were highly proficient and balanced early bilinguals. Since the bilingual advantage in overall RTs observed in those studies was not always accompanied by the reduced cost of conflict resolution, authors concluded that bilingualism primarily influences the monitoring system rather than the conflict resolution processes. In the present study, the bilingual advantage on overall RTs was observed only in combination with a reduced conflict cost for early bilinguals, whose L1 proficiency was rather limited. Although bilinguals from the studies by Costa et al. ([2008](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B26), [2009](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114252/#B25)) and the early bilinguals from the current study differed from each other in many aspects of language experience, they shared one common characteristic – the early age of acquisition.

**Cognitive Control in Heritage Language Bilinguals**

As Torres & Sanz (2015) address, many studies that consider bilingual speakers may not sufficiently separate distinct language profiles such as heritage language (HL) bilinguals. The bilinguals in some research, such as the Catalonians studied in Costa et al (2008), for example, are educated in bilingual schools and therefore, possess an inherently different language profile than the Spanish-English bilinguals in the US who have a certain degree of proficiency at an early age and may use Spanish in their homes, but for whom the dominant language shifts to English as they are schooled in US monolingual programs (Polinsky & Kagan, 2007; Torres & Sanz, 2015). Torres & Sanz (2015) are among the few to have investigated the role of HL bilingualism and its effect on cognition, as most research of this burgeoning field approaches the population from a sociolinguistic perspective (e.g. Hornberger & Wang, 2008), pedagogy (e.g. Marijuan, XXXX; Bowles, XXXX), or linguistic development and properties of grammar (Benmamoun, Montrul, & Polinsky, 2013). Torres & Sanz (2015), in this first study of executive control in HL bilinguals, find no differences for HL bilinguals and late classroom-emerging bilinguals of Spanish in performance on the Attentional Network Task (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002). While Torres & Sanz (2015) take the important first step to investigate how or whether cognitive differences exist between HL bilinguals (under a *narrow* perspective of HL bilinguals, defined below) and late-L2 bilinguals, differences in the employment of executive control during linguistic tasks, such as ambiguity resolution, remains to be understood. Indeed, the participants sampled are at the prime age of cognitive control, and so although we don’t see differences in performance on the ANT, language processing involves much more coordination, so a linguistic task modified by a cognitive adaptation task may reveal subtle differences in young adult bilinguals that we cannot observe in strictly nonlinguistic tasks. The current study would use the conflict adaptation paradigm addressed above to observe how the engagement of cognitive control affects conflict resolution for heritage language bilinguals.

**Cognitive Control in L3 learners**

Beyond this increased understanding of how cognitive control plays a role in Heritage bilinguals’ language processing and conflict resolution, a gap exists in our understanding of the role of cognitive control in language learning as it pertains to bilinguals learning their third language (L3). As mentioned, the different sociolinguistic contexts experienced by different populations of bilinguals (e.g. HL in the US vs. Catalan-Spanish biliterate bilinguals) has been shown to play a role on linguistic outcomes (Sanz, 2000), and potentially cognitive advantages (see Kroll & Bialystok, 2013; compare Torres & Sanz, 2015 and Costa et al., 2008). These linguistic outcomes include subsequent language acquisition, although unfortunately, L3 acquisition remains understudied in a world WHERE MORE THAN HALF OF THE POPULATION IS BILINGUAL

Little is currently understood about the role of executive functions in L3 language use.