Elizabeth Munsterberg Koppitz Fellowship Application

Goals

Language skills play a critical role in students' academic success. Research over several decades has identified links between early language abilities and academic achievement, suggesting that interventions that target language skills in infancy may lead to improved educational outcomes. The goal of this project is to understand the origins of individual differences in infants' skill in spoken language understanding. Specifically, my dissertation explores relations between early language experience and the development of language processing skills and vocabulary in Spanish-learning children from low socio-economic (SES) backgrounds. This research program has two specific aims:

Specific Aim 1: To characterize critical aspects of the language environments of low-SES Latino infants based on 12-hour home recordings at 18, 24, and 36 months. Although most children live in social environments where they hear speech from many different sources, previous studies of child-directed speech have focused primarily on mother-child interactions during play or book reading. My goal is to examine children's exposure to speech in interactions with other family members and caregivers as well, focusing on both the quantity and quality of language heard by the child across a wide variety of contexts in everyday life.

Specific Aim 2: To explore relations between children's early language experience and the development of speech processing efficiency and vocabulary from 18 to 36 months. Using representative samples of children's language environments collected at home and powerful real-time measures of *language processing*, I will investigate how children's early language experience relates not only to vocabulary growth but also to the development of efficiency in spoken language processing. One possibility is that language experience and language-processing skills make *independent* contributions to individual differences in lexical development. In other words, variation in children's vocabulary development could be due to 1) differences in the amount and quality of speech to which children are exposed, and thus their opportunities to learn words, and 2) inherent differences in children's ability to process language in real time, with some children better able to take advantage of the input they receive. Alternatively, early experience with language could be critical in strengthening and fine-tuning the very mechanisms by which language knowledge is acquired. Here, I test the hypothesis that *verbal interactions in the home promote skill in spoken language understanding*, enabling children to learn language more efficiently.

My dissertation is part of a larger research program that seeks to discover the causal pathways by which early language experience influences language development, as well as the mechanisms children employ when learning language in complex, natural settings. One unique aspect of this project is the application of rigorous experimental methods used in infancy research to study language development in children from diverse backgrounds. This research will provide insights into key features of early language interactions that facilitate the development of critical language skills. The long-term goal is for these ideas to help shape the development and application of intervention strategies for disadvantaged children.

Potential Impact on Child Psychology

This project makes several valuable contributions to developmental psychology. First, it brings together cognitive and socio-cultural perspectives on the study of early language development. Many studies exploring sources of variability in lexical development have focused

exclusively on environmental factors, while other have asked how infants' skill in processing speech sounds might also account for differences in language learning. In my research I explore how differences in children's language environments *and* in language processing skills might account for differences in vocabulary growth. Moreover, I explore the possibility that verbal interactions in the home provide opportunities for practice in interpreting language, tuning up language-processing skills that enable children to learn language more efficiently.

This project also engages with current debates about the importance of social interaction to language learning. Much research over the last few decades has focused on the computational mechanisms that enable children to learn the sounds and words of their language, and has thus treated linguistic input simply as data to this computational system. Yet recent research suggests that infants do not learn from non-social sources (e.g., television) in the same way that they learn from social interactions. My research will examine the relative contributions of different sources of speech to children's language development, focusing on different 'streams of talk' that children encounter in their daily lives, such as speech directed to them by adult caregivers or siblings, overheard speech from adults and children, and speech from television and other media.

Finally, this research has implications for children's educational outcomes. Children from lower socio-economic backgrounds continue to fare less well in school than their more advantaged peers, despite many efforts to close these enduring achievement gaps. Research has shown that SES-differences in verbal and cognitive skills are present by the time children enter school, and these early differences are predictive of academic success years later. By helping us understand relations between children's home environments and the development of critical language skills, we can design programs to help parents engage with their children in ways that promote language development and enhance school readiness.

Prior Research and Plans for the Current Research Program

There is a long history of research showing that the course of children's language development varies as a function of socio-economic status (Fernald & Weisleder, in press), and several influential studies have linked this variation to differences in the quantity and quality of children's early language experience (Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Hoff, 2003). In a landmark study, Hart & Risley (1995) followed 42 children from different SES groups for two and a half years, doing monthly recordings of their home interactions. They found that parents from different socio-economic backgrounds varied greatly in the amount of speech they addressed to their children, and differences in amount of parental speech were correlated with children's vocabulary growth. By their estimates, a 4-year-old child from a professional family had heard 30 million more words than a 4-year-old child from a welfare family, and these differences in experience were reflected in the size of their vocabularies.

Similar links between amount of parental speech and vocabulary growth have been found within a group of middle-class families (Huttenlocher et al., 1991), suggesting that variation in caregiver talk is related to language outcomes in families from similar socio-economic backgrounds. Furthermore, a recent study found that features of maternal speech mediate the relation between SES and children's vocabulary, showing that variation in language outcomes is directly attributable to characteristics of caregiver talk (Hoff, 2003).

While all of these studies have focused on traditional offline measures of language knowledge, new approaches are now available that enable us to characterize early language proficiency using measures of infants' skill in *real-time language processing*. Studies with both

English- and Spanish-learning children have shown that during the course of development children not only add more words to their vocabularies, but also get better and faster at recognizing known words in fluent speech (Fernald, Pinto, Swingley, Weinberg & McRoberts, 1998; Hurtado, Marchman, & Fernald, 2007)

Thus, a number of recent studies have asked how infants' early skill in *processing speech sounds* might account for differences in language learning. These studies have found that early abilities in speech-processing efficiency are related to differences in language-learning trajectories in both English- and Spanish-learning children (Fernald, Perfors, & Marchman, 2006; Hurtado, Marchman & Fernald, 2008). Furthermore, speed of spoken word recognition at 25 months is predictive of performance on standardized tests of language and cognitive skills at 8 years of age (Marchman & Fernald, 2008), showing that *processing speed in infancy is related to long-term language and cognitive outcomes.*

These findings suggest that early differences in children's speech processing abilities may be partly responsible for differences in language outcomes. But could these critical processing skills also be shaped by children's early experiences with language? A recent study was the first to address this question (Hurtado, Marchman, & Fernald, 2008). In this study, Latino infants and their mothers were recorded in a laboratory play session at 18 months. Infants were tested longitudinally at 18 and 24 months in real-time processing of familiar nouns, and parental report of vocabulary was collected. Those children whose mothers talked more and used more varied language were also those who had larger vocabularies at 24 months, replicating previous studies. The new discovery in this research was that features of maternal talk also predicted children's skill in lexical processing: those infants who heard more and more varied speech were also faster in spoken word recognition at 24 months. *Thus caregiver talk is related not only to children's vocabulary learning but also to the development of efficiency in real-time language processing*

Yet as in most previous research on early language input, this study relied on a short sample of maternal talk obtained in a lab observation, which fails to capture important aspects of the language children hear at home. One important goal of my proposal is to obtain a *much larger, more comprehensive, and more representative sample of the language children experience in everyday life,* as they interact with different family members at home. The central goal is to identify features of daily language interactions that confer the greatest benefits to the development of language processing skills and vocabulary.

Research Strategy

My dissertation research consists of a longitudinal study of the relation between home language experience and language development in Spanish-learning children from low-SES backgrounds. Twenty-five participants have taken part in testing at three time points (ages 1;6, 2;0, 3;0), with measures of vocabulary and real-time language processing. Audio-recordings of the home language environment have been made at each time point, to assess correlations between features of the language environment and child language outcomes. All testing was conducted in Spanish by native Spanish-speakers at a community-based research facility.

Offline measures of child language: At 18 and 24 months, parents completed the Spanish version of the *MacArthur-Bates Communicative Development Inventory* (CDI; Jackson-Maldonado et al., 2003), which yields measures of children's receptive and productive vocabularies. As a convergent measure of vocabulary knowledge, the Spanish version of the Peabody Picture Vocabulary Test (TVIP; Dunn, Lugo, Padilla, & Dunn, 1986) was administered

on the last session, at 36 months.

Online measures of language processing: The "looking-while-listening" (LWL) procedure (Fernald et al., 1998) was used to monitor the time course of infants' language comprehension. On each trial, infants look at pairs of pictures (e.g., dog, baby) while hearing sentences naming one of them (e.g., *Where's the doggie?*). Their gaze patterns are video-recorded as the sentence unfolds, and eye movements are subsequently analyzed frame-by-frame. The goal is to document how efficiently children interpret sentences in relation to the visual scene - i.e., how quickly and reliably they establish reference after hearing a familiar noun. Measures of children's looking patterns on each trial are analyzed in relation to the acoustic onset of the target noun, yielding two measures of their *efficiency in real-time understanding*: **reaction time (RT)** and **accuracy**. RTs are calculated by measuring the latency to initiate a shift in gaze from distracter to target. Accuracy is calculated by computing the proportion of time spent looking at the target picture divided by the time spent looking at either picture.

Naturalistic recordings of children's language environments: At each time point, two different samples of children's language environments were collected, one based on a traditional 20-minute lab observation and one based on a 6-16 hour home recording, enabling direct comparison of the of the traditional sampling method and the new methods we are developing here using longer, more representative samples.

Procedure for lab observations: Parents were asked to play with their child as they would at home for 20 minutes, with sessions video- and audio-recorded. These recordings will be analyzed using the LENA speech analysis system, described below.

Procedure for home recordings: Home recordings were obtained using the LENA analysis system. This system is designed to provide information about the language environment of infants and toddlers. Children wear a digital recorder in specially designed clothing that records all the sounds in the child's environment for up to 16 hours. The audio data are then transferred to a computer and analyzed by the LENA analysis software.

Parents were asked to record their child during a typical 12-hour day in the home, providing a representative sample of children's daily experiences with language, as they interact with different family members in a variety of contexts. Parents also kept a logbook on the days of the recording, to provide additional detail relevant to periods of interest in the recordings.

Data Reduction and Measures: Home and lab recordings are downloaded to a computer and processed by the LENA analysis software. This software contains advanced speech-identification algorithms that segment the audio data and generate estimates of different features of the language environment, including the number of adult words and conversational turns in the recording. This system was originally validated for use in English language environments (Yapanel, Gray, & Xu, 2008). An analysis based on 70 1-hour samples selected from naturalistic home recordings found a high correlation (r = .92) between LENA-based estimates of adult words and word counts obtained from human transcribers (Yapanel, Gray, & Xu, 2008 [LENA^{TM} technical report]). An independent study, based on 17 30-minute lab samples, found lower, but still substantial correlations (r=.71–.85) between LENA-based and transcriber-based word counts (Oetting, Hartfield, & Pruitt, 2009). To assess the accuracy of the LENA system in Spanish language environments, we conducted our own validation study and found a high correlation (r=.80) between LENA-based and transcriber-based estimates.

Further analysis of the home recordings will focus on identifying different *streams of talk* that children encounter in their home environment. Native Spanish-speaking coders listen to the recordings and classify each speech segment based on the context (e.g., play, book-reading,

meal), the people participating in the interaction (e.g., mother and child, father and siblings), and whether the speech is directed to the child or overheard. This allows us to analyze differences in the quantity and quality of talk between interaction contexts, and to examine the relative contributions of different sources of speech to children's language outcomes.

In addition to differences in the amount of speech children experience, I will also examine variation in the quality of lexical input across contexts and across families. Further analysis of the home recordings will examine 'quality features' of child-directed speech during four different interaction contexts – play, book-reading, meals, and routines. This analysis will focus on different forms of contextual support for learning word meanings (Beals, 1997; Weizman & Snow, 2001). One-hour samples taken from the 12-hour recording will be transcribed. Spanish-speaking coders will then review these transcripts and code each exchange in which parents provide direct or indirect cues about a word's meaning. These exchanges will be classified based on the type of 'strategy' used to offer information about a word, including: 1) appeals to the physical or social context, 2) appeals to the child's prior knowledge, and 3) uses of semantically related words. I will then examine differences in the degree to which parents use these 'quality features' in conversations with their children, and whether these features contribute to children's language outcomes over and above the amount of talk they hear.

Data Analysis and Interpretation

The longitudinal design of this research enables examination of concurrent and predictive relations between measures of the language environment and children's language outcomes. Various multivariate analytic techniques, including cross-lag correlations, mediation analyses, and structural equation modeling, will be used to examine different patterns of relations between language experience, processing efficiency, and lexical development. Two different conceptual models will guide our analyses. The first model proposes that language experience facilitates vocabulary development *through its influence on language-processing skills*. Children who hear more child-directed talk obtain more practice in skills such as parsing speech, accessing lexical representations, and using predictive cues to interpret speech incrementally, thus becoming more efficient language processors. Better processing skills could in turn enable more efficient learning of new words, thus explaining the relation between language experience and vocabulary growth. Analytically, this would suggest a mediation model in which processing efficiency mediates the relation between language experience and vocabulary.

Conversely, the second model will examine whether vocabulary is a mediator of the relation between language experience and processing efficiency. This model proposes that language experience promotes the development of processing efficiency *through its influence on vocabulary knowledge.* More child-directed speech exposes children to more different words, more exemplars of each word in different contexts, and more different cues to word meaning, providing children with more and better opportunities to learn new words. In turn, children with bigger vocabularies may exhibit better processing skills because they have more refined lexical representations that allow faster lexical access. Both of these models will be contrasted with a third model in which language experience and processing skills make *independent* contributions to children's vocabulary knowledge.

Conclusion

Language skills are crucially important to school achievement. Vocabulary knowledge and listening comprehension skills are powerful predictors of reading ability. These skills are

also related to children's self-regulation skills, and are important for learning in classroom settings. Yet the development of language skills begins years before children enter the school system. Thus, investigations of children's early home environments are crucial to understanding differences in academic achievement, and are especially important for understanding the learning trajectories of children from low-SES backgrounds, who are typically under-represented in research on language and cognitive development (Fernald, 2010).

Yet this idea – that differences in home environments can explain differences in academic achievement – has a long and controversial history (see Fernald & Weisleder, in press). Starting in the 1940's, researchers turned to examining children's home environments as a way to explain IQ differences between children from different social classes, and by the 1960's many studies focused specifically on patterns of parent-child interaction (Bernstein, 1961; Hess & Shipman, 1965). Although the shift from genetic to environmental explanations for IQ differences was initially viewed positively, this approach – which emphasized between-group differences and often involved comparisons between high-SES white children and low-SES minority children – led to a characterization of low-SES environments as "deficient", and was soon renounced as racist and culturally insensitive (Cole & Bruner, 1971).

Importantly, much of the criticism directed at this earlier research was rooted in methodological concerns that can be duly addressed (Sroufe, 1970). In my research, the focus is on characterizing variability in the quality of language environments within a group of low-SES Latino children, with the goal of identifying features of verbal interactions that confer the greatest benefits to children growing up in this cultural setting. In addition, by using unobtrusive technology that records children's natural language environments, I hope to minimize artifacts introduced by the presence of an experimenter or parents' reactions to a laboratory setting. Finally, all testing is conducted in a community-based research facility staffed by fully bilingual, bicultural researchers, in order to give all children the best opportunity to demonstrate their skills.

Socio-economic differences in cognitive and verbal abilities are present by the time children enter school (Stipek & Ryan, 1996; Farkas & Beron, 2004). Even when low-income children enter good schools and learn at the same rate as their high-income peers, it is hard to make up for the time lost, and many of them never catch up. Because early experiences lay the foundation for later learning, we will not be able to level the playing field between children from different social classes until we address these early differences. Research exploring the causes of variation in early language development can offer insights into questions that have important consequences for children's academic success and for our theories of child development.

Timeline

- Autumn 2010 and Winter 2011 Quarters (present – March 2011):
  - conduct last round of data collection (36-month-old time point)
  - begin analysis of audio data from 18- and 24-month time points
- Spring and Summer Quarters 2010 (April – September 2011):
  - continue analysis of audio data
- Autumn Quarter 2011 (September – December 2011):
  - finish analysis of audio data
  - begin statistical analyses

- begin writing the dissertation

• Winter Quarter 2012 (January – March 2012):
- finish data analysis
- continue writing the dissertation

• Spring Quarter 2012 (April – June 2012):
- finish writing the dissertation and send to committee
- incorporate feedback from readers
- dissertation defense

Full budget and justification

1. Health insurance	3200
2. Vaden Student Health Center Fee	668
3. Dissertation fees	300
4. Research fees	480
5. Housing	12000
6. Food	3200
7. Medical expenses	500
8. Estimated taxes	3750
9. Transportation	900
TOTAL:	24998

1. Stanford University health insurance is $800/quarter
2. Vaden Student Health Center charges a fee of $167/quarter
3. Stanford University dissertation fees total $300
4. Research fees include a $20 incentive for 24 participants
5. Palo Alto, CA has an extremely high cost of living
6. Estimating $60/week for 52 weeks
7. Medical expenses: co-pays for prescriptions and doctor visits
8. Estimated at 15% for $25,000 income
9. Costs for travel to SRCD and APA conferences 2011