ABSTRACT

Title of Thesis: SES-RELATED DIFFERENCES IN WORD
                                    LEARNING: EFFECTS OF COGNITIVE
                                    INHIBITION AND WORD LEARNING

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                                    Speech Sciences

Socioeconomic status (SES) influences language and cognitive development, with

discrepancies particularly noticeable in vocabulary development. This study examines

how SES-related differences impact the development of syntactic processing,

cognitive inhibition, and word learning. 38 4-5-year-olds from higher- and lower-SES

backgrounds completed a word-learning task, in which novel words were embedded

in active and passive sentences. Critically, unlike the active sentences, all passive

sentences required a syntactic revision. Measures of cognitive inhibition were

obtained through a modified Stroop task. Results indicate that lower-SES participants

had more difficulty using inhibitory functions to resolve conflict compared to their

higher-SES counterparts. However, SES did not impact language processing, as the

language outcomes were similar across SES background. Additionally, stronger

inhibitory processes were related to better language outcomes in the passive sentence

condition. These results suggest that cognitive inhibition impact language processing, but this function may vary across children from different SES backgrounds

SES-RELATED DIFFERENCES IN WORD LEARNING: EFFECTS OF
COGNITIVE INHIBITION AND WORD LEARNING

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Arts
2016

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Table of Contents

1. Introduction

Socioeconomic status (SES) significantly influences language and cognitive development, resulting in a significant gap in language ability (Brocki & Bohlin, 2004; Farah et al., 2006; Hackman & Farah, 2009; Hoff, 2003; Huang, Leech, & Rowe, 2015; Huttenlocher, 1998; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Noble, Norman, & Farah, 2005; Sarsour et al., 2011:). Overall, children from lower-SES backgrounds have a notably smaller lexicon and use less complex syntactic structures compared to their higher-SES counterparts (Hart & Riseley, 1995; Hoff, 2003; Huang et al., 2015; Huttenlocher et al., 2002; Noble et al., 2005). SES-related differences in the quality and quantity of language input negatively impact children's language development (Harkness, 1977; Hoff, 2003; Hoff, Laursen, & Tardiff, 2002; Hoff-Ginsberg, 1998; Huttenlocher et al., 2002; Huttenlocher, 1998; Snow, Pearlman, & Nathan, 1987). However, the precise mechanisms that mediate this relationship remain unclear.

The current study will investigate the extent to which SES-related differences in input impacts children's real-time language processing and how well children access information within their input during word learning. It will also explore how differences in language processing may be related to SES-related variation in inhibitory processes (Ardila, Matute, & Guajardo, 2005; Farah et al., 2006; Hackman & Farah, 2009; Noble et al., 2005; Noble, McCandliss, & Farah, 2007). In the remainder of the Introduction, relevant literature will be discussed regarding the effects of SES on language development, cognitive processes, and the interactions between the two during language acquisition. Then, hypotheses regarding the impact these interactions may have on

1

language processing and word learning will be introduced. Finally, a study that investigates whether possible differences in inhibitory processes impact language outcomes in children from different SES backgrounds and the subsequent implications will be described.

1.1 SES differences in language ability and caregiver input

SES-related impacts on children's expressive and receptive language abilities are particularly noticeable during vocabulary development. Children from lower-SES backgrounds build their vocabularies at slower rates, resulting in a more limited lexicon for children from lower-SES backgrounds than those from higher ones (Arriaga, Fenson, Cronan, & Pethick, 1998; Dollaghan et al., 1999; Feldman et al., 2000; Hart & Risley, 1995; Hoff, 2003; Morisset, Barnard, Greenberg, Booth, & Spieker, 1990; Rescorla, 1989; Rescorla & Alley, 2001). SES also impacts syntactic growth. Compared to their higher-SES counterparts, children from lower-SES backgrounds tend to use simpler and less varied syntactic structures (Harkness, 1997; Hoff-Ginsberg, 1998; Huttenlocher et al., 2002) and exhibit weaker comprehension of complex constructions (Huang et al., 2015; Huttenlocher et al., 2002;).

But how do these differences develop? SES-related differences in language input contribute to this disparity in linguistic ability (Dollaghan et al., 1999; Hart & Risley, 1995; Hoff, 2003; Huttenlocher, 1998; Morisset, et al., 1990). Huttenlocher (1998) measured the quantity and quality of the language input provided by mothers from higher- and lower-SES backgrounds and the vocabulary development in their children. Results indicated that the greater quantity of linguistic input provided by the higher-SES mothers in this study accounted for some of the differences seen in the advanced

vocabularies of their children compared to their lower-SES peers. Across several studies and literature reviews, parents from higher-SES backgrounds also have a tendency to provide a higher quality of language input; they tend to use more complex grammatical structures, more sophisticated vocabularies, and provide a greater amount of contingent responses to elicit more conversation when speaking to their children (Arriaga et al., 1998; Hoff et al., 2002; Hoff-Ginsberg, 1998; Snow, 1999).

Caregiver input also affects syntactic development. Greater input quantity increases the rate of syntactic development (Hoff-Ginsberg 1997, 1998). Input quality also affects the development of specific syntactic forms, such as the auxiliary (Hoff-Ginsberg, 1985; Newport, Gleitman, & Glietman, 1977). Some studies have suggested that an imperative utterance might be beneficial for younger children, as this structure facilitates associations between novel referents and their meanings (Barnes, Gutfreund, Satterly, & Wells, 1983; Furrow, Nelson, & Benedict, 1979; Hoff-Ginsberg, 1985). However, over-use of the imperative has been shown to be maladaptive. For instance, parents from lower-SES backgrounds tend to use a greater proportion of imperatives, thereby exposing their children to a more limited set of syntactic structures. This high proportion of imperatives has been associated with lags in development of noun phrase constituents (Newport et al., 1977).

1.2 The role of inhibitory control in syntactic processing

Overall, greater quantity and quality of language input appears to have similar beneficial effects on vocabulary and syntactic development. These striking parallels raise the question of how these two domains are related. According to the syntactic bootstrapping theory, children's use of syntactic cues may allow them to narrow down

novel word meanings (Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman, 1990;

Naigles, 1990; Naigles, Fowler, & Helm, 1992; Naigles, Gleitman, & Gleitman, 1993;

Naigles & Hoff-Ginsberg, 1995; Naigles & Kako, 1993). For example, in the sentence,

"The *blicket* is quickly eating the seal," children can utilize the meaning of "eating" and

realize that it is a transitive verb that requires both an agent and a patient. Children might

then use the syntactic cue of word order to help narrow down the meaning of "*blicket.*"

In English, sentences are typically ordered subject, verb, and then object (SVO). Using

this information, children can assign "*blicket*" as the subject/agent because "*blicket*"

appears first in the sentence and infer that it must be a large carnivorous animal that can

eat seals.

However, additional evidence suggests that children sometimes have difficulties

using syntactic cues during sentence comprehension, particularly when processing

garden-path (temporarily ambiguous) sentences (Kidd & Bavin, 2005; Novick,

Trueswell, &Thompson-Schill, 2005; Trueswell, Sekerina, Hill, & Logrip, 1999;

Weighall, 2008). In Trueswell et al., (1999), five-year-old children and adults were

presented with temporarily ambiguous sentences (e.g., "put the frog on the napkin in the

box") and unambiguous sentences (e.g., "put the frog *that's* on the napkin in the box").

Both children and adults initially misinterpreted ambiguous sentences (i.e., assuming that

the napkin is the goal of 'put'). Critically, adults revised these misinterpretations by

utilizing relevant syntactic cues (i.e., 'in the box' is the actual goal so 'on the napkin'

must be a modifier), whereas children were unable to do so. Therefore, unlike adults,

children demonstrated an inability to use syntactic cues appropriately to resolve

ambiguity during online language processing.

It has been argued that children's difficulty with syntactic revision may be the result of weak executive functioning, specifically inhibitory processes (Mazuka, Jincho, & Oishi, 2009; Novick et al., 2005; Ye & Zhou, 2009). Executive functions allow for effective and efficient responses to novel stimuli and are recruited for planning, decision-making, reasoning, skill learning, error correction, and problem solving (Mazuka et al., 2009). Critically, these functions are late to mature, which might explain why children display errors in language comprehension (Huttenlocher & Dabholkar, 1997; Pribram, 1997). Support for this hypothesis comes from associations between language and executive functions of memory, self-regulation, and attention (Adams & Gathercole, 1995; Kaler & Kopp, 1990; Kopp, 1989; Wolfe & Bell, 2004). Across coarse-grained measures, children with stronger abilities in executive functions produce more complex language and have better comprehension abilities.

However, it has been difficult to distinguish the exact roles that various executive functions play during language processing. Most of the studies that isolate specific mechanisms have been conducted with adults (January, Trueswell, & Thompson-Schill, 2009; Novick, Trueswell, & Thompson-Schill, 2010). For example, using fMRI measures, January et al., (2009) found that the executive function of inhibition is associated with the resolution of ambiguity. Adults completed a sentence comprehension task and a Stroop task. In the sentence comprehension task, they were presented with sentences and corresponding images that contained either a low, middle, or high level of conflict. Participants then completed the Stroop task. The results indicated that when conflict arose, areas in the brain associated with inhibitory processes were activated. These findings raise questions of what role inhibition may play during language

5

development, when children must resolve conflicts caused by lexical and syntactic ambiguity. Additionally, these findings raise questions of how this role might vary across children from different SES backgrounds who have varying levels of inhibitory control.

1.3 What a processing model might explain about SES differences and language outcomes.

Recent evidence suggests that children from lower-SES backgrounds have more difficulty processing complex syntactic structures, such as passive sentences (Huang et al., 2015). Three- to seven-year-old children from higher- and lower-SES backgrounds were asked to act out active and passive sentences. Critically, the passive sentences either require syntactic revision (e.g., "The seal was quickly caught by it") or did not require syntactic revision (e.g., "It was quickly caught by the seal"). Children performed equally well for active sentences and for passive sentences that did not require a syntactic revision. Critically, those from lower-SES backgrounds performed worse than those from higher-SES backgrounds when the passive sentence required a syntactic revision. This finding suggests that children are able to use syntactic cues to comprehend different constructions, but have difficulty processing sentences that require revision of a misinterpretation.

In a follow-up study, Huang and Arnold (2015) found that challenges with syntactic revision contribute to less effective word learning in children from higher-SES backgrounds. Children heard critical sentences comprised of active and passive constructions that now contain a novel word ("*blicket*"). They were highly accurate at inferring the meanings of the novel words when they occurred in active sentences and passive sentences that did not require a syntactic revision (e.g., "The seal was quickly

caught by the *blicket*"). But, they performed poorly on passive conditions that required a syntactic revision (e.g., "The *blicket* was quickly caught by the seal"). In this sentence, children were more inclined to assign "*blicket*" to an agentic role due to children's agent-first biases. The children were unable to revise this interpretation upon encountering the syntactic cue of the past participle in the passive sentence. Further, the children's abilities to recall the novel word meanings were affected by challenges in language processing during certain conditions. Namely, there was a higher likelihood of the children inaccurately recalling a novel word meaning in learning contexts where the processing demands were high, as in the novel NP1 passive condition.

These findings suggest that challenges with real-time syntactic processing can negatively impact word learning. However, they raise questions of how these effects unfold in children from lower-SES backgrounds and the extent to which variation in cognitive inhibition impacts word learning and vocabulary development. There is evidence that children from lower-SES backgrounds have decreased executive functioning compared to children from higher-SES backgrounds (Ardila et al., 2005; Noble et al., 2005; Noble et al., 2007). Furthermore, across a battery of assessments, there are significant interactions between SES, language, and inhibition (Farah et al., 2006; Noble et al., 2005; Noble et al., 2007; Sarsour et al., 2011). One can imagine that if children had greater inhibitory control, they could inhibit some biases, such as an agent-first bias, and revise their initial misinterpretations for temporarily ambiguous sentences. Over the course of development, this ability may result in more accurate word learning and a more extensive vocabulary.

1.4 The current study

The current study investigates the effects of syntactic processing on word learning in children from higher- and lower-SES backgrounds. The primary measures were the language processing and recall measures used by Huang and Arnold (2015). In the current study, participants were presented with active and passive sentences containing novel stimuli in the NP1 position such as in (1) and (2).

1. Novel NP1 Active: "The *blicket* is quickly eating the seal."

2. Novel NP1 Passive: "The *blicket* is quickly eaten by the seal."

Participants' eye movements were recorded as they listened to these sentences. After each sentence, participants were asked to select an object that they interpreted to be the referent for the novel word. Upon completion of the processing task, the participants were asked to remember the novel word meaning in a delayed recall task. In addition to language processing and recall measures, participants also completed Part II of the *Diagnostic Evaluation of Language Variation* (DELV) as a way to evaluate individual differences in overall language abilities (Seymour, Roeper, De Villiers, & De Villiers, 2003). Finally, the current study also included a secondary measure, a modified version of the Stroop task (1935), to measure individual differences in inhibitory control.

Based on previous studies, participants across all SES backgrounds are expected to perform worse on passive compared to active sentences, since the former requires syntactic revision (Huang et al., 2015; Huang & Arnold, 2015). Critically, in a word-learning context, two additional patterns could also arise with passives. One possibility is that children from a higher-SES background will be more accurate in their interpretations of novel words compared to their lower-SES counterparts. Support for this pattern comes

from prior literature demonstrating more advanced language abilities, on average, for children from higher-SES backgrounds compared to those from lower-SES backgrounds (Harkness, 1977; Hart & Riseley, 1995; Hoff, 2003; Hoff et al., 2002; Hoff-Ginsberg, 1998; Huang et al., 2015; Huttenlocher et al., 2002; Huttenlocher, 1998; Noble et al., 2005; Snow, Pearlman, & Nathan, 1987). In addition, Huang et al., (2015) found that children from a higher-SES background outperformed their lower-SES counterparts when processing and interpreting passive sentences.

However, a second possibility is that the increased processing demands of word learning diminish previously documented SES differences in syntactic revision. Previous research has found that a word-learning context can minimize differences that are otherwise present in a non-learning context. For example, Werker & Stager (1997) found that while 14-month olds were able to discriminate sounds in the syllable discrimination task (e.g., 'bih' vs. 'dih'), they were unsuccessful when these sounds were linked to referents in a word-learning task (e.g., a lollipop-like image vs. a crown-like image). This finding suggests that the increased complexities involved in word learning may have overwhelmed the infants, thereby decreasing the sensitivity of their speech perception abilities. Thus, based on the study by Werker & Stager (1997), it is possible that the additional processing challenges involved in the word-learning task will mask SES-related variation in syntactic revision abilities since all children may find these contexts to be difficult, irrespective of their background.

Finally, the current study also explores the effect of individual differences in cognitive inhibition on children's syntactic-revision abilities. In the Stroop task, it is expected that across all children, incongruent trials (which require a resolution of

conflict) will be more difficult than congruent trials (which lack the conflict present in the incongruent trials). Moreover, consistent with prior research (Ardila et al., 2005; Noble et al., 2005; Noble et al., 2007), it is expected that children from lower-SES backgrounds will exhibit weaker inhibitory functions compared to their higher-SES counterparts. Critically, since the passives sentences in the present study require syntactic revision for correct interpretation, it is expected that children with stronger inhibitory functions will be more successful at revising initial misinterpretations, leading to more accurate interpretations of novel words. Thus, a positive correlation between incongruent Stroop trials and correct interpretations of novel words in passive sentences may emerge across all children, irrespective of SES background. However, minimal relationships are expected to occur between Stroop trials and word learning in the active sentence condition and between the congruent Stroop trials and the passive sentence condition.

2. Methods

2.1 Participants

A total of 38 participants, 21 participants from lower-SES backgrounds (M = 56 months; SD = +/- 6 months; Range = 49-69 months) and 17 from higher-SES backgrounds (M = 61 months; SD = +/- 6 months; Range = 53-75 months), were recruited from schools and Head Start programs within the Baltimore-Washington region. Participants were randomly assigned to one of two experimental lists, where they were presented with active and passive sentences containing novel words. Prior to any testing, written consents and demographic information were collected from the parents of the participants. This demographic form was used to acquire information about parental education, parental income, and number of books found in a child's home. This

information was converted from categorical variables of years of education, income in dollars, and number of books, to a numerical value. Further, questions regarding diagnoses of ADHD or language-learning disabilities were asked to reduce confounds and ensure the sample population is comprised of typically developing children.

2.2 Procedure

The experiment was implemented over two sessions, each lasting approximately 20-30 minutes. During the first testing session, participants performed a language-processing measure. During the second testing session, participants performed a modified Stroop task and a portion of the *DELV* part II, a language screening assessment (Seymour et al., 2003).

Language processing. This part of the experiment was divided into two sections: a language- processing measure and a recall measure. During the language-processing measure, each participant sat in front of a computer that presented the stimuli. First, a practice trial was given where two objects, one familiar and one unfamiliar, were shown to each participant. Then, each participant was instructed to click on the unfamiliar object. Following the completion of the practice trial, the experiment began. For each trial, the participant watched a video of three objects interacting with each other. This video was followed by an orally presented sentence in either an active or passive construction that described the scene with a novel word (e.g., *blicket*). Next, the participant was asked to click on the object that corresponded to the novel word. Throughout this measure, eye movements were recorded using an Eyelink1000 eye-tracker (SR Research Ltd). Following this language-processing measure, the participants performed the recall measure. During the recall measure, the pair of novel images

11

presented for each critical sentence was shown to each participant. The participant was then asked to select the correct image that corresponded to the novel word. The accuracy of the participants' selections was recorded.

DELV. The *DELV* is a two-part language screening assessment that was designed to distinguish whether language deviations were the result of a language disorder or a dialectal variation. Due to time constraints and relevance of the content, only a portion of Part II: Diagnostic Risk Status was administered to compare the language abilities of the participants. During administration of the *DELV*, the participants were orally presented with short stories by the experimenter. The experimenter then asked the participants to provide oral responses to various questions about the short stories that required the use of various syntactic elements.

Modified Stroop task. During the modified Stroop task, the participants went through practice trials where they were introduced to a dog and taught its name. The participants were instructed to say the dog's name when the dog appeared. During these 12 practice trials, each presented for a maximum of 15 seconds, the child said the dog's name. Following these practice trials, the participants were introduced to four dogs: a blue dog named Red, a red dog named Blue, a green dog named Green, and a brown dog named Brown. In each of the 12 critical trials, which lasted for a maximum of 6 seconds, the participants were asked to provide the name of each dog they saw.

2.3 Materials

Language processing. The stimuli for the language-processing measure were the same as the stimuli used in Huang and Arnold (2015), except the current study only tested the sentences where the novel word was located in the NP1 position. Sentences

differed between active and passive constructions. Critically, all passive sentences required a syntactic revision. Additionally, an adverb was inserted between NP1 and NP2 to create a period of ambiguity before the disambiguating phrase (e.g., "The *blicket* will be quickly eat*ing* the seal."). Each of the 12 critical sentences was paired with a visual display, involving three objects: a likely theme (e.g., small, unthreatening object), a familiar expressed noun (e.g., seal), and a likely agent (e.g., large, threatening object). Figure 1 illustrates that likely themes are smaller, making it plausible for the likely agent or expressed noun to act upon it. Likely agents are larger, making it plausible for the likely agent to act on the expressed noun or likely theme.
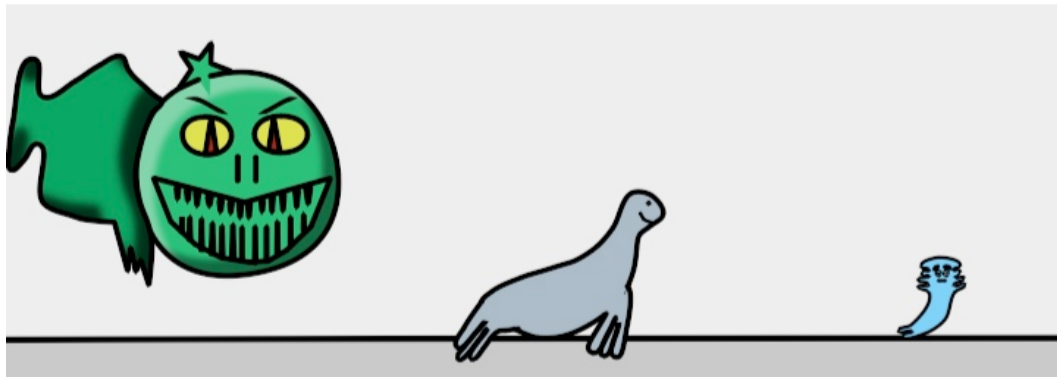

Figure 1. Example image of a trial with the likely agent (the green monster), the expressed noun (the seal), and the likely theme (the blue monster).

In addition to the critical trials, six filler sentences were randomly presented. The filler sentences contained familiar items (e.g., polar bears, penguins, and squirrels) and were presented as active sentences. These simple trials encouraged performance by promoting good testing behaviors and reducing fatigue. Appendices A and B lists all critical trial displays and sentences.

Modified Stroop task. A modified Stroop task was administered to the participants. Traditionally, the Stroop task involves words with different ink colors. To make the Stroop task appropriate for the largely pre-literate target population, colored dogs were presented to the participants. There were four dogs (see Figure 2): two incongruent dogs (2a,b) and two congruent dogs (2c,d). A dog is congruent when the name and color of the dog match. A dog is incongruent when the name and color of the dog do not match.
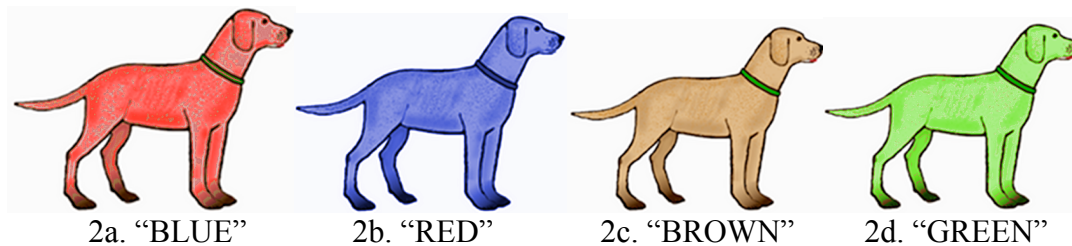

2a. "BLUE"   2b. "RED"   2c. "BROWN"   2d. "GREEN"

Figure 2. Images used for incongruent (2a and 2b) and congruent (2c and 2d) Stroop Trials.

2.4 Coding

Eye movements. Eye movements were recorded using the Eyelink1000 eye-tracking software. Three fixation locations were recorded by the eye-tracker. Preferences to look at either the agentic or the thematic stimuli were calculated by subtracting the number of looks to the agent from number of looks to the theme. Critically, the more negative values correspond to a greater preference to look at the agentic stimuli and the more positive values correspond to a greater preference to look at the thematic stimuli.

Actions. Participants' actions during the language-processing task were recorded using the Eyelink1000 eye-tracking software. As in the eye-coding section, the percentage of clicks was calculated for the target item, the competitor item, and the expressed noun. A click to the target indicated that the participant clicked on the correct novel image that corresponds to the novel word. A click to the competitor item indicated that the participant clicked on the incorrect unfamiliar object. Participant's ability to

14

recall the meanings of novel words was also recorded. The total number of correct and incorrect role assignments was calculated. A correct role assignment was awarded when the participant chose a correct novel word-image pair. An incorrect role assignment was awarded when the participant chose an incorrect novel word-image pair.

DELV. Coding for the DELV measured the children's language abilities. Participants' responses were scored according to the presence or absence of syntactic elements, after which a total score was calculated. The raw scores were then compared to observe any differences in linguistic abilities between the participants.

Modified Stroop task. Coding for the modified Stroop task measured the participant's response accuracy. A response was considered accurate if the participant correctly named the dog; a response will be considered inaccurate if the participant incorrectly named the dog.

3. Results

To identify SES-related and cognitive-inhibition effects on word learning, we conducted several sets of analyses. First, we analyzed participants' demographic information to place the participants into one of two groups based on SES. Second, the participants' accuracy during a modified Stroop task was measured to assess their inhibition skills. Third, we analyzed eye-movement data to assess the participants' sensitivities to syntactic cues while interpreting sentences to assign roles to novel words. Fourth, we analyzed the accuracy of the participants' role assignments to the novel words. Fifth, we analyzed participants' ability to recall initial interpretations of the novel words. Finally, we analyzed the relationship between participants' performances on the language and cognitive tasks.

3.1 Demographics

For all the analyses, SES was determined using the primary measure of parental annual income. Parental annual income was highly correlated with school status ($r(32) = .84$, $p < 0.001$) and parental education ($r(32) = .85$, $p < 0.001$). To improve the clarity of the presentation of the data, participants were grouped into two discrete SES categories based on parental annual income or school status, in the event that income was unavailable. Given the distribution of the current sample, most analyses (unless otherwise noted) categorized participants into two SES groups. Based on the histogram of the current sample, a participant was placed in the higher SES group if the parental annual income was $90,000 or more ($n = 17$); a participant was placed in the lower SES group if the parental annual income was less than $90,000 ($n = 21$).

A series of one-way ANOVAs were used to assess SES differences in age and DELV scores. The results from the ANOVAs indicate that there was no SES difference for DELV scores ($F(1, 32) = 1.38$, $p = 0.71$). These results indicate that the participants had similar syntactic abilities across SES backgrounds. Critically, there was a significant difference in ages between the groups ($F(1, 36) = 4.21$, $p < 0.05$). Participants from the higher-SES group ($M = 61$ months, $SD = 6$ months) were older than the participants from the lower-SES group ($M = 56$ months, $SD = 6$ months). We will return to both these issues in the Discussion.

3.2 Cognitive Inhibition

Overall, participants performed more accurately on congruent Stroop trials ($M = 81\%$, $SD = 0.24$) than incongruent ones ($M = 62\%$, $SD = 0.34$). Further, as illustrated by Figure 3b, participants from the higher-SES background ($M = 82\%$, $SD = 0.24$)

16

performed similarly to their lower-SES counterparts (M = 80%, SD = 0.24) on the

congruent Stroop trials. In contrast, on the incongruent condition, participants from the

higher-SES background (M = 74%, SD = 0.27) outperformed the participants from the

lower-SES background (M = 52%, SD = 0.35). In addition, the magnitude of the

difference in accuracy scores between the congruent and incongruent Stroop trials

appears to be more striking for the participants in the lower-SES group. This result

suggests that all participants experienced conflict during the incongruent Stroop trials, but

the participants from the higher-SES group were better at resolving this conflict.

To confirm these effects, a 2 x 2 ANOVA was conducted, where SES background

(higher-SES background vs. lower-SES background) was the between-subject variable

and Stroop trial (congruent trial vs. incongruent trial) was the within-subject variable.

This analysis confirmed a main effect of condition (F(1,36) = 8.43, p < 0.001), whereby

accuracy for the congruent Stroop trials was higher than accuracy for the incongruent

Stroop trials. It also revealed a marginal effect of SES (F(1,36) = 3.2, p > 0.082), where

responses by participants from the higher-SES group were more accurate overall

compared to those from the participants in the lower-SES group. However, while this

effect is driven by differences in the incongruent trials, the interaction between Stroop

Condition and SES background did not approach significance (F(1,36) = 2.69, p > 0.100).

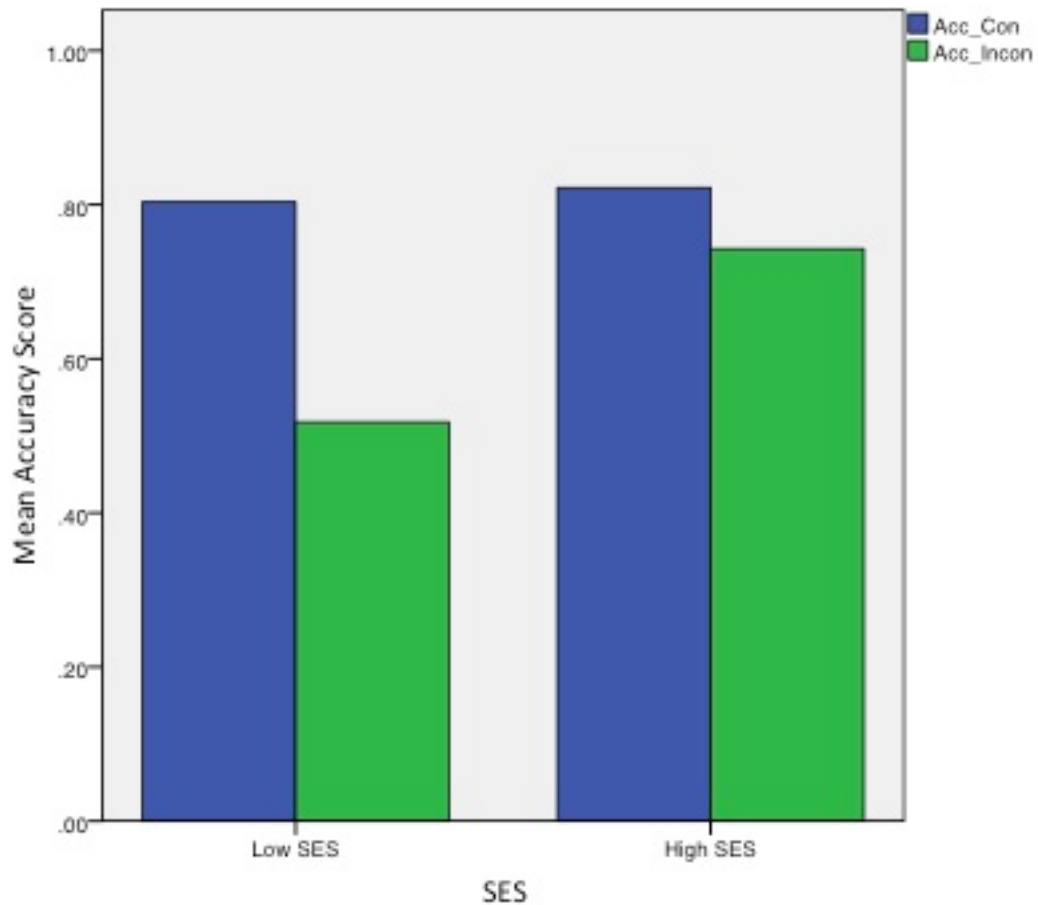*Figure 3.* The participants' Stroop accuracy by condition and SES.

3.3 Language Processing

Eye movement analyses. Our primary measure of language processing identified how participants were using syntactic cues during sentence interpretations to assign meanings to novel words. Specifically, this measure was used to determine (1) the participants' sensitivity to linguistic cues when assigning meanings to novel words and (2) if processing difficulties impacted the participants' performance. To measure these differences, the participants' eye movements were recorded and used to analyze the percentage of looks to the agentic and thematic stimuli following the onset of the verb, which marked the disambiguation point between active and passive sentences. The

18

disambiguation period was shifted 200ms to account for the time needed to generate

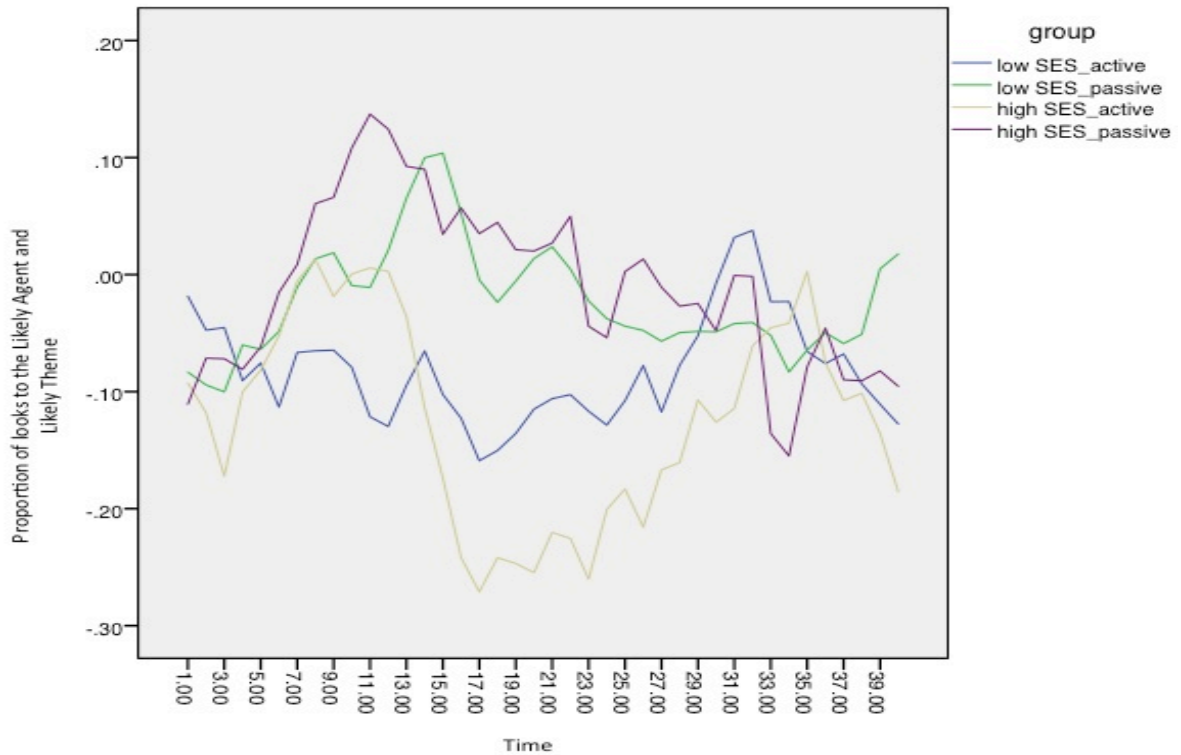saccadic eye movements (Martin, Shao, & Boff, 1993).

Figure 4. The time course of looks to the Likely Agent and Likely Theme. Time is
plotted in increments of 50ms.

Figure 4 illustrates that eye movements varied by construction and SES background.

A divergence in looks to the Likely Agent and Likely Theme begins within a range of

250-500ms after the onset of linguistic disambiguating cue (i.e., eat*ing* in the active

sentences vs. eat*en by* in the passive sentences). This finding indicates that participants

have relatively similar sensitivity to linguistic cues when interpreting passive and active

sentences. However, the magnitude of the divergence in looks to the Likely Agent is

more striking for the higher-SES group, mostly due to those participants' excellent

performances at interpreting active sentences. Therefore, this greater divergence in looks

to the Likely Agent indicates that participants from a higher-SES background are slightly

better at using syntactic cues when interpreting sentences to assign meanings to novel words compared to participants from lower-SES backgrounds. Unfortunately, due to the limited sample size in the present study, statistical analyses could not be performed to provide direct support for these qualitative findings.

Action Data. A participant's accuracy at assigning the correct referents to the novel words was analyzed (see Figure 5). Figure 5 indicates that participants from the higher-SES background performed similarly during the active (M = 78%, SD = 0.16) and passive conditions (M = 25%, SD = 0.29) to the participants from the lower-SES background during the active (M = 71%, SD = 0.22) and passive conditions (M = 27%, SD = 0.25). This result indicates that all participants experienced similar difficulties during interpretations of passive sentences, which resulted in similar language outcomes.

To confirm these effects, a 2 x 2 ANOVA was conducted, where SES background (higher-SES background vs. lower-SES background) was the between-subject variable and syntactic construction (active vs. passive) was the within-subject variable. The analyses indicate that there was a main effect for construction ($F(1, 36) = 88.35$, $p < 0.001$), but there was no main effect for SES ($F(1, 36 = 0.18$, $p = 0.68$), or interaction between, SES and construction ($F(1, 36) = 0.80$, $p = 0.38$). This finding suggests that all participants, irrespective of SES background, experienced challenges with passives in a word-learning context.
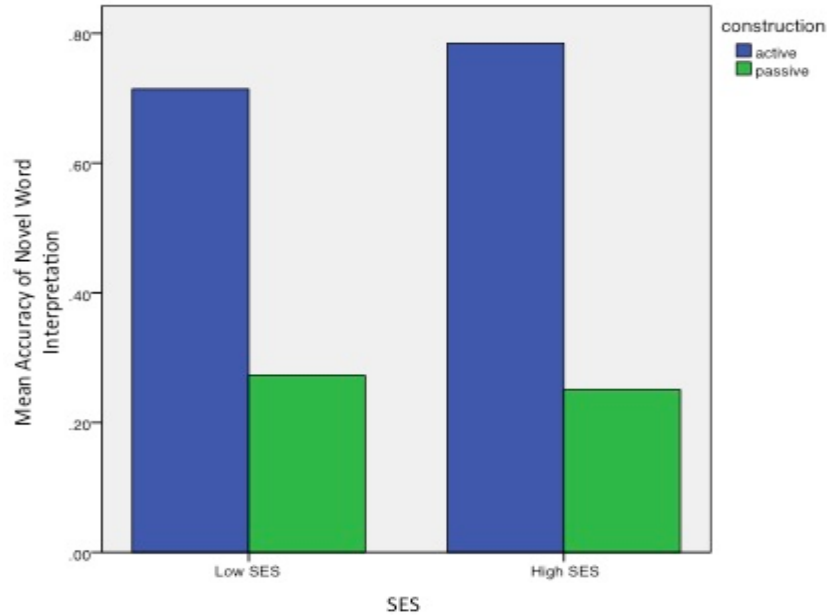
Figure 5. Participants' accuracy of interpretations of novel words by condition and SES.

Recall Data. Participants' recall accuracy were compared in order to measure how well they remembered their initial responses and if this ability was affected by the condition in which the novel word was presented. To determine the likelihood that the responses matched between the action and the recall tasks, a 2 x 2 ANOVA was conducted across all analyses, where sentence construction was the within-subjects variable and SES was the between-subjects variable.

First, the likelihood of matching responses in the recall task was analyzed when the initial interpretations of the novel words were incorrect in the action task (see Figure 6). Critically, in order for a match to occur, participants must incorrectly select the Likely Theme in the active conditions and the Likely Agent in the passive conditions in both action and recall tasks. Figure 6 shows that when participants incorrectly assigned a referent to a novel word during the action task, they were significantly more likely to recall that interpretation for the passive condition (M = 84%, SD = 0.28) compared to the

21

active condition (M = 24%, SD = 0.36). This result occurred irrespective of SES

background, and led to a main effect of sentence construction ($F(1, 30) = 54.27$, p <

0.001), but no main effect of SES ($F(1, 30) = 1.69$, p < 0.20) or interaction between the

two ($F(1, 30) = 0.22$, p = 0.65). Altogether, this pattern suggests that if participants

selected an incorrect referent, they were more likely to recall that response based on a

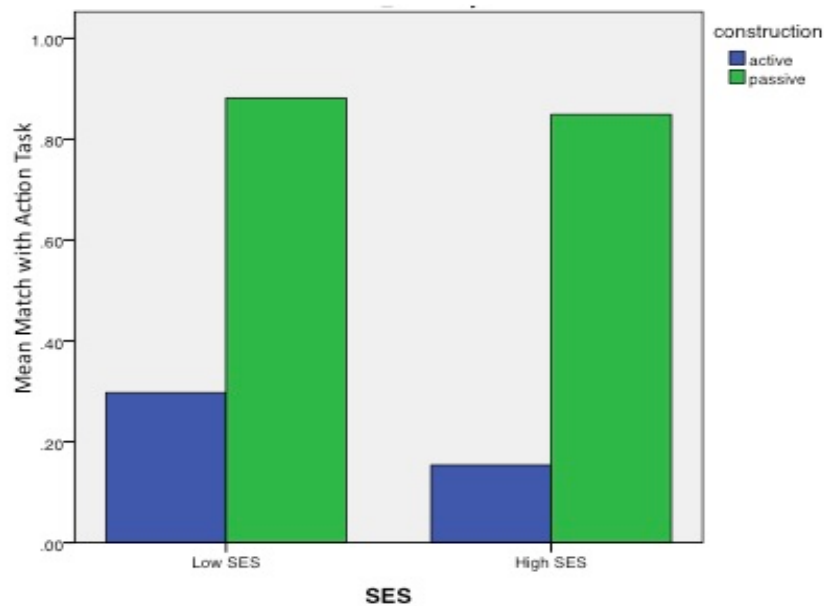preference for a stimulus item (e.g., the appearance or size of the Likely Agent).

Figure 6. Mean match of recall task with action task, when interpretation during action task was inaccurate.

Next, the likelihood of matching responses was analyzed when the initial

interpretations of the novel words were correct. Critically, participants here needed to

select the Likely Agent in the active conditions and the Likely Theme in the passive

conditions in both the action and recall tasks for a match to occur. As demonstrated in

Figure 7, participants were more likely to recall the correct referent in the active

condition (M = 73%, SD = 0.39) compared to passive condition (M = 41%, SD = 0.39).

This result led to a main effect of construction ($F(1, 24) = 7.71$, p = 0.01), but no main

effect of SES ($F(1, 24) = 0.80$, p = 0.38) or interaction between the two ($F(1, 24) = 0.01$,

p = 0.94). This finding suggests that recall for the active condition is far more accurate, possibly because actives do not require syntactic revision. As a result, more cognitive resources can be allocated to encoding the word-referent pair into memory, thereby improving recall of novel words. In contrast, fewer cognitive resources are available to encoding these word-referent pairs when a revision is required. Therefore, participants have more trouble recalling novel word meanings in the passive condition.
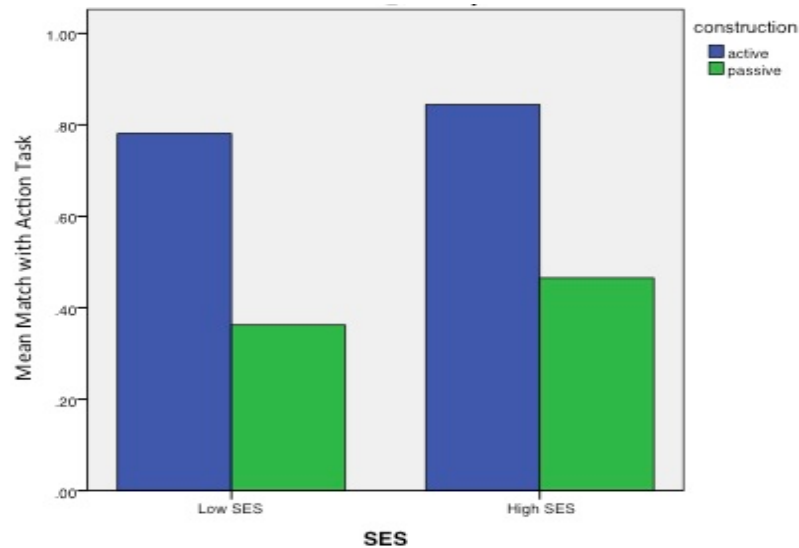

Figure 7. Mean match of recall task with action task, when interpretation during action task was accurate.

3.4 Interaction between language processing and cognitive inhibition

Finally, we assessed possible relationships between participants' cognitive inhibition and their ability to make syntactic revisions. A series of Pearson correlations analyzed interactions between performance on active and passive sentences in the language task and congruent and incongruent trials in the Stroop task. No relationship was found between accuracy on congruent Stroop trials and interpretation of active ($r(38) = -0.06$, $p = 0.74$) and passive sentences ($r(38) = 0.04$, $p = 0.80$). Similarly, there was no significant relationship between accuracy on incongruent Stroop trials and the active condition ($r(38)$

= 0.24 p = 0.14). Critically, increased accuracy on the incongruent Stroop trials was significantly correlated with increased accuracy in the passive condition (r(38) = 0.42, p < 0.01). Follow-up partial correlations found that this relationship remained significant, even while controlling for performance on the congruent Stroop trials (r(35) = 0.42, p < 0.01), active trials (r(35) = 0.42, p < 0.01), and age (r(29) = 0.39, p <0.05). Altogether, this result suggests that learning words in a context requiring syntactic revision are related to the recruitment of cognitive-inhibition abilities. Individual differences in cognitive inhibition may improve one's ability to flexibly acquire words in diverse linguistic contexts and may improve comprehension of varying linguistic inputs.

4. Discussion

The present study sought to discover how SES related-differences in cognitive inhibition might impact SES-related differences in children's language processing and word learning. We found that participants from the lower-SES group had more difficulty dealing with conflict presented in the incongruent Stroop trials compared to participants from the higher-SES group. This pattern is consistent with prior studies demonstrating weaker inhibitory functions by the children from the lower-SES background (Ardila et al., 2005; Noble et al., 2005; Noble et al., 2007). Moreover, similar to the results from Huang and Arnold (2015), participants utilized syntactic cues more successfully in the active condition, but were less successful in the passive condition. In addition, similar differences in the recall measure for both SES groups were noted between the current study and Huang and Arnold (2015). Finally, individual differences in inhibitory control were found to significantly relate to syntactic revisions in the passive condition.

In the remainder of the discussion, we will discuss: (1) possible relationships between SES, cognitive inhibition, and language processing in the current study; (2) clinical implications for these findings; and (3) limitations of this study and possible future directions.

4.1 Effect of SES and cognitive inhibition on language processing

Based on prior research (Huang et al., 2015; Huang and Arnold, 2015), it was expected that SES differences might emerge in the passive condition. However, contrary to this hypothesis, all participants performed similarly on the passive condition, regardless of SES group. While there was a significant age discrepancy between the two groups, this factor alone is unlikely to have reduced any SES effect since the younger age of the lower-SES group would have limited performance across all linguistic tasks. In contrast, we found that participants from both SES groups had similar language outcomes on measures of language-processing and vocabulary acquisition during the language-processing tasks and on the DELV.

Another possibility for this outcome is that SES differences in language abilities were minimal across the current sample. The current study did not employ a direct means to measure language input, but instead used annual income/school status and DELV scores as measures for SES and overall language abilities, respectively. According to statistical analyses, these measures were sensitive enough to detect differences in annual income and parental education between the higher-SES group (M = >$90,000, SD = 0.00; M = received an undergraduate degree from a university or approximately 17 years of education) and lower-SES group (M = <$45,000, SD = 1.82; M = received some college or vocational degree or approximately 14 years of education). Further, previous research

studies have shown that the DELV is sensitive enough to highlight SES-related differences in linguistic ability (Leech, Rowe, & Huang, submitted). Despite a distinct difference between SES groups in the current study and the documented sensitivity of these measures, the linguistic abilities for participants in both groups were surprisingly similar. As a result, the language outcomes could be the result of the participants' similar linguistic abilities at the time of the study.

Finally, properties of the current task may also contribute to similarities in performance across SES backgrounds. Recall that in Werker and Stager (1997), infants were unable to match novel words to referents in a word-learning task, despite having adequate speech-perception abilities in the syllable-discrimination task. Therefore, any variation in speech perception by the infants was masked during the word-learning task due to the complex nature of the task. Similarly, it is possible that this learning component involved in acquiring novel vocabulary in the present study masked any processing advantage experienced by participants in the higher SES group. Thus, participants from both SES groups would show similar language outcomes, which was the case in the present study.

However, in keeping with our original hypothesis, performance on the incongruent trials of the Stroop task did predict accuracy in the passive condition. This correlation is consistent with a recent study conducted by Woodard, Pozzan, and Trueswell (2016), which found that children's cognitive flexibility, as measured by Flanker and No Go tasks, predicted their ability to resolve temporary ambiguity in garden path sentence (e.g., "*Put the frog on the napkin into the box*"). This finding suggests that other executive functions, in addition to inhibition, may be required for children to resolve syntactic

ambiguity and revise initial interpretations. It also suggests that passives may belong to a larger category of constructions with similar real-time demands of syntactic revision. Moving forward, a more direct way to manipulate the role various cognitive functions have during language processing is needed to isolate the exact relationship these cognitive functions have with language processing and outcomes (Hsu & Novick, 2016).

4.2 Clinical Implications

The results of this research also have implications for clinical and educational interventions. There is a significant difference in vocabulary size and word learning between children from higher- and lower-SES backgrounds (Arriaga et al., 1998; Dollaghan et al., 1999; Feldman et al., 2000; Hart & Risley, 1995; Hoff, 2003; Morisset, et al., 1990; Rescorla, 1989; Rescorla & Alley, 2001). This gap in vocabulary size may impact academic functioning, as vocabulary size has been found to be a strong predictor for academic success (Laufer & Goldstein, 2004). Therefore, it is important to isolate the cognitive and linguistic factors involved in word learning in order to create successful interventions that promote vocabulary development, particularly in children from lower-SES backgrounds.

Surprisingly, the present study demonstrates that differences in inhibitory processes between children from higher- and lower-SES backgrounds do not appear to impact word learning. However, inhibition might impact children's language processing in other ways, as inhibitory processes have been found to impact language processing, particularly in adult studies (January et al., 2009; Novick et al., 2010). Therefore, this study can be used to help guide future research in its evaluation of the effect of other cognitive functions on vocabulary development in children.

4.3 Limitations

There were several limitations with this study. First, there was a significant age difference between the higher- and lower-SES groups. This significant age difference between groups could have impacted the results of the current study. Namely, the age difference might have masked certain trends in the data, or made current patterns difficult to interpret. For example, the effect of SES on cognitive inhibition could be the result of an age effect. Past research has shown that cognitive functions develop over time, with inhibitory processing being one of the latest functions to mature (Huttenlocher & Dabholkar, 1997; Pribram, 1997). Thus, poorer accuracy responses by the participants in the significantly younger lower-SES group might have been the result of more immature inhibitory functioning. However, this age effect does not fully explain the discrepancy in inhibitory functioning. After running partial correlational analyses that controlled for age, the relationship between response accuracy during incongruent Stroop trials and parental incomes remained significant ($r(29) = 0.39$, $p < 0.05$). This finding indicates that SES might have a more global impact of cognitive functioning, which goes above and beyond effects of age on language processing. To interpret the effects of SES on inhibitory functioning, it is critical that the sample populations be age matched in future studies.

In addition, while differences in the accuracy of interpreting active and passive sentences were noted, the underlying cause for this difference remains unclear in the current study. It could be that the differences in the frequency of exposure to these sentences constructions affected the language outcomes, namely the children are better at interpreting language inputs they hear more frequently (actives) as opposed to more infrequent input styles (passives). However, in the Huang and Arnold (2015) study,

children from a higher-SES background were presented with active and passive sentences that contained novel words in the NP2 position ("The seal was quickly eating/eaten by the blicket."). Here, children's interpretation of passives was far more accurate when a syntactic revision was not required. These results indicate that the children were able to correctly interpret active and passive sentences, but their performances were significantly affected when a syntactic revision was required.

Therefore, it would have been beneficial to administer the NP2 condition in the Huang and Arnold (2015) study to children from higher- and lower-SES backgrounds. The language outcomes of the lower-SES children in this condition might better explain the language outcomes from participants in the lower-SES group in the current study. More specifically, this condition would explain if the language outcomes of the lower-SES participants were the result of (1) a failure to learn and interpret passive sentence constructions or (2) if their performances are due to challenges in retrieving prior knowledge to aid in their comprehension of linguistic inputs, namely their knowledge of the syntactic revision process. If the lower-SES children performed worse than their higher-SES counterparts in the NP2 condition, then these results indicate the former. However, if both higher- and lower-SES children perform similarly in the NP2 condition, then the later would be the more likely cause for the language outcomes.

4.4 Future Directions

Based on these findings and the findings in previous research, it would be interesting to discover how other cognitive functions, particularly memory, would impact children's word learning. In the present study, there was a significant memory component in the language processing and recall tasks. During the language-processing task, the children

were taught how to use a computer mouse to select their answers. As a result, the children

took a significant amount of time selecting their answers. During this time, the children

might have forgotten the critical sentences and instead selected the items they preferred

(usually the Likely Agent). Then, the children were asked to recall their initial

interpretations of the novel words.

Therefore, one line of future research might focus on the impact of memory on

vocabulary acquisition. When children acquire novel words, they must first match the

novel word to its referent, encode that connection, and then recall that connection in the

future. It is possible that children with superior memories acquire novel words faster, as

they require fewer exposures to novels words to learn and encode the novel word-referent

pairing and be better equipped at recalling the meaning of the novel word in the future.

Further, those children with superior memories would be able to allocate more cognitive

resources to other, possibly more demanding, tasks involved in language processing and

acquiring novel vocabulary. In the context of the current study, participants with stronger

memory abilities could have allocated more cognitive resources to making syntactic

revisions, thereby improving the accuracy of their language outcomes. Further, these

participants might have been better able to recall the meanings of the novel words.

Therefore, it would be interesting to examine the relationship between a participant's

memory ability and their ability to learn new vocabulary.

In addition, the results of SES impacts on language abilities in the current study

contradicted the findings from previous studies. As previously mentioned, the current

study used proxy measures for language input. It is possible that a lack of direct measures

of language input limited the ability to comprehensively identify SES-related differences

in language abilities and made interpretations of patterns of language outcomes more difficult. As a result, the proxy language input measures used in the current and previous studies could lead to inconsistent findings in differences in linguistic abilities across SES background, which could influence the interpretations of language outcomes. Therefore, future work should employ more direct means of measuring language input to more accurately assess language abilities of the participants at the time of the study and to avoid possible confounds while interpreting language outcomes.
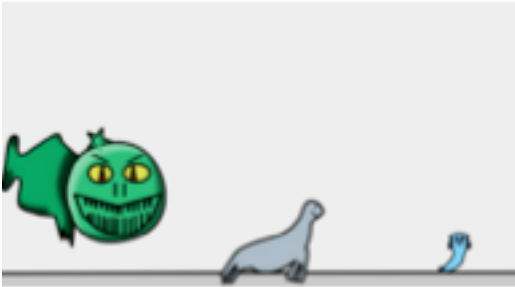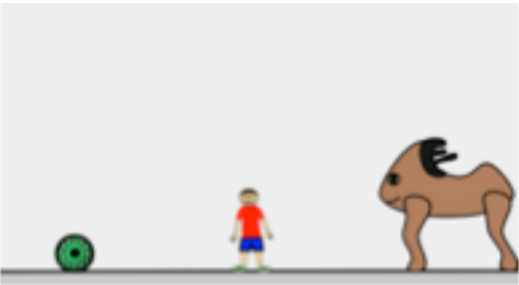
5. Conclusion

The present study examined how cognitive inhibition was related to language processing when a syntactic revision was required. The results showed that all participants, regardless of SES background, performed similarly on the language tasks, namely all participants had difficulty acquiring novel words in complex sentence constructions that required a syntactic revision. However, SES-related differences in cognitive inhibitory process were observed, where participants in the higher-SES group had significantly stronger inhibitory processes and were better able to resolve conflict compared to the participants in the lower-SES group. Finally, a relationship between cognitive inhibition and language processing was noted, namely that those with superior cognitive inhibitory processes had superior language outcomes. Therefore, the results from the present study indicate that inhibitory processes do impact a child's ability to process linguistic inputs and acquire novel vocabulary. However, inhibitory processes alone do not account for language differences displayed by children from higher- and lower-SES backgrounds.

Appendices

Appendix A

List of Critical Items

Expressed Noun: Seal Action: Eat	Expressed Noun: Cat Action: Scare
Expressed Noun: Dog Action: Chase	Expressed Noun: Boy Action: Kick
Expressed Noun: Rabbit Action: Eat	Expressed Noun: Frog Action: Catch

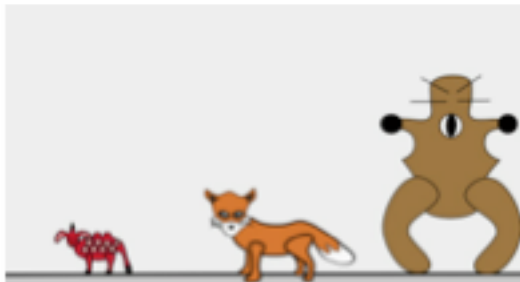| Expressed Noun: Rock Action: Smash	Expressed Noun: Girl Action: Lift
Expressed Noun: Mouse Action: Grab	Expressed Noun: Car Action: Squish
Expressed Noun: Fox Action: Chase	Expressed Noun: Seal Action: Eat

Appendix B

List of Critical Sentences and Novel Words

Novel Word	Active NP1	Passive NP1
Bellwer	The *bellwer* will be quickly chasing the fox.	The *bellwer* will be quickly chased by the fox.
Blicket	The *blicket* will be quickly eating the seal.	The *blicket* will be quickly eaten by the seal.
Chowvag	The *chowvag* will be carefully lifting the girl.	The *chowvag* will be carefully lifted by the girl.
Coopa	The *coopa* will be quickly chasing the dog.	The *coopa* will be quickly chased by the dog.
Daylon	The *daylon* will be quietly catching the frog.	The *daylon* will be quietly caught by the frog.
Furpin	The *furpin* will be quickly scaring the monkey.	The *furpin* will be quickly scared by the monkey.
Handtil	The *handtil* will be gently kicking the boy.	The *handtil* will be gently kicked by the boy.
Leepo	The *leepo* will be slowly eating the rabbit.	The *leepo* will be slowly eaten by the rabbit.
Nedoke	The *nedoke* will be quickly scaring the cat.	The *nedoke* will be quickly scared by the cat.
Noytoff	The *noytoff* will be loudly squishing the car.	The *noytoff* will be loudly squished by the car.
Tayvak	The *tayvak* will be loudly smashing the rock.	The *tayvak* will be loudly smashed by the rock.
Vaychip	The *vaychip* will be quickly grabbing the mouse.	The *vaychip* will be quickly grabbed by the mouse.

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