Online lexical processing in a diverse group of preschool children

by

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ABSTRACT

Recent research using the looking while listening paradigm has shown that 18-month-olds with larger vocabularies look more rapidly to pictures of familiar objects than their peers with smaller vocabularies. The purpose of this study was to extend this work to older children (30 to 60 months) and to include children from both middle- and low-socioeconomic status (SES) families. Because the children were older, we used a four alternative forced choice (4AFC) rather than a 2AFC paradigm. Children were presented with four pictures of familiar objects (the target as well as semantic, phonological, and unrelated foils) in a 2 x 2 array and their eye movements were tracked as they heard phrases such as *find the duck*. Results indicated that the 4AFC paradigm was sensitive to differences in expressive vocabulary size; children with larger vocabularies from middle-SES families looked more to the target than peers with smaller vocabularies. When eye gaze patterns for looking to target of children from low- and mid-SES families were compared, there was an effect of expressive vocabulary size, but no independent effect of SES and no SES by expressive vocabulary size interaction. It is hypothesized that the lack of effect of SES is due to one or more of the limitations of this study.

CHAPTER ONE

INTRODUCTION

One of the earliest indicators that a child is learning to talk is when he or she produces a first word. Most children produce their first word at about 1 year of age and start rapidly learning new words at about 18 months (e.g., Hoff, 2005). In the toddler and preschool years, vocabulary size is one of the best ways to differentiate between normal and disordered language development and it is also a strong predictor of future academic success (Fernald & Marchman, 2011; Hart & Risley, 1995; Hoff, 2003; Metsala & Walley, 1998; Rescorla, 2002; Rescorla, 2009). Word learning is not only important in its own right, but it is also important for syntactic and phonological development in the preschool years. For example, children's production of the regular and irregular past tense is related to how many verbs they have in their productive vocabulary (Marchman & Bates, 1994; Marchman, Wulfeck, & Ellis Weismer, 1999) and children's ability to repeat nonwords accurately is also related to vocabulary size (Edwards, Beckman, & Munson, 2004). Vocabulary acquisition is also important for later literacy development. Children with larger vocabularies are able to use analogical reasoning to use words that they already know to access the educational curriculum at a higher level in both oral language and in reading for information.

Virtually all studies of children's receptive vocabulary rely on picture-pointing responses to verbal prompts. The advantage of this type of assessment is that it is easy to administer and score and can be used even with non-verbal children. However, two children may recognize the same words, but one child may be faster at accessing these words, and traditional receptive vocabulary tests can't differentiate between these two children. These two children can be differentiated, however, with the looking-while-listening (LWL) paradigm (Fernald, Perfors, &

Marchman, 2006). The LWL paradigm examines eye gaze patterns in response to verbal prompts. Children see two pictures on a computer screen, they hear a word, and their eye gaze patterns are recorded and analyzed in response to the word presented. Using the LWL paradigm, Marchman and Fernald (2008) found that children at 18 months with large vocabularies looked at pictures of familiar objects (e.g., *apple*, *cookie*) more quickly than children with small vocabularies. Furthermore, response times to familiar object-names at 18 months predicted vocabulary size up to 8 years of age (Marchman & Fernald, 2008).

Besides vocabulary size, socioeconomic status (SES) also influences how quickly children recognize familiar words in the LWL paradigm. Fernald, Marchman, and Weisleder, (2013) found that 18- to 24-month-old children from low-SES families looked more slowly to pictures of familiar objects relative to their age matched peers from middle-SES families. While it has been well-established that children from low-SES families have smaller vocabularies than children from middle-SES families (e.g., Hart & Risley, 1995, Hoff, E., 2003, Brooks-Gunn, J., Duncan, G.J. & Klebanov, P., 1994), this is the first study to show that online lexical processing speed differs between these two groups of children, even for highly familiar words that all children recognized by 18 months of age.

A limitation of the two-picture LWL paradigm is that it becomes too easy for preschool-aged children and response times no longer differentiate among children with different vocabulary sizes (A. Fernald, personal communication, June 6, 2011). The two-picture paradigm is too easy for this age group because it only includes two picture choices with one image being the target image and the other image being completely unrelated. In order to avoid ceiling performance, it is necessary to make the task more difficult.

The current study extends the study by Fernald et al. (2013) and addresses the ceiling performance limitation. To do this, we used a four alternative forced-choice (4AFC) task rather than a 2 AFC. We also made the task more difficult by including a phonological foil and a semantic foil for each target in addition to an unrelated item.

To summarize, the purpose of this study was to compare eye gaze patterns in response to familiar words of preschool-aged children (30 to 60 months) from both middle- and low-SES families using the LWL paradigm. A 4AFC experimental paradigm that included both a semantic and a phonological foil for each target item was used. Two specific research questions were addressed. The first question was methodological: Is the 4AFC paradigm sensitive to differences in vocabulary size for children in the 30-60 month age range? The second question concerned the effect of SES and vocabulary size on eye-gaze patterns: What lexical processing differences are observed between children from middle- and low-SES families in the age range of 30-60 months, given the differences that Fernald et al. (2013) observed in 18- and 24- month old children? Do these differences remain static or do they increase or decrease over time?

CHAPTER TWO

METHODS

Participants. There were two sets of participants. A large set (n = 34) of children from middle-SES families participated in this study. A smaller set (n = 8) of children from low-SES families also participated. For question 1, which focused on the effect of vocabulary size on online lexical processing, we analyzed the data of the children from middle-SES families. For question 2, which focused on the effect of SES on online lexical processing, we compared the data of the children from low-SES families to a comparison group of 8 children from middle-SES families. To form this comparison group, we matched each child from a low-SES family to a child from a middle-SES family on the basis of age (within three months) and gender (if possible).

All participants were recruited from families with 30- to 60-month-old children. All parents reported their child had no cognitive delays, no speech and language delays, and no impairments in hearing or vision. Children from middle-SES families were recruited from local preschools and a database of children who had previously participated in experiments at the UW-Madison. An intensive effort was also made to recruit children of families from low-SES households. Recruiters delivered fliers to Head Start centers as well as other childcare centers in low-income neighborhoods around Madison, Wisconsin. Recruiting was also done at large events including a Martin Luther King Day celebration, Boys and Girls Club events, and parent meetings at Head Start, libraries, and local childcare centers. Parents completed a demographic questionnaire and SES was assessed from self-reported family income and the education level of the primary caregiver. Information about both education level and family income were converted to Likert scales.

Participants were excluded from the study if they failed a hearing screening at 1000, 2000, and 4000 Hz at 25 dB or had more than 50% mistracking of their eye gaze patterns in the LWL experiment. No children from low SES families were excluded. Two children from mid-SES families were excluded because of excessive mistracking (a 35-month-old female and a 43-month-old male).

Standardized Testing. Each child's vocabulary was assessed using the *Expressive Vocabulary Test*, *2nd edition* (EVT-2, K. Williams, 2006). Table 1 provides demographic information for the two participant groups.

Table 1. Demographic information for all children from middle-SES families (SD in parentheses)

Number of males/ females	Average age in months	EVT-2 standard score	Average years of education for primary caregiver[1]	Average family income[2]
15 males 19 females	38.8 months (6.6)	128.8 (11.5)	5.6 (.6)	3.8 (1.1)[3]

[1]The 6-step Likert scale for education level was: 1 = less than high school degree, 2 = GED , 3 = high school degree, 4 = some college, 5 = college degree, and 6 = post-graduate degree.

[2]The 5-step Likert scale for total family income was: 1 = below $20,000/year, 2 = $20,000 to $40,000/year, 3 = $41,000 to $60,000/year, 4 = $61,000 to $100,000/year, and 5 = above $100,000/year.

[3]Three families chose not to answer the question about family income, but maternal education for all three of these families was a college or post-graduate degree.

Table 2. Demographic information for the children from low-SES families and their middle-SES comparison group (SD in parentheses). Appendix D shows data by participant for EVT-2 standard score, maternal education, and family income.

	Number of males/ females	Number of AAE speakers	Mean Age	Mean EVT-2 standard score	Average years of education for primary caregiver[1]	Average family income[2]
Middle SES backgrounds	3 males 5 females	0	45.4 months (6.1) range = 38-57 months	128.1 (11.7)	5.5 (.8)	4.0 (1.2)
Low SES backgrounds	3 males 5 females	8	48.4 months (7.6) range = 39-59 months	100.3 (16.6)	3.4 (1.0)[3]	1.5 (1.0)[3]

[1]See table note for table 1.

[2]See table note for table 2.

[3]One family chose not to answer the questions about education level and total family income. SES was inferred because participant resided in an area with a high low-SES population.

Stimuli. Words were selected using published databases that provided information on age of acquisition (CDI, Fenson, Marchman, Thal, Dale, Reznick, & Bates, 1993; Morrison, Chappell, & Ellis, 2010; PPVT-4, Dunn & Dunn, 2007). The words were grouped into four groups according to age of acquisition, 38.5, 44.5, 50.5, and 56.5 months (see Appendix A). All of the words were nouns and were easily represented by a photograph. The photographs were found through an internet search of high-resolution pictures. Two images were chosen for each object name. There was nothing in the foreground of any of the pictures and any background was digitally edited out of each picture. The image was then placed within a gray square of 450 pixels with the image centered and normalized by the largest dimension, no larger than 400 pixels width or height. Pictures were normed using children from two preschool classrooms, a classroom at the Waisman Early Childhood Preschool (children from middle-SES families) and at a local Head Start Center (children from low-SES families). 30 children were shown the pictures in a closed set of four images (including a semantic and a phonological foil). Pictures that were not recognized by at least 80% of the children in both classrooms were replaced.

Sound stimuli were recorded in a sound treated booth by two young adult females who were native speakers of the local WI dialect. One of the speakers spoke Mainstream American English (MAE) while the other female speaker spoke in African American English (AAE). The speakers used child directed speech to produce the target words within the phrases, "Find the ___", and "See the ____". The carrier phrases were also recorded using the phrase "Find the egg", and "See the egg", to ensure that no coarticulation was influencing the sound recording. The carrier phrases and the target words were then spliced separately and concatenated. All target items within a dialect were normalized to the same duration and all phrases were normalized to the same amplitude level. It should be noted that the AAE words were slightly shorter in duration than the MAE words (150 ms, on average). This difference was taken into account in the analyses.

Each word used was matched with a semantic foil, phonological foil and an unrelated image (see Appendix B). There were two blocks of the experimental task and each image was presented four times within each block, once as the target word and three additional times as a semantic, phonological, or unrelated foil. Different pictures and different repetitions of each word were used in the two blocks of 33 trials. Figure 1 is a visual example of a stimulus presentation.

All children were tested in their native dialect. Children whose parents spoke MAE were presented with stimuli in MAE; children whose parents spoke AAE were presented with stimuli in AAE. A criterion checklist was used to decipher whether AAE or MAE should be presented to a child. (Felder, 2006; Craig & Washington, 1994) If any of the following five conditions were present, the child was presented AAE stimuli: 1. Caretaker exhibited features consistent with AAE during initial telephone contact. 2. Caretaker or participant self-identifies as African-American, or as an AAE speaker. 3. Participant was recruited from a known population of AAE speakers. 4. Participant lives in an area with a large population of AAE speakers and SES associated with more AAE speakers. 5. Participant or caretaker exhibited AAE features during experimental visit. An MAE-speaking examiner was present at all test sessions with MAE-speaking participants; similarly, an AAE-speaking examiner was present at all test session with AAE-speaking participants.

Procedure. The experiment was programmed in ePrime and ran on a Tobii Eye 2150 Tracking system. The experiment was presented to the children as "watching movies" and a short booklet to explain the task was sent home to the parent prior to their arrival in the lab, so that they could prepare their child for the experiment. At the beginning of each trial, a calibration was run, using Tobii Studio, to ensure the child was approximately 60 cm from the screen and that the eyetracking equipment could track the child's eye movements accurately to five locations on the screen. Figure 2 shows the time line of a single trial. For each trial, children saw four pictures on a large monitor, after 150 ms, the phrase "find the ____" or "see the ______” was presented. After 1800 ms, a reinforcing phrase (way to go, super, good job, etc.) was presented and then there was a 500 ms inter-trial interval during which the screen was blank. After six or seven trials, a brief 3-second movie of a familiar animated image was presented moving across the screen always ending in the middle. The Tobii 2150 eye-tracker uses an infrared cameras to measure the x,y position of the two eyes during the entire experiment.

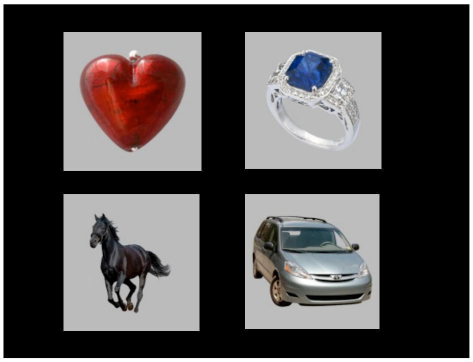

Figure 1. Sample of a stimulus presentation. Four images are presented: Heart (target); ring (semantic foil); horse (phonological foil), van (unrelated).

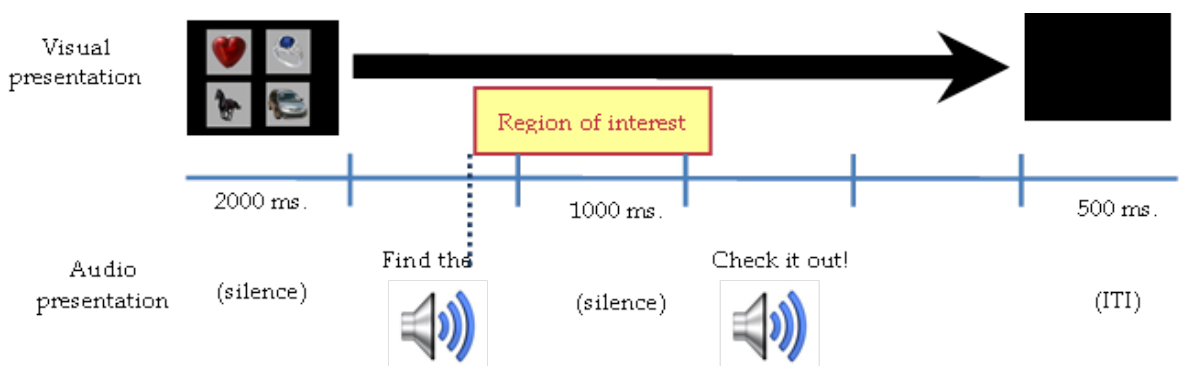

Figure 2. Timing illustration of a single trial.

Data reduction. The eye-gaze patterns were coded in terms of looks to the four pictures (Areas of Interest or AOIs). At each time point, a child's eye gaze was coded as a 1 (look to the AOI of the target), 2 (look to semantic foil), 3 (look to phonological foil), 4 (look to unrelated foil), or NA (not looking at any of the four AOIs). Missing data were imputed as follows: if there was a mistracking within a 100 ms period and then the child's eye gaze returned to the same AOI, the mistracking was coded as a look to that AOI. This was because a voluntary eye movement, a saccade, is at least 200 ms (Duchowski, 2007). Then, data were averaged across three samples of 17 ms (51 ms total) as proposed by Barr (2008). The log odds of looking to the target at each time point was calculated, as was the log odds of looking to the semantic foil, the phonological foil, or the unrelated foil. The log odds is the log of the odds of looking to the target relative to looking to the other three distractors.

Data analysis. The most common way of analyzing LWL data is to calculate latency of the first look to the target object and to calculate relative looking time to target (looking time to target relative to total looking time). It is more difficult to compute latency for a 4AFC task as compared to a 2 AFC task because it can't be assumed that a movement away from a distractor is a movement to the target. Furthermore, latency and relative looking time analyses do not examine changes in eye gaze patterns over time. Several recent researchers have proposed that growth curve analysis can be used to examine eye gaze patterns over time. (Barr, 2008; Mirman, Dixon & Magnuson 2008). A growth curve analysis similar to that proposed by Mirman et al (2008) was used in this study. The dependent variable was the log odds of looking to target (in this case, looking to the target AOI) at each time point. The onset of the analysis window was 250 ms. This time point was chosen by plotting the grand mean of looks to target and identifying the earliest time point at which the curve began to move upward (Barr, 2008). The end of the analysis window was 1750 ms because many previous studies (e.g. Marchman & Fernald, 2008), have used a 1500 ms window of analysis. For both analyses, the independent variables at level 1 were Time and $Time^2$. For question 1, the subject-level variables at level 2 were Age (in months), and Expressive Vocabulary Size. EVT-2 raw scores were used as an estimate of expressive vocabulary size. For question 2, the subject-level variables at level 2 were Group (middle SES versus low SES), Age, and Expressive Vocabulary Size. Because raw vocabulary scores are highly correlated with age, age was included as an independent variable. Models including Receptive Vocabulary Size (PPVT-4 raw scores) were also examined. PPVT-4 and EVT-2 raw scores are highly correlated, but Expressive Vocabulary Size was consistently a better predictor than Receptive Vocabulary Size. There is some debate as to how to calculate degrees of freedom in this type of growth curve analysis. (Marchman & Bates, 1994). Therefore, I considered *t*-values of more than (±) 1.96 to be significant for $p<0.05$. This is a conservative estimate of significance because it assumes that the *t*-distribution approximates the normal distribution.

CHAPTER THREE

RESULTS

First, I present the results for question 1, which focused on the influence of vocabulary size on eye-gaze patterns with a 4AFC task. Figure 3 shows percent of looks to the four response choices (target, phonological foil, semantic foil, unrelated foil) over time from 200 ms to 1800 ms for the children from middle-SES families. This is plotted separately for the top, middle, and bottom third of expressive vocabulary size, based on EVT-2 raw scores. (It should be noted that expressive vocabulary was input into the model as a continuous variable; the three thirds of expressive vocabulary size are shown here simply for illustration.) It can be observed that as vocabulary size increases, there were more looks to target over time and fewer looks to the three foils. The results of the growth curve analysis confirmed this observation. There was a significant effect of Expressive Vocabulary Size on looking to target (t= 2.58). As expected, there was also a significant effect of Time and Time^2 on the eye gaze patterns (t= 18.32 and t= -4.20, respectively).

We ran a similar growth curve analysis for each of the other three response choices. For the phonological foil, there was also a significant effect of Expressive Vocabulary Size on looking to the phonological foil (t= -2.9). As vocabulary size increased, there were fewer looks to the phonological foil. There was also a significant effect of Time on the eye gaze patterns (t= -9.47).

For the semantic foil, the only significant predictor on eye gaze patterns was Time (t= -3.94). I hypothesized that the reason that there was not a significant effect of Expressive Vocabulary Size on eye gaze patterns for the semantic foil was that not all semantic foils were strongly related to the target. There were some target words with very strong semantic relationships (e.g. target-*sheep*, semantic foil-*goat*) and others with much weaker semantic relationships (e.g. target-*swan*, semantic-*crab*). This is because the design required that each word be presented the same number of times so that image novelty was not a factor. Because all stimulus items were shown exactly four times, some semantic foils were less than optimal. The growth curve analysis for looking to the semantic foil was rerun with a subset of the stimuli using only strongly related semantic foils (see Appendix C). However, Expressive Vocabulary Size was still not a significant predictor of looking to the semantic foil.

For the unrelated foil, there was a significant effect of Expressive Vocabulary Size on looking to the unrelated foil (t= -2.42). As with the phonological foil, as vocabulary size increased, there were fewer looks to the unrelated foil. There was also a significant effect of Time and Time^2 on the eye gaze patterns (t= -11.23 and t= 2.88, respectively).

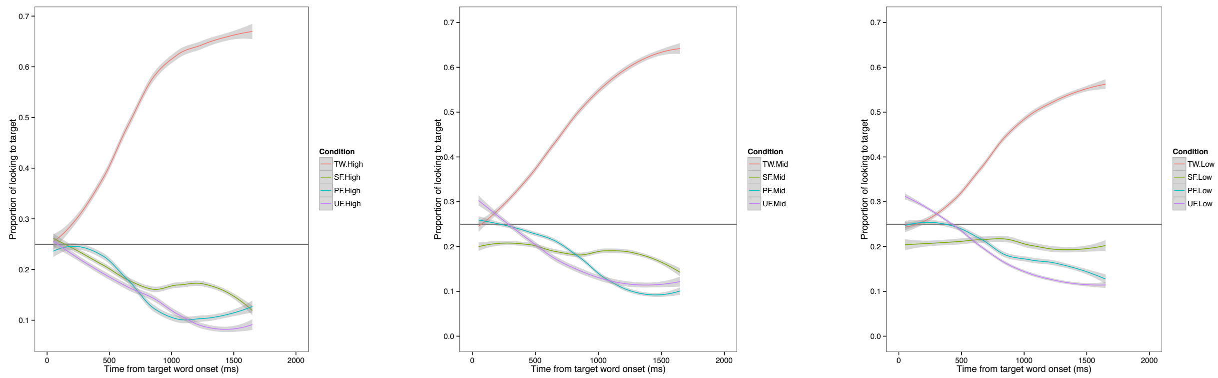

Figure 3. Proportion of looks to target and three foils over time for the top third (leftmost plot), middle third (middle plot), and bottom third (rightmost plot) of EVT-2 raw scores for all children from middle-SES families. The shaded area shows the 95% confidence interval.

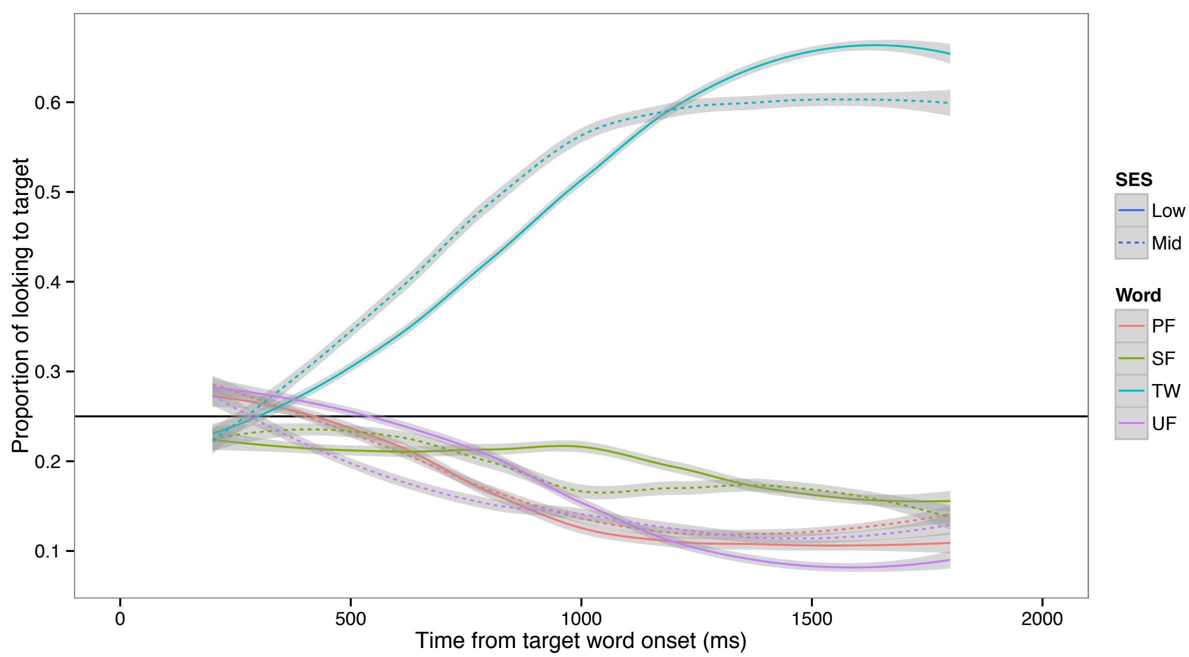

Figure 4. Proportion of looking to target and three foils over time for children from middle- and low-SES families. The shaded area shows the 95% confidence interval.

The results for question one confirmed that the 4AFC task was sensitive to differences in expressive vocabulary size for preschool-aged children. Therefore, I turned to the second question of interest: the effect of SES on eye gaze patterns in this 4AFC task. Figure 4 shows percent of looking to the four response choices over time for children from middle- and low-SES families. It can be observed that the eye gaze patterns for the two SES groups for looking to target are similar. The results of the growth curve analysis confirmed this observation. SES was not a significant predictor of looking to target. As expected, there was a significant effect of Time on the eye gaze patterns (t= 8.58). There was also a significant interaction between Expressive Vocabulary Size and Time (t=1.99). This interaction is illustrated in Figure 5. It can be observed that there are different slopes of the eye gaze patterns for children in the top third of vocabulary size, the middle third of vocabulary size, and the lowest third of vocabulary size. As predicted, the children in the lowest third of vocabulary size, have the shallowest slope. Surprisingly, the children in the middle third of vocabulary size, have steeper slopes than the children in the top third of vocabulary size. A possible explanation of this result will be considered in the Discussion.

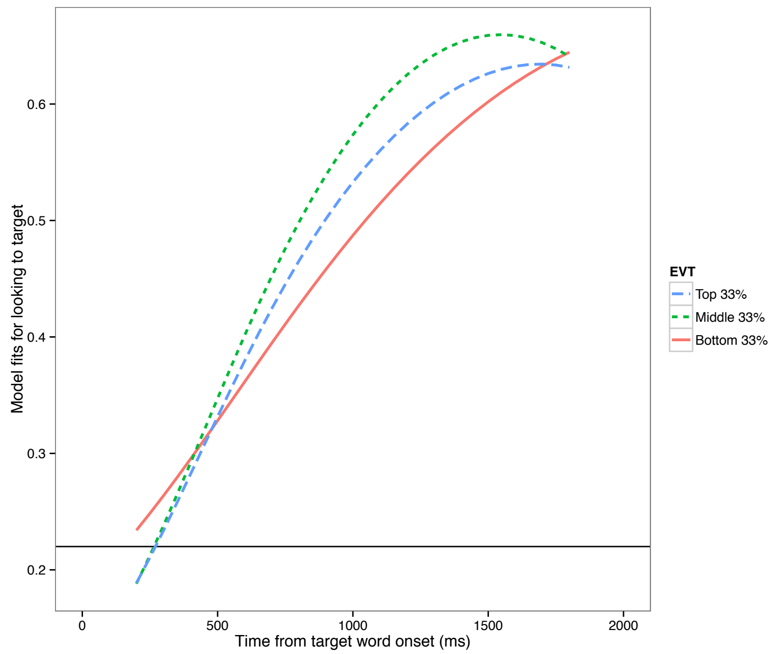

Figure 5. Model fits for looking to target for the three groups (top 33%, middle 33%, and bottom 33%) of Expressive Vocabulary Size (averaged across the two SES groups).

We ran a similar growth curve analysis for each of the other three response choices. For the semantic foil, there was a significant effect of Time on the eye gaze patterns (t= -2.77). There was also a significant interaction between Age and Time (t=-2.10), which is illustrated in Figure 6. It can be observed that older children were more quick to reject the semantic foil than younger children.

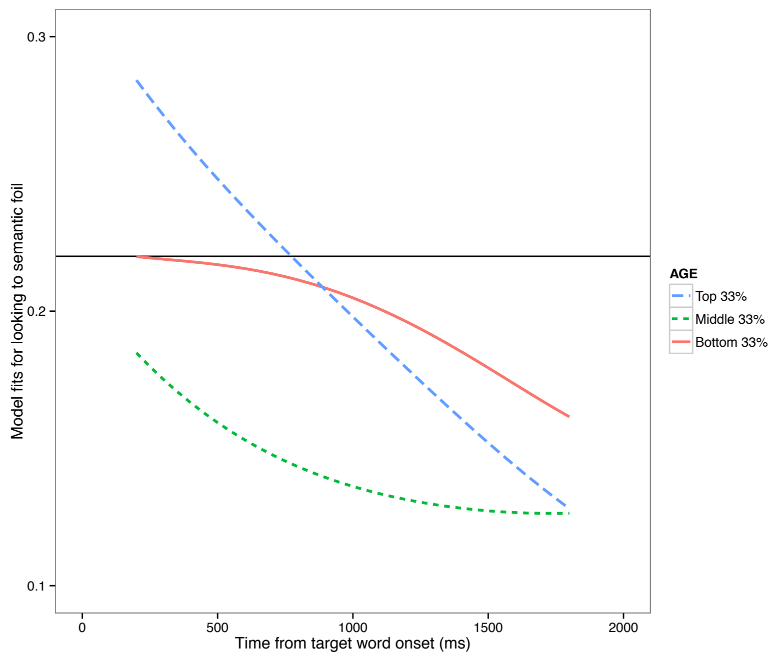

Figure 6. Model fits for three equal groupings of age (averaged across the two SES groups). (Age was input into the model as a continuous variable; the three thirds of age are shown here for illustration.)

For the phonological foil, there was a significant effect of Time and Time^2 on the eye gaze patterns (t= -7.84 and t= 2.68, respectively). There was also a significant interaction effect between Expressive Vocabulary Size and Time (t=-2.63). Figure 7 shows the model fits for the three thirds of expressive vocabulary size. It can be observed that as children's expressive vocabulary size increased, they rejected the phonological foil more quickly. There was also a significant interaction effect between Expressive Vocabulary Size, SES, and Time (t=2.55). Figure 8 shows model fits separately for the two SES groups, also separated into the top and bottom 50% of EVT-2 raw scores. The three-way interaction between time, EVT-2 raw score, and SES is due to the fact that there is a steeper slope for the high-vocabulary children as compared to the low-vocabulary children from low-SES families, but the opposite pattern is observed for the children from middle-SES families.

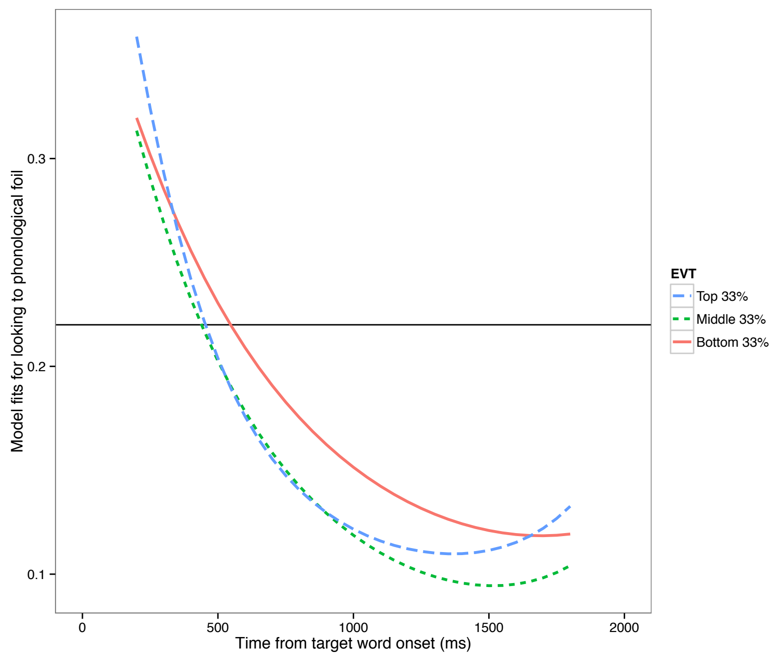

Figure 7. Model fits of proportion of looking to phonological foil for three thirds of Expressive Vocabulary Size (averaged across both SES groups).

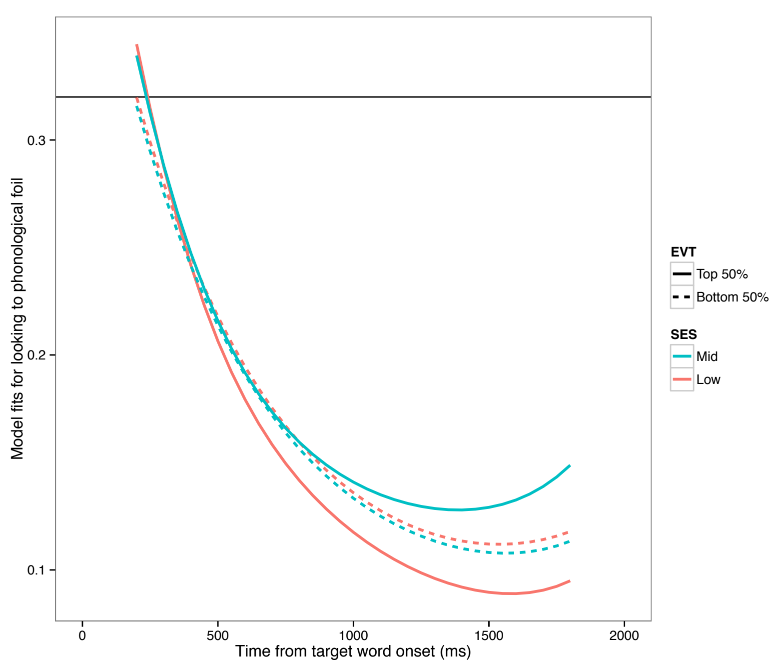

Figure 8. Model fits for the top and bottom 50% of Expressive Vocabulary Size separately for the two SES groups.

For the unrelated foil, there was a significant effect of Time on the eye gaze patterns (t= 5.132). No other significant predictors were observed.

CHAPTER FOUR

DISCUSSION

Two questions were addressed in this study. The first question was whether a 4AFC task would be sensitive to differences in vocabulary size for 30- to 60-month-old children from middle-SES families. An effect of Expressive Vocabulary Size on eye gaze patterns on this 4AFC task was observed in this study. As expressive vocabulary size increased, children looked more to the target pictures and less to the distractors; conversely, as vocabulary size decreased, children looked less to the target pictures and more to the distractors. The second question was whether there was an influence of SES on eye-gaze patterns of 30- to 60-month-old children. A significant effect of SES on eye-gaze patterns was not observed. There were no significant differences in eye gaze patterns for looking to the targets or the three foils as a function of SES. However, there was a significant effect of Expressive Vocabulary Size on how quickly children looked to the target as well as on how quickly they rejected the phonological foil.

The first finding extends the work of Fernald and Marchman (2008), who found an influence of expressive vocabulary on latency of looking to target and percent looking time to target in a 2AFC task with 18-, 24-, and 36-month-old children. The measure of vocabulary in the Fernald and Marchman (2008) study was the CDI. This study extends this finding with an older group of children, a more complex task, and a different measure of expressive vocabulary size. To assess vocabulary size, I used a direct measure (EVT-2) rather than a parent report (CDI). This finding suggests that children with larger vocabularies have a significant learning advantage relative to children with smaller vocabularies. Children who can process familiar words more quickly will have greater cognitive resources to spend on other aspects of linguistic and more general learning. In this study, only children with expressive vocabularies within the normal range were included, but it is predicted that children with even smaller vocabularies due to language impairment would have a similar or even greater delay in online lexical processing. This may explain, in part, why it is so difficult for children with language impairments to reach the normal range of language development.

The second finding is more inconclusive. While Fernald et al. (2013) found an effect of SES on latency and accuracy of looking to familiar words in a 2AFC task with 18- and 24-month-old children, I did not observe an effect of SES on eye gaze patterns to familiar words in a 4AFC task with 30- to 60-month-old children in this study. There was an effect of Expressive Vocabulary Size on speed of looking to target and children from low-SES families tended to have smaller vocabularies, but there was no independent effect of SES. There are a number of possible explanations for this finding. The first and simplest explanation is that the number of subjects is simply too small to observe a significant effect of SES or a significant SES by Expressive Vocabulary Size interaction. There were only 8 children in each of the two SES groups.

The second possible explanation is related to another significant limitation of this study. All of the children from middle-SES families were European American and spoke Mainstream American English while all the children from the low-SES families were African American and spoke African American English. While I tried to recruit European American children from low-SES families, I was unsuccessful. At least in part, this was because in Madison, WI most low-SES families who are European American live at least 30 minutes from the Waisman Center where the data were collected and participants were reluctant to travel this far despite the fact that we were providing cab service. Because I tested all children in their native dialect, the children from low-SES families and the children from middle-SES families heard different speakers. There could have been speaker differences that resulted in the AAE stimuli being somehow more intelligible than the MAE stimuli.

Finally, this finding could be related to the possibility that the definition of a "large" vocabulary is different between the two SES groups. While the average EVT-2 scores of the two groups were significantly different, there were a number of children from low-SES families with relatively high EVT-2 scores. For example, the three highest EVT-2 standard scores of children in this group were 113, 117, and 118. These scores came from children whose families variously had a father in prison, had a mother with only a GED, and had a total family income of less than $20,000 (with four children in the home). Given these circumstances, these children (and their mothers) must truly be exceptional to have expressive vocabularies that are about one standard deviation above the mean. This is illustrated in Figure 9, which shows eye gaze patterns for looking to target for the two SES groups, separately for the top and bottom 50% of EVT-2 raw scores. It can be observed that the eye gaze patterns for the top and bottom 50% of vocabulary size are similar to each other for children from middle-SES families. This is not surprising given the small n (four subjects in each group). However, the difference in eye gaze patterns between the two vocabulary groups for the children from low-SES families is considerable. Furthermore, for the four children from low-SES families with very high EVT-2 scores, the eye gaze patterns look similar in slope and reach an even higher level of accuracy of looking to target as the eye gaze patterns of children from middle-SES families. While the high-vocabulary children from low-SES families (mean EVT-2 standard score=110) have lower standard scores than the high-vocabulary children from middle-SES families (mean EVT-2 standard score=137), they are recognizing familiar words as quickly and at least as accurately as their middle-SES peers. The patterns in Figure 10 also explain the counter-intuitive finding in Figure 5 in which it was observed that the children in the middle third of vocabulary size had steeper slopes for looking to target than children in the top third. The children in the middle third of vocabulary size include these high-vocabulary children from low-SES families.

It would be interesting to know more about these high-vocabulary children from low-SES families. It would be useful to have more information on other aspects of their linguistic and cognitive processing. It would also be helpful to have information on the linguistic input they receive. A number of studies have shown that linguistic input from caregivers is directly related to vocabulary size (e.g., Hart & Risley, 1995; Gilkerson & Richards, 2009). Unfortunately, in this study I did not obtain information about linguistic input in the home setting. In the current longitudinal study, a LENA recording device will be used to obtain linguistic input in the home setting. This information can be used to determine whether these children did have more linguistic input as would be predicted.

The children from low-SES families with low expressive vocabularies (mean EVT standard score=90) are at the greatest disadvantage in terms of cognitive load; they require more time for lexical processing even for familiar words. This places them at a significant risk for subsequent language development and academic success.

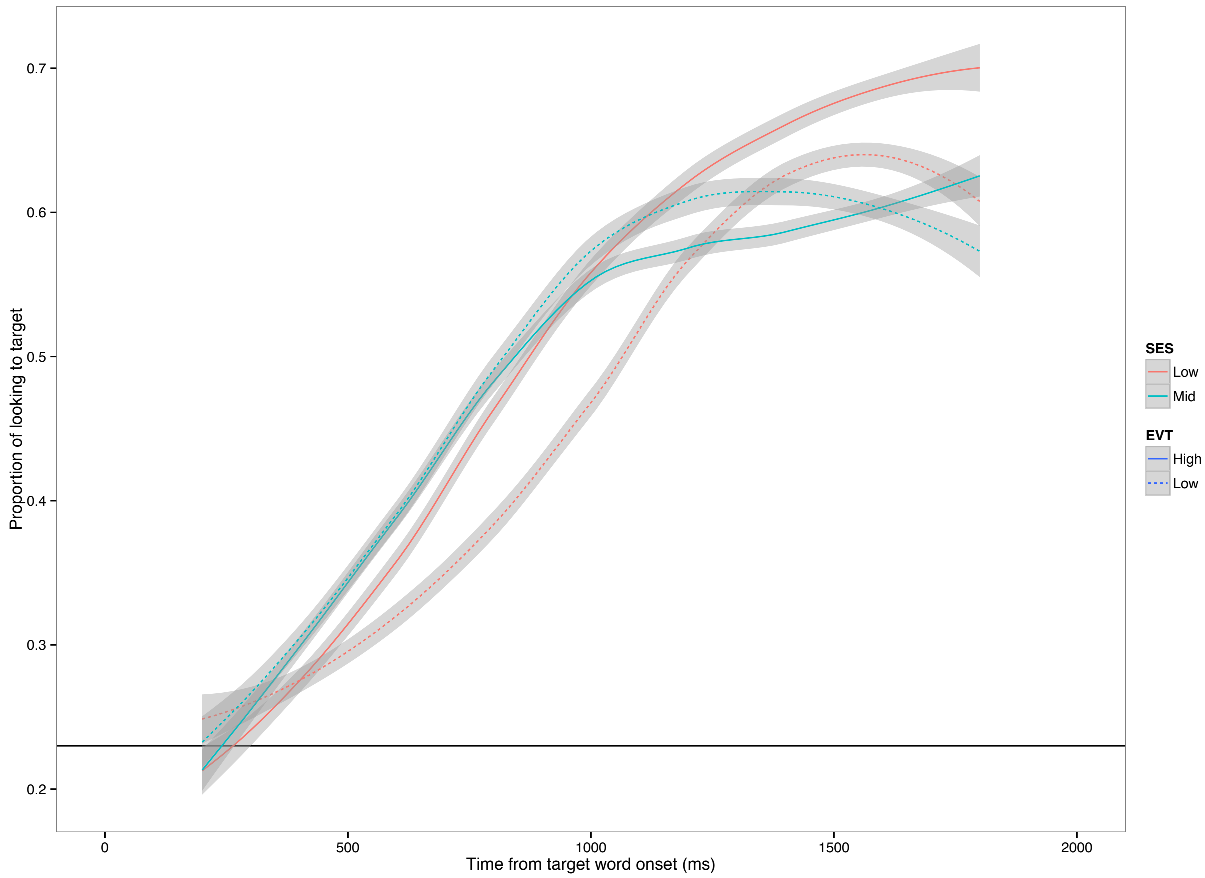

Figure 9. Proportion of looking to target for the two SES groups for the top and bottom 50% of expressive vocabulary size. The shaded area shows the 95% confidence interval.

CHAPTER FIVE

CONCLUSIONS

Differences in online lexical processing can be observed even among very young children. This study extended the work of Fernald and Marchman (2008) and showed that preschool-aged children with larger expressive vocabularies are quicker to process familiar words relative to their peers with smaller expressive vocabularies. This is important because a child who is quicker to understand a familiar word will have more cognitive resources to spend beyond lexical processing.

Significant differences in lexical processing of familiar words as a function of SES were not observed. However, the sample size was small and there were also other limitations of this study as discussed above. It is essential that more information be obtained so that we can truly see the continuum of lexical processing and expressive vocabulary size among children from families of different income levels. The children in this study who came from low-SES families and had high expressive vocabularies especially warrant further study. In future research, it will be important to recruit children from low-SES families who are European American and speak MAE and if possible, children from mid-SES families who are African American and speak AAE.

While this study did not find evidence for a direct effect of SES on lexical processing, there was a significant effect of expressive vocabulary size on eye gaze patterns to familiar words in the analyses for both question one and question two. Most of the attention on the achievement gap has focused on school-aged children although researchers (e.g. Hart & Risley, 1995) have noted that preschool-aged children from low-SES families have smaller vocabularies than peers from middle-SES families. Children with smaller expressive vocabularies, whether these smaller vocabularies are a result of SES, language impairment, or simply normal within-group variability, seem to process familiar words more slowly than their peers with larger expressive vocabularies. This slower lexical processing puts these children at a significant disadvantage for language learning, as well as for more general academic learning.

While there are a number of explanations for the relationship between vocabulary size and online lexical processing, it is beyond the scope of this study to understand the mechanisms underpinning this relationship. Another question that this study does not address is what types of intervention could be provided to increase lexical processing speed or vocabulary size. Other studies have identified parental talk as an indicator of vocabulary size of young children. Recent research has shown increasing parental talk during a child's first three years of life can be accomplished by informing parents of the importance of talking to their young child and providing them with feedback. Studies using LENA, a language environmental analysis processer, have found that by using the device, families have increased the amount of talking a parent does with their child. (Gilkerson & Richards, 2009). Increasing parental talk may be an effective way of increasing expressive vocabulary size for many children. Further research is needed to understand whether this use of LENA works with all children, regardless of the reason for the small vocabulary, and whether these increased vocabularies result in faster lexical processing.

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Appendix A: Age of acquisition word list

Objective AOA: 38.5	Objective AOA: 44.5	Objective AOA: 50.5	Objective AOA: 56.5
Bowl Box Bread Clown Comb Dress Flag Horse Kite	Bell Cheese Crown Pan Pear Pen Sheep Spoon Shirt	Bear Belt Crab Drum Heart Ring Swing Sword Van	Bee Fly Gift Goat Shirt Swan Vase

Appendix B: Word groupings

Target	**Semantic**	**Phonological**	**Unrelated**
flag	kite	fly	comb
sheep	goat	shirt	gift
drum	bell	dress	fly
ring	dress	swing	horse
swan	crab	spoon	pan
kite	flag	comb	bell
gift	box	goat	flag
bell	drum	bee	pan
heart	ring	horse	van
crab	bee	crown	vase
crown	sword	comb	bread
bread	cheese	box	goat
vase	bowl	van	pear
box	gift	bear	ring
cheese	bread	shirt	crown
fly	bee	flag	crown
pen	sword	pear	swing
dress	shirt	drum	crab
van	box	pan	drum
pan	bowl	pear	swing

sword	pen	swan	bread
bowl	spoon	bell	swan
bee	fly	belt	clown
belt	ring	bear	vase
pear	cheese	pen	van
clown	bear	kite	vase
shirt	dress	sheep	heart
horse	sheep	heart	pen
swing	kite	spoon	heart
spoon	bowl	swan	crab
bear	horse	belt	cheese
goat	sheep	gift	clown

Appendix C. Strong semantic foils

Target	**Semantic**
flag	kite
sheep	goat
drum	bell
kite	flag
gift	box
bell	drum
crown	sword
bread	cheese
box	gift
cheese	bread
fly	bee
dress	shirt
bowl	spoon
bee	fly
shirt	dress
horse	sheep
spoon	bowl
bear	horse
goat	sheep

Appendix D.

Demographic information by participant for children from low-SES families.

Participant	**Total Household Income**	**Mother's Education Level**	**EVT-2 Standard Score**
080C	Less than $20,000	Some College	73
081C	$41,000-$60,000	Trade School	119
083C	$20,000-$40,000	4 year college degree	106
085C	[1]		117
086C	Less than $20,000	Some College	83
087C	$20,000-$40,000	Some College	99
088C	Less than $20,000	GED	113
089C	Less than $20,000	GED	92

[1]One family chose not to answer the questions about education level and total family income.

SES was inferred because participant resided in an area with a high low-SES population.

Demographic information by participant for children from middle-SES families.

Participant	**Total Household Income**	**Mother's Education Level**	**EVT-2 Standard Score**
005C	$61,000 to $100,000	Some College	117
021C	$100,000 to $200,000	Graduate degree (Masters or professional)	137
029C	$41,000 to $60,000	Graduate degree (Masters or professional)	146
036C	$61,000 to $100,000	4 year college degree	133
039C	$100,000 to $200,000	4 year college degree	129
099C	More than $200,000	Graduate Degree	116
106C	More than $200,000	Graduate Degree	134
108C	$20,000-$40,000	Graduate Degree	113