Doctoral Exam #2

**The role of Cognitive Control and Proficiency**

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

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**1. Introduction**

As presented in my previous doctoral exam, cognitive control is directly involved in both non-linguistic and linguistic ambiguity resolution. Recent research shows that language proficiency and language dominance and switching are also closely related to cognitive control. Recent work in psycholinguistics has developed a method to engage cognitive control in order to directly improve syntactic ambiguity resolution, provided that cognitive control resources are not already maximally engaged, at which point, the engagement has no effect or even worsens ambiguity resolution. The current work proposes three studies that utilize variations of this methodology to further investigate the relationships between second language proficiency and cognitive control and between bilingual language use/dominance and cognitive control.

**2. Cognitive Control and Proficiency in Emergent Bilinguals**

The role of cognitive control during the acquisition of a second language (L2) is an area of SLA that merits more research. This brain region associated with cognitive control has been shown through neuroimaging studies to play a major role during the processing of a non-native, non-highly proficient language, a role which becomes less significant during proficient or native processing (Abutalebi, 2008), but how cognitive control differences affect linguistic performance at these different stages of learning is still very unclear. While many studies consider working memory capacity’s (WMC) role in different aspects of L2 development (e.g. Baralt, 2010), WMC is a more monolithic cognitive variable, while cognitive control is a specific capacity within working memory with a specific linguistic correlate: conflict resolution. The very few studies that have compared the role of cognitive control at different proficiency levels are presented below.

One study that has considered L2 development’s correlation with cognitive control differences considered Chinese learners of English who differed in L2 proficiency and/or in language interpreting experience (Dong & Xie, 2014). However, despite significant differences between groups in most measures of development (verbal fluency, general proficiency, language exposure), there was an overall homogeneity between these groups and their experiences. For example, all groups were English language or English interpretation majors at Guangdong University; self-reported exposure to English ranged from 41.5-48.4% (where the sum of Chinese and English exposure is 100%); and self-reported proficiency averages, from 0-40, were also quite similar for three of the four groups, though all but two differed statistically (21.5 > 23.2, 22.9 > 29.8). Results indicate that flanker task performance did not differ according to English proficiency, although the data does trend towards favoring higher proficiency, regardless of flanker condition. The raw scores are presented in Table 1. However, the ANOVA revealed no main effect for participant group, nor an interaction between participant group and condition.

Table 1. Raw data from flanker task of Dong & Xie (2014) for each of four groups.

|  | **Noninterp-1 *n* = 45** | **Noninterp-2 *n* = 43** | **Interp-1 *n* = 46** | **Interp-2 *n* = 20** |
| --- | --- | --- | --- | --- |
| Neutral | 543 (103) | 536 (91) | 533 (76) | 518 (90) |
| Incongruent | 583 (111) | 578 (87) | 569 (83) | 548 (67) |
| Congruent | 528 (119) | 516 (81) | 518 (73) | 497 (86) |
| Difference | 55 ms (36) | 62 ms (50) | 51 ms (33) | 51 ms (35) |

Linck and Weiss (2011) investigated the role of WMC and cognitive control on the acquisition of a L2 over the course of a semester, and found that WMC became a stronger predictor of success in language performance at the end of the semester, while cognitive control was not a predictor. While this finding is often used to discuss proficiency and cognitive capacity, there are issues with this interpretation, since beginning German and intermediate Spanish participants were combined when no group differences were found in the model’s predictor or criterion measures in the preliminary analyses, even though these participants completed different language measures (German: fifteen fill-in-the blank items from University of Wisconsin placement exam; Spanish: grammar and vocabulary section of the *Diplomas de Español como Lengua Extranjera, DELE*). Therefore, the role of cognitive variables during a semester of classroom-learning may be hidden by other confounds, especially considering the findings of Serafini and Sanz that succeeded this study.

As outlined in my previous doctoral exam, Serafini and Sanz (2016) conducted a longitudinal study considering proficiency, cognitive capacities, and gains during one semester on ten different morphological structures in Spanish. The robust correlations between linguistic gains and cognitive variables were only observed for beginners, while cognitive capacity differences revealed no significant correlations with gains in the advanced learners. This study’s findings therefore help interpret the neuroimaging findings of Abutalebi (2008): cognitive capacity may play a major role in language learning at low proficiencies, but as the L2 becomes more proficient, cognitive capacity advantages begin to wane. Serafini and Sanz (2016) are the first researchers, to my knowledge, to compare the role of cognitive functions at several highly distinct points of L2 proficiency (beginner, intermediate and advanced). However, the researchers motivate the use of fewer targets to investigate more deeply how cognitive variables play a role in the second language learning process.

Syntactic ambiguity resolution, directly associated with cognitive control, is one target that can answer that call of Serafini and Sanz (2016). As mentioned in the previous exam, Pozzan and Trueswell (2015) observed childlike resolution of syntactic ambiguity by adult intermediate learners of English (L1: Italian), despite high familiarity with the structure in the first language. Relating their findings to those of Abutalebi (2008), who observed higher cognitive control demand during non-highly proficient L2 processing, they suggest this finding may relate to a lack of available cognitive control resources to intercede during reanalysis, which would explain the childlike performance. However, because they only consider intermediate learners and do not collect any cognitive control measures, they cannot conclude with certainty any such relationship. Given the differential role of cognitive control during linguistic performance that has been observed in the literature outlined above, the assumption of Pozzan and Trueswell likely reflects some relationship between these variables. However, more research is in order to justify this claim empirically. A study to respond to this need is outlined in Section 6.1, and the corresponding testable hypothesis in Section 5.1.

**3. Conflict Adaptation: Stroop effects and Cognitive Control**

The Stroop effect is one of the most important findings in modern experimental psychology. Since it was first published in English over 80 years ago, the Stroop task has been the subject of hundreds of studies and has been used in many distinct branches of cognitive science (MacLeod, 1991). In the original of its many incarnations, the Stroop task requires participants to respond to the color of the ink in which a color-word is written, rather than reading the color-word itself (Stroop, 1935). Manipulations of the Stroop task all hinge on presenting conflicting information to examine the role of interference in different cognitive processes. The consensus of these Stroop-like interference tasks is that an incongruent trial is more difficult than a congruent trial, revealed by slower reaction times (RTs) and higher error rates (see MacLeod, 1991 for review).

Variations of the color-word Stroop task often present a center target flanked by either congruent or incongruent distractors, and the Stroop effect of such flanker tasks is relative to the congruency of the flanking elements. For example, the Attentional Network Task (ANT), discussed in my first doctoral exam, is a flanker task utilizing a rightward or leftward central arrow with either congruent or incongruent flanking arrows, where participants must resist responding to the four flanking arrows and respond strictly based on the center arrow’s direction. The ANT was developed to mitigate linguistic interference (by eliminating words from the paradigm) and isolate cognitive control procedures (Fan, McCandliss, Sommer, Raz & Posner, 2002). Due to the simple design utilizing non-linguistic conflict, the task can be used with populations with known executive function problems, such as children, patients and monkeys, and can be used to make conclusions about domain-general cognitive functions.

Much of the literature that utilizes Stroop-like tasks has considered the role of the anterior cingular cortex (ACC) and cognitive control in the Stroop effect. The shared resources involved in ACC activation, cognitive control, and conflict resolution have been sufficiently well documented in the literature (see MacLeod, 1991 for review). And while it has been understood for many years that the conflict involved in Stroop trials engages cognitive control, researchers have also understood that the Stroop effect extends beyond a trial-by-trial basis. The detection of conflict during a given Stroop trial has been shown to initiate *sustained* cognitive control procedures, specifically conflict resolution, that continue into the subsequent trial. For example, Logan and Zbrodoff (1979) observed that manipulations to the probability of conflict stimuli modulate the Stroop effect, where higher probabilities of conflictive trials result in proportionally faster responses on incongruent trials. Likewise, Gratton, Coles and Donchin (1992) showed that the preceding trial’s congruency contributes to the speed of a response, specifically that an incongruent trial immediately preceding an incongruent critical trial (i-I) leads to faster responses than congruent trials immediately preceding incongruent critical trials (c-I). Theoretically, these results have been attributed to economy: sustaining cognitive control attenuates the cost of subsequent conflict resolution.

It should be noted that this finding was questioned by Mayr, Awh and Laurey (2003), who observe the same phenomenon as a case of stimulus-specific priming (the “repetition-priming” account). In a conceptual replication of Gratton and colleagues’ study, they found that faster reactions were associated with pairs of trials in which the latter’s target was a repetition of the former’s target. However, subsequent research confirmed the earlier “conflict monitoring” account, specifically because sequential dependency effects do present themselves regardless of repetition of stimuli (Ullsperger, Bylsma & Botvinick, 2005). For example, in the second experiment of Ullsperger and colleagues (2005), the conflict adaptation effect was still observed when participants were presented with a numerical, underlined single-digit target between 1-9 with 4 competing flankers, also a single digit. This paradigm eliminated the risk of priming because the researchers were able to exclude trial-to-trial repetition. While the researchers found slower reaction times than in the standard two-option directional flanker task, they attribute this to a speed-accuracy tradeoff associated with nine options that did not diminish the effect of conflict engagement. In other words, preceding trial incongruency in this experiment still resulted in a conflict adaptation effect, where i-I RTs were 26% faster than c-I RTs.

**3.1 Conflict Adaptation and Dynamic (Cross-Task) Engagement of Cognitive Control**

Non-linguistic conflict resolution has been shown to co-localize within the ACC and to share cognitive control resources with linguistic conflict (Thompson-Schill, Bedny, & Goldberg, 2005; Novick, Kan, Trueswell & Thompson-Schill, 2009; January, Trueswell, Thompson-Schill, 2009, Teubner-Rhodes et al., 2016). These shared resources have also been observed in correlational behavioral studies in children with protracted cognitive control development (Trueswell, Sekerina, Hill & Logrip, 1999); and in patients with prefrontal damage affecting cognitive control (Novick et al., 2009). Domain-general cognitive control is suggested to be responsible for both behavioral adjustments to resolve conflict during information processing (Botvinick, Braver, Barch, Carter & Cohen, 2001) and reanalysis following incorrect linguistic interpretation (Novick, Trueswell & Thompson-Schill, 2005).

Despite this, it is only very recently that researchers used the principles of sustained cognitive control engagement to develop a cross-task conflict adaptation paradigm. Hsu and Novick (2016) developed such a paradigm that allows the observance of causal relationships between non-linguistic conflict detection and linguistic conflict resolution. Specifically, the researchers conducted a 2x2 experiment on healthy adult sentence processing by pseudo-randomly presenting congruent and incongruent Stroop trials and temporarily ambiguous and unambiguous sentences. Here, a temporary ambiguity is a sentence that forces a particular incorrect initial analysis that must later be reanalyzed as more of the sentence is processed, such as their example (1), which can be compared to the unambiguous example in (2):

1. Put the dumpling on the plate into the wok.
2. Put the dumpling that’s on the plate into the wok.

In their study, Hsu and Novick asked participants to carry out the instructions they heard, always similar to those in (1) or (2), within a visual world represented on a computer screen. During processing, participants interpret the first prepositional phrase (the reduced relative clause that modifies the noun) as the goal due to the verb *put*’s subcategorization (Spivey, Tanenhaus, Eberhard & Sedivy, 2002). However, when they reach the second prepositional phrase, a reanalysis must take place. As participants engaged with the visual world, researchers collected both act-out moves and eye movement data. Hsu and Novick interleaved Stroop and linguistic trials and observed that Stroop incongruity in the preceding trial reduced the participants’ commitment to the initial incorrect parse of ambiguities when compared to Stroop congruity, in terms of both behavioral and eye-tracking data. It is important to bear in mind that critical analyses in this study were pairings of conditions: incongruent-ambiguous (i-A) and congruent-ambiguous (c-A).

In both the action responses and the fixations to the correct goal, a significant sentence-type-by-Stroop-trial-type interaction was encountered, whereby participants made fewer performance errors or fewer fixations to the incorrect goal on i-A trials than on c-A trials. As expected, Stroop incongruity did not modulate consideration of the correct goal in the unambiguous linguistic condition (i-U did not statistically differ from c-U), likely because there was no conflict to be resolved and online interpretation and action responses approached ceiling. These results show that cognitive-control engagement helps listeners abandon incorrect parses earlier and correctly carry out instructions without the same degree of error.

Thus, returning to the questions outlined in Section 2, this cross-task conflict adaptation paradigm can be used to test how cognitive control plays a differential role during ambiguity processing at different L2 proficiencies. When cognitive control resources are maximally engaged, as is the case in child- and patient-processing, i-A trials will not differ from c-U trials. However, where cognitive control resources are available, i-A trials will show earlier disambiguation. This hypothesis is further outlined in Section 5.2, and a description of a study to test it is outlined further in Section 6.2.

**4. Language dominance and Cognitive Control in Heritage Language Bilinguals**

In recent years, fields such as education, linguistics, sociology and psychology have rekindled interest in heritage language (HL) speakers. Montrul (2010) defines heritage speaker, broadly, as “child or adult members of a linguistic minority who grew up exposed to their home language and the majority language” (p. 4). Theoretical and sociolinguistic research has granted researchers better understanding of the grammars of HL speakers, including vocabulary, morphology, syntax and semantics, (for reviews, see: Montrul, 2010; Brinton, Kagan, & Bauckus, 2008), while other areas such as instructional strategies have also received considerable attention (Montrul & Bowles, 2008, for example). The role of metalinguistic knowledge has been a major focus of this pedagogical HL research, often comparing HL learners and L2 learners. For example, Bowles (2011) evaluated both groups in an array of tasks that ranged from more to less explicit. She found that HL learners performed better than L2 learners on tasks requiring less metalinguistic or explicit knowledge, while L2 learners outperformed HLLs on those with more metalinguistic knowledge requirements.

However, despite the increased interest in these many different aspects of HL language use and control, online sentence processing has been much less studied, which is particularly interesting given that language processing paradigms, such as the visual world paradigm used in Hsu and Novick (2016) or Pozzan and Trueswell (2015), often require effectively no metalinguistic knowledge and can serve to ask relevant questions regarding language interpretation and processing.

In a certain regard, this dearth of literature is more appropriately a failure to distinguish between distinct populations of bilinguals in language processing literature; as Torres and Sanz (2016) note, heritage speakers are often grouped under the umbrella term ‘bilingual’ in psycholinguistic studies. In other words, while researchers do in fact study heritage language speakers, they do not clearly distinguish them from other bilingual populations. However, this is a flawed practice because different environments contribute to the development of distinct language profiles (Hilchey & Klein, 2011; Bialystok, 2009). For example, research suggests that bilingualism at the individual level can manifest differently according to external conditions such as societal bilingualism (Sanz, 2000). Thus, biliterate Catalan-Spanish speakers in Barcelona, for example, are inherently different from many heritage speakers of Spanish in the United States, where Spanish is a minority language and where many heritage speakers never attain literacy in their HL.

In fact, the term ‘heritage bilingual’ is itself an umbrella term. Most adult heritage speakers are dominant in the majority language, while minority or heritage language skills vary considerably from speaker to speaker (Montrul, 2010), to the extent that some heritage speakers are limited to receptive skills while others show advanced oral and written skills. The development of these skills often depends on the community and the language, in addition to the *sequence* of bilingualism: simultaneous bilinguals who learn both the majority and minority languages at the same time tend to show less dominance of the minority language when compared to sequential bilinguals who exclusively use the minority language for a longer period and therefore generate greater exposure (Montrul, 2008, 2010).

Torres and Sanz (2016) are the first researchers to isolate this language profile to investigate the ‘bilingual advantage’ in cognitive control as it pertains to HL speakers. The authors find no differences between HL bilinguals and late emergent bilinguals of Spanish in performance on the ANT, although they do note that data trended to show that HL bilinguals resolved conflict easier and at fewer cross-task costs. Despite this trend, these results are surprising when situated within the ‘bilingual advantage’ research of Bialystok and colleagues, outlined in my first doctoral exam, which tends to situate this advantage as dependent on pre-critical period bilingualism (see Bialystok, 2007, 2009, for reviews)[[1]](#footnote-1). According to the findings of Torres and Sanz, however, HL and emergent-L2 bilinguals performed comparably on the ANT, which raises several questions for further research.

For example, the study by Torres and Sanz (2016) and a previous study by Costa, Hernández and Sebastián-Gallés (2008) both compare early bilinguals to a group that is not fluent in a L2. In Costa and colleague’s (2008) study, bilingual, biliterate Catalan-Spanish speakers were compared to Tenerife Spanish speakers, who are considered ‘monolingual’ in the study despite certain knowledge of a L2 because of foreign language courses they took in school[[2]](#footnote-2). Meanwhile, Torres and Sanz (2016) compared heritage Spanish speakers in the U.S. to classroom learners of Spanish. Both teams of researchers gathered information through questionnaires regarding their participants’ language skills. Costa and colleagues (2008) gathered information on a five-point Likert scale, from 0 (*‘very bad’*) to 4 (*‘native speaker’*), while Torres and Sanz (2016) gathered similar information on a six-point Likert scale, from 1 (‘*beginning’*) to 6 (*‘native*’). Although these scores aren’t comparable because they are different scales, some observations can be made from the relative scores, so for ease of comparability, this data was converted to a ratio and is presented in Table 2. Torres and Sanz also utilize a modified version of the DELE to evaluate proficiency of both their groups, following previous HL research such as Montrul (2005), the sections of which were chosen to specifically tap skills that are shared by both sets of learners without presenting tasks that are highly explicit, to favor the L2 learners, or highly implicit, to favor the HL speakers. The results of the modified DELE are also presented in Table 2.

While only Torres and Sanz used such a standardized test, some observances can be drawn from the self-reported data. The heritage speakers rate themselves as far less confident in all four language skills than their bilingual Catalan peers. In addition, despite Costa and colleagues’ classification of the comparison group as ‘monolingual’, they rate themselves as moderately capable in a second language. In fact, they rate themselves higher than the emergent L2 bilinguals in Torres and Sanz’s study do on their respective scales.

Another important consideration is the power of the respective studies. While Catalan-Spanish bilinguals are quite accessible in Barcelona, heritage Spanish speakers of the narrow definition that Torres and Sanz assume are much more difficult to gather, which may contribute to the different sizes of the participant pools. Therefore, the findings of the U.S.-heritage population may not have enough power to reveal a significant difference, especially if advantages are on a gradient scale reflecting bilingual proficiency.

Table 2. Language skills of participants in two ‘bilingual advantage’ studies

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Costa et al. (2008) | | | | Torres & Sanz (2016) | | | |
| Language Skill | ‘Monolingual’  (n = 100) | | Bilingual  (n = 100) | | Emergent (L2)  (n = 23) | | Heritage  (n = 25) | |
|  | Spanish | L2 | Spanish | Catalan | English | Spanish | English | Spanish |
| Comprehension | 1.0 | .575 | 1.0 | 1.0 | .98 | .40 | .97 | .86 |
| Reading | 1.0 | .60 | 1.0 | 1.0 | .98 | .42 | .97 | .76 |
| Speaking | 1.0 | .50 | .95 | 1.0 | .98 | .30 | .92 | .74 |
| Pronunciation | 1.0 | .475 | .925 | 1.0 | -- | -- | -- | -- |
| Writing | 1.0 | .525 | .975 | .975 | .98 | .44 | .90 | .60 |
| DELE (placement) | -- | | -- | | .504  (low) | | .650  (intermediate) | |

To recap, in a study of cognitive control using the ANT, biliterate-bilingual Catalan-Spanish speakers who report themselves to be ‘native’ or native-like in *all four* linguistic skills outperformed Tenerife Spanish speakers whose dominance of a L2 was moderate, but not ‘very bad’[[3]](#footnote-3). A separate study using the same task considered U.S.-English Spanish-heritage speakers, whose skills as a group ranged from intermediate (DELE) to native-like (listening comprehension). The heritage speakers did not outperform late bilinguals, who were self-rated as intermediate in all linguistic skills but who received a ‘low’ according to the DELE.

These findings are far from cut-and-dry, and as mentioned earlier, should not be compared. We can, however, observe them simultaneously, and as they stand, a nuanced analysis would suggest that variables such as language use, proficiency, dominance and literacy may play a role in capturing the subtle cognitive performance advantages at hand in bilingual research. However, to my knowledge, only one other study has considered how low literacy may play a role in the development of the oft-cited ‘bilingual advantage’ in cognitive control. Finger, Billig and Scholl (2011) investigated performance on a non-linguistic and linguistic inhibitory control task in older-adult (60-71 years old) population of Hunsrückisch-Portuguese bilingual farmers with low levels of education and a monolingual comparison group with otherwise similar characteristics. The authors cite a bilingual advantage in the non-linguistic task but not in the Stroop task due to linguistic interference, which follows their hypothesis and previous research (e.g. Bialystok, Craik and Luk, 2008). However, the authors advise that the results should be taken with caution because of the population size (21 participants in each group). In addition, both groups had very little exposure to written sources on a daily basis, according to the authors. This study also considers older adults’ cognitive control, but no study to my knowledge has considered the role of literacy on cognitive control advantages within young adult bilinguals, who are at the height of their cognitive control (Bialystok, Craik & Luk, 2008). It is quite clear, then, that more studies are needed to explore the interaction between cognitive variables and language use and dominance within heritage bilinguals, especially since we know that increased language use is a clear predictor of maintenance and complete acquisition of the heritage language (Montrul, 2005).

One strategy to tease apart the findings presented above is to conduct a study that looks at these language skills as continuous variables in order to investigate whether there is a connection between cognitive control and language dominance or use. Many of these studies try to control these characteristics in their samples, a wise methodological practice but one that may not reveal all of the subtle distinctions within the bilingual population. Considering these phenomena as continuous variables is a particularly promising strategy given that recent studies suggest that frequent language switching is a leading cause of the bilingual advantage in conflict monitoring. For example, a recent neuroimaging study showed that it is precisely language switching trials that activate the same brain region as conflicting flanker trials (Abutalebi et al., 2012). Likewise, in a study on code-switching, using a modification of the cross-task conflict adaptation task first developed in this same lab, heritage speakers were presented with a block of flanker trials following each of four separate blocks of linguistic ambiguities, including English, Spanish, inter-orational and intra-orational code-switches (Adler, in progress). Reaction times and accuracy following the intra-orational code-switches improved beyond the other three blocks, suggesting that this frequent alternating may engage cognitive control resources beyond other language tasks. 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).

In addition, these studies reveal that cognitive control resources are particularly engaged during certain linguistic tasks, which also raises the question of how the groups in Costa et al. (2008) and Torres and Sanz (2016), who were alike in terms of education, age and other cognitive factors, might differ in their *employment* of cognitive control during *linguistic* conflict resolution. To consider this question, a conflict adaptation task, utilizing a linguistic conflict task modified by a non-linguistic cognitive control task, in the vein of Hsu and Novick (2016) may allow us to observe differences between the heritage and emergent bilinguals of Torres and Sanz (2016) that are hidden or too subtle to observe during a non-linguistic task. A hypothesis concerning these questions is presented in Section 5.3, and a study to test it is outlined in Section 6.3.

**5. Research Questions and Hypotheses**

**5.1. Research Questions and Hypothesis regarding Study 1**

1. RQ1.2: How does cognitive control correlate to L2 syntactic ambiguity resolution?
2. RQ1.1: How does L2 proficiency correlate to L2 syntactic ambiguity resolution?
3. RQ1.3: Does cognitive control relate to L2 syntactic ambiguity resolution for learners at different proficiency levels?

Given that previous research suggests that the role of cognitive capacities, such as executive function and short-term phonological memory, decreases at increasing levels of proficiency, the working hypothesis of Study 1 is that cognitive control (as measured by the ANT) will play a differential role in ambiguity resolution across proficiency levels. Specifically, use of a the L2 will impinge more on the cognitive control resources available for syntactic ambiguity resolution at low proficiencies than at high proficiencies, meaning that beginner learners’ ANT scores will correlate to faster abandonment of incorrect parses and more accurate behavioral responses, but this advantage for high cognitive control participants will diminish with increasing proficiency, as cognitive control resources become available for adult-like parsing.

**5.2. Research Questions and Hypothesis regarding Study 2**

1. RQ2.1: How does cognitive control engagement affect L2 syntactic ambiguity resolution by L2 learners?
2. RQ2.2: How do different reactions to cognitive control engagement during L2 syntactic ambiguity resolution relate to different proficiency levels of learners?

Given that previous research suggests a greater role of cognitive control at lower levels of proficiency, the working hypothesis of Study 2 is that cognitive control engagement will play a differential role in ambiguity resolution across proficiency levels. Specifically, for lower proficiencies, the presentation of an incongruency before critical trials will not facilitate disambiguation, because cognitive control resources will already be engaged, regardless of the congruency of the preceding trial, due to the use of a non-highly proficient second language. However, as cognitive control resources are freed up at higher proficiencies, cognitive control engagement will begin to play more of a role to facilitate disambiguation, approximating native speaker patterns.

* 1. **Research Questions and Hypothesis regarding Study 3**

1. RQ3.1: How does cognitive control engagement affect syntactic ambiguity resolution by heritage bilinguals?
2. RQ3.2: How do different reactions to cognitive control engagement during syntactic ambiguity resolution relate to distinct language profiles?

Study 3 is more exploratory than Studies 1 and 2. However, given the results of Costa and colleagues (2008), Torres and Sanz (2016), and Adler (in progress), the working hypothesis of Study 3 is that participants who interact the most with the heritage language will be the fastest to process and reanalyze the ambiguities. However, those who engage in the most language switching will respond most to cognitive control engagement (that is, will have the most drastic difference between i-A and c-A trials) because of high cognitive control development associated with frequent language switching (Abutalebi et al., 2012). Because this is the first study of this kind, an alternate possibility is that those who engage in the most language switching will have the most occupied cognitive control resources and therefore, like patients and children, will show less response to the engagement of these resources through an incongruent preceding trial.

**6. Methodology**

**6.1. Study 1**

*6.1.1. Participants*

Study 1 will recruit participants from 3 levels of Spanish, each 2 semesters apart (that is, Beginner I, Intermediate I, Advanced I *or* Beginner II, Intermediate II, Advanced II). Participants will be between 18 and 28 years old, an age range that entails most university students and avoids protracted prefrontal development or cognitive control degeneration. This age range follows Hsu and Novick (2016) and Pozzan and Trueswell (2015). Participants will be included if they are (i) native speakers of English, (ii) learning Spanish as a second language, with limited knowledge of any other language, and (iii) have normal or corrected-to-normal vision, to allow for proper interaction with the eye-tracker and visual world. Approximately 15-20 participants will be needed per group to conduct analyses at power similar to previous studies (Hsu & Novick, 2016, for example).

*6.1.2. Procedures and Materials*

Participants will complete the experiment in one session, first completing a language background questionnaire and a segment of the DELE, then the Visual World component, and finally the ANT.

Attentional Network Task

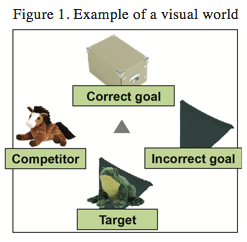
To measure cognitive control, participants will complete the ANT (Fan et al., 2002), following Torres and Sanz (2016), Costa and colleagues (2008), and recommendations from Novick (personal communication, April, 2016), to avoid the linguistic interference of the Stroop task that may manifest with second language speakers of varying proficiencies. In the ANT task, participants focus at a center fixation point and are presented with one of four cue conditions (no cue, center cue, double cue, and spatial cue) immediately followed by a flanker type (neutral, congruent, or incongruent). Inter-trial intervals are jittered between three conditions (400 ms, 1000 ms, 1600 ms). Participants must indicate the direction of the central arrow, suppressing the information of flanker arrows, during each trial presentation by pressing a key on the right or left side of the keyboard (‘z’ or ‘/’). The critical comparison for cognitive control psychometry is [no cue, incongruent] vs. [no cue, congruent].

Visual World Syntactic Disambiguation

All linguistic stimuli will be presented using Tobii Studio. Eye movements will be recorded using Tobii pro TX300. Previous research has recorded act-out movements using a digital camcorder centered on the computer screen. Alternative option is a four-button mouse situated to represent the four quadrants of the visual world. The linguistic stimuli will be Spanish translations of the stimuli used in previous renditions of this paradigm (Hsu and Novick, 2016; Pozzan and Trueswell, 2015; Trueswell et al., 1999). Specifically, like Hsu and Novick, the current study will not include referential context as a condition, given that Pozzan and Trueswell found that adults use referential context while children do not. Given that no child comparisons will be made, this condition is irrelevant.

Participants will listen to spoken instructions and interact with the visual world on a computer screen according to the instructions (that is, act out the instructions). These instructions will be pre-recorded by a female speaker of Mexican Spanish. This dialect was chosen, recognizing that L2 students come from classes with instructors of many dialects, and therefore, a neutral, highly-spoken dialect with a high written grapheme-spoken phone ratio was desired. Of the dialects that meet such a description, Mexican Spanish is likely to accommodate more heritage speakers (for Study 3), given that the great majority of Hispanics in the U.S. are of Mexican descent: 63% in 2010 according to the U.S. Census Bureau (Ennis, Rios-Vargas & Albert, 2011).

Instructions in this task consist of single sentences with a “*poner*” command. Sentences will be temporarily ambiguous (24), unambiguous (24), or filler sentences (48). Sentences will be counterbalanced resulting in two versions of the paradigm: if a sentence is in the unambiguous condition in version 1, it will be in the ambiguous condition in version 2. Item locations will also be counterbalanced, following previous studies using this task.

Examples of the sentences to be used follow (3-5), all of which instruct the participant to act out with respect to a visual world such as the world presented in Figure 1:

1. Temporarily ambiguous: *Pon la rana en la servilleta encima de la caja*.
2. Unambiguous: *Pon la rana que está en la servilleta encima de la caja*.
3. Filler: *Pon la rana en la caja*.

As the ambiguous sentences are heard, listeners fixate on the modifier (e.g. ‘*en la servilleta*’) as if it is the goal until the disambiguating information (e.g. ‘*encima de la caja*’) is reached, at which point the parser must reanalyze the structure. With such sentences, eye movements to the correct goal are delayed when compared to unambiguous sentences such as (4), which is the critical comparison as it concerns syntactic disambiguation.

Language Background Questionnaireand *Diplomas de Español como Lengua Extranjera*

The language background questionnaire (LBQ) will gather information relating to participants’ experience with English and Spanish, as well as any potential experience with an additional language. Questions will focus on variables such as age at which second language study began, years studying Spanish, and external exposure to Spanish. In addition to the LBQ, and to ensure that participants from each proficiency are appropriately sorted, a component of the DELE will be completed. The same portion used in Torres & Sanz (2016) will be used, consisting of a fill-in-the-blank vocabulary section and a cloze passage. This will be used for both the L2 and heritage participants (Studies 1-3) because it avoids highly-explicit and highly-implicit knowledge, to accommodate both groups, and to minimize variability of materials between studies.

**6.2. Study 2**

*6.2.1. Participants*

Study 2 will follow Study 1 chronologically by one semester and will recruit participants from the same level of Spanish as Study 1, with the same inclusion/exclusion criteria. Approximately 15-20 participants will be needed per group to conduct analyses at power similar to previous studies (Hsu & Novick, 2016, for example).

*6.2.2. Procedure and Materials*

Study 2 will be completed in one session. The same LBQ and segment of the DELE will be used as Study 1, both of which will be presented before the interleaved language comprehension-flanker component. The critical difference between Studies 1 and 2 is that Study 2 will interleave flanker tasks within the syntactic disambiguation trials to engage cognitive control before select trials, instead of presenting two distinct tasks.

Interleaved flanker-to-sentence sequences

Before data collection begins, participants will complete a practice phase of both the flanker task (during which they will learn the appropriate response buttons, the different conditions, etc.) and the sentence interpretation task (during which they will learn to act out the instructions, will become familiar with the speaker, etc.). Following the practice phases, the will begin the interleaved task.

The pseudorandom presentation of trials will allow incongruent or congruent flanker trials to precede ambiguous or unambiguous sentence-interpretation trials, resulting in four conditions: i-A, i-U, c-A, and c-U. Twelve pairs of each condition will be prepared, using the same stimuli as Study 1 and counterbalancing in the same vein, to ensure that if a sentence falls in the i-A condition in version 1, it will fall within the i-U condition in version 2. In addition, the 48 filler sentences of Study 1 and additional flanker trials will serve as distractors to prevent participants from predicting the upcoming trial type or condition. However, the critical comparisons are the four primary conditions listed above. At the end of the study, participants will have engaged with the same number of flanker trials and sentence comprehension trials as the participants in Study 1, though the order of the presentation varies between studies.

**6.3. Study 3**

*6.3.1. Participants*

Study 3 will recruit participants from Georgetown University who speak Spanish and who meet Montrul’s (2008) definition of ‘heritage speaker’ (members of a linguistic minority who grew up exposed to their home language and the majority language) within the age range used in Studies 1 and 2 (18-28 years old). While many studies aim to recruit participants from a very narrowed, controlled linguistic profile of heritage speakers, the current study aims to explore differences *between* heritage speakers based on differences in the linguistic profile, so language use and proficiency heterogeneity is preferred. However, educational level and other socioeconomic factors may contribute to differences in cognitive control, so Study 3 will aim to limit differences in these variables. Participants will be excluded if they (i) do not have normal or corrected-to-normal vision; (ii) moved to the U.S. after the age of 6;0; or (iii) received formal education in Spanish other than foreign language or heritage language high school or university courses. Exclusion criteria (ii-iii) follow the definitions of second- and third- generation Spanish-speaker in the U.S. proposed by Hualde, Olarrea, Escobar and Travis (2010), combining definitions from Silva-Corvalán (1994) and Otheguy, Sentella and Livert (2007), among other research. Participants who meet these criteria are difficult to find, but a target of 25 participants will be needed to conduct analyses at power similar to previous studies (Hsu & Novick, 2016, for example).

*6.3.2. Procedures and Materials*

Participants will complete the study in one session. The same segment of the DELE will be used as in Studies 1 and 2, presented following a language background questionnaire specific to the heritage language experience (HLBQ). Following these two components, participants will engage in the same interleaved language comprehension-flanker task outlined in Study 2.

Heritage Language Background Questionnaire

To gather information regarding language background, Study 3 looks to Torres and Sanz (2016) and Gollan, Starr & Ferreira (2015). The information presented in these studies is included in Table 3 to compare related information. The HLBQ will combine select questions from the questionnaires used in these two studies and as recommended in other research (e.g. Montrul, 2008, 2010).

Table 3. Language background questionnaire data points collected by Gollan et al. (2015) and Torres & Sanz (2016)

|  |  |  |
| --- | --- | --- |
|  | Gollan, Starr & Ferreira (2015) | Torres & Sanz (2016) |
| Age of Acquisition | * English | * English * Spanish |
| Self-rated proficiency | * English * Heritage language | * English (each of four linguistic skills) * Spanish (each of four linguistic skills) |
| Years of study | --- | * Spanish * Dual/immersion program? |
| Frequency of use | * Reading in heritage language * Daily language use in English * Daily language use in English as child | * Use of English * Use of Spanish |
| Frequency of language switching | * Frequency of language switching when conversing with bilinguals * Frequency of language switching as child | --- |
| Caregiver language abilities | * Primary caregiver’s ability to speak English * Primary caregiver’s ability to speak heritage language * Secondary caregiver’s ability to speak English * Secondary caregiver’s ability to speak heritage language | --- |

**6.4. Tabular Summary**

To summarize the intentions of Studies 1-3, Table 4 compares various methodological and procedural intentions of each study.

Table 4. Principle differences and similarities of the studies herein proposed.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Study 1** | **Study 2** | **Study 3** |
| **Participants** | L2 learners of beginner, intermediate and advanced proficiencies | L2 learners of beginner, intermediate and advanced proficiencies | Heritage language speakers, with varying dominance of the heritage language |
| *Age* | 18-28 | 18-28 | 18-28 |
| *Educational background* | High school degree, some college | High school degree, some college | High school degree, some college |
| *Knowledge of a L3* | Little to none (maximally limited to 3 years of high school experience) | Little to none (maximally limited to 3 years of high school experience) | Little to none, depending on availability of participants |
| **Linguistic materials** | Translations of Hsu & Novick (2016), recorded by female native speaker of Mexican Spanish | Translations of Hsu & Novick (2016), recorded by female native speaker of Mexican Spanish | Translations of Hsu & Novick (2016), recorded by female native speaker of Mexican Spanish |
| **Cognitive control materials** | Attentional Network Task, presented after linguistic materials | Flanker trials (from ANT), interleaved within linguistic materials | Flanker trials (from ANT), interleaved within linguistic materials |
| **Conflict adaptation?** | No, correlational | Yes | Yes |
| **Other materials** | * Language background questionnaire * Segment of DELE (Torres & Sanz, 2016) | * Language background questionnaire * Segment of DELE (Torres & Sanz, 2016) | * Heritage language background questionnaire (Gollan, Starr & Ferreira, 2015; Torres & Sanz, 2016) * segment of DELE (Torres & Sanz, 2016) |

**7. Conclusion**

The above-proposed studies will help us disentangle cognitive control’s complex relationship with L2 proficiency and with bilingual language dominance. Such research is timely, considering recent research in SLA, psycholinguistics and neuroimaging that suggests that cognitive control plays a differential role across L2 development and considering recent research in the ‘bilingual advantage’ literature that reconsiders the umbrella term ‘bilingual’ to study how distinct language profiles may possess distinct ‘advantages’ due to varying bilingual experiences.

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1. One study even found that bilinguals who began learning both languages at birth outperformed bilinguals who began learning their second language at age 3 on a Simon task, even though proficiency in both groups’ proficiency in both languages was equivalent (Struys, Mohades, Bosch & van den Noort, 2015). [↑](#footnote-ref-1)
2. It should be noted that the bilingual group had also reported comparable proficiency in a third language (beyond Spanish and Catalan) that they similarly learned in school. This presents a further difficulty for comparing Costa et al. (2008) and Torres & Sanz (2016). [↑](#footnote-ref-2)
3. Costa et al. (2008) and Torres & Sanz (2016) only include the labels of the poles of their Likert scale, so the choice of words is my own to reflect the numerical data presented and to reflect how the authors represented that data in their own descriptions, unless presented in quotes. [↑](#footnote-ref-3)