

Personal Statement  
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The world around us is saturated by sound from countless sources: televisions, traffic, radios, voices, dogs and birds, wind and rain. It all washes over our ears simultaneously, yet somehow we make sense of this vast confusion. We unconsciously separate the sounds from one another, choosing which ones to interpret, and which ones to ignore. We identify the person doing the speaking, subdivide the fluent stream into individual words, match those words to their individual meanings, and combine these concepts together into an interpretable message. We accomplish this seemingly Herculean task with virtually no apparent effort at all. How do we so effortlessly execute a task that routinely stumps supercomputers? How do infants learn to do it so early in their lives? Answering these questions is at the heart of my research agenda.

My research can be subdivided into two main areas: Speech perception (identifying the speech segments in the sounds reaching our ears) and lexical access (linking individual sounds to their associated meanings). Below, I identify the major problems in each of these areas and how my research addresses them. I then describe my work combining speech perception and lexical access, and my ultimate goal of creating a more integrated theory of how people comprehend spoken language.

### **Research in Speech Perception – Making sense of sound**

#### Listening in noise

The core of speech perception is the act of identifying the intended phonemes in the acoustic signal arising from someone's speech. One of the first stages in this process involves separating the signal from the speech of background talkers, a process known as stream segregation. This has long been recognized as a critical issue in adult speech perception, but it had not been addressed directly in the developmental literature. It is an essential question for language acquisition, because much of the language input that children receive takes place in the presence of background speech. In order to learn language in these multi-talker settings, infants must be able to separate the different streams of sound.

I undertook to investigate the extent to which infants could succeed at separating speech streams. I proposed that one indication that infants could attend to a stream of speech would be if the infants showed subsequent recognition for information that occurred only in that particular stream.<sup>1</sup> This would indicate that the infants processed at least some of the information in the target speech. My initial research demonstrated that infants do have some capacity to extract information from speech even in the presence of a competing voice. However, infant listeners are far more sensitive to background talker noise than we expected. They can recognize well-known words (such as their own name) in quiet laboratory settings, but fail to do so in noise levels comparable to those found in many day care centers.<sup>2</sup> These findings are particularly important given concerns over the quality of childcare environments, and the impact such environments might have on language acquisition.

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<sup>1</sup> Newman & Jusczyk, 1996.

<sup>2</sup> Newman, 2005.

I proceeded to investigate this issue in greater depth, studying the types of cues that infants use to succeed at stream segregation tasks.<sup>3</sup> I found that infants use some, but not all, of the cues used by adults to solve the stream segregation problem. For example, infants use audiovisual correspondence to help them separate streams of speech, and they perform better when they are familiar with the talker's voice. However, infants do not exploit their knowledge of the language to help them fill in gaps in the signal. They also do not focus their attention selectively or take advantage of variation in loudness level (amplitude modulation) in the background speech.

These findings led me to develop a new model of infant speech perception in noise that integrates a wide variety of findings from infant research into a cohesive picture of auditory development. The model argues that the use of certain cues for listening in noise is automatic and present at birth, while other cues develop only through experience with the language. The model therefore makes predictions about the types of listening environments in which infants will be able to acquire language information, versus the types of environments that will prove particularly detrimental. I recently submitted a grant proposal to the National Science Foundation and am working on a proposal for a National Institutes of Health grant to permit me to test this theory.

### Variability in the signal

Even after the signal has been separated from background noise, listeners have to adjust their perception for variation in the signal. No two people produce sounds in exactly the same way, and no single person produces the same intended sound consistently across situations. Listeners need to adjust for these differences among talkers, speaking rates, and contexts in order to interpret the signal accurately, and this adjustment requires effort on the part of the listener.<sup>4</sup>

Much of my research in this area has investigated how listeners adjust for variation in speaking rates.<sup>5</sup> I began by exploring the limits of this adjustment, discovering that there is a temporal window of approximately 250 milliseconds over which it occurs. My more recent studies have shown that adjustment occurs automatically, without consideration of the type of speech sounds involved. Moreover, adult listeners cannot 'reset' their perception for a new speaker in a conversation instantaneously – they need time to adjust their strategies to a new talker. These findings have clarified how listeners compensate for variability in the signal, pushing research in speech perception to conditions closer to those faced in daily life.

## **Research in Lexical Access - Finding the words**

### Accessing the lexicon

The outcome of speech perception is a series of phonetic patterns or word forms that are useful only when connected with meaning. Adult speakers know thousands of words and must select the correct one to match the incoming speech signal. The same problem occurs when speaking – the speaker has to select and retrieve the appropriate words to match the concepts he or she wants to express from thousands of possible choices. Both processes require fast and accurate access to the mental dictionary, or the lexicon.

Much of my work has investigated how the lexicon is organized, and what processes people use to gain access to this information. In some of my research, I have explored properties of

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<sup>3</sup> Barker & Newman, 2004; Hollich, Newman & Jusczyk, 2005; Newman, 2004, 2005, & in press; Newman & Hussain, 2006.

<sup>4</sup> Newman, Clouse & Burnham, 2001.

<sup>5</sup> Newman & Sawusch, 1996, in revision, & in progress; Sawusch & Newman, 2000; Sawusch, Measer & Newman, in revision.

words that influence the ease with which they are accessed.<sup>6</sup> Most recently<sup>7</sup>, I have used these data to propose a new model of how lexical access works, and am now working to articulate more fully and test this model's value in describing the processing stages of lexical access.

### Comparative analyses

I have also explored how these lexical access processes differ in clinical populations<sup>8</sup>, seeking to determine the stage in these individuals' processing systems during which problems are likely to originate. A recent paper on individuals who stutter<sup>9</sup> is a case-in-point. These people have long been thought to have a speech *production* disorder. However, we found that they have subtle lexical encoding difficulties, ones that can only be detected using sensitive measures of lexical retrieval speed and accuracy that compare their response patterns to those seen in unimpaired speakers. Moreover, these difficulties seem to occur at a relatively early stage of processing, rather than being at a stage at which individuals prepare to articulate words. This finding supports a newly emerging emphasis on language encoding impairment as an underlying cause of stuttering, a view receiving increased support in the research literature.

As with my research on speech perception, I feel it is important to study not only language processing in adults, but also the development and change in processing abilities across the lifespan.<sup>10</sup> In one such study, we compared younger and older adults' errors at naming words, looking for effects both at a semantic stage of lexical access (finding the right meaning) and at a later form-based stage (matching the concept to the correct sound pattern).<sup>11</sup> Our findings show that aged listeners may experience difficulties transmitting information between these two processing stages, although each of the individual stages continues to work normally. Only by looking across the lifespan were these changes apparent.

### **Linking the disciplines**

Speech perception and word recognition traditionally have been treated as distinct areas of research: the former relating to issues in hearing, acoustics, and auditory attention, and the latter encompassing issues in memory retrieval, information storage, and categorization. In spite of these distinctions, the two levels of processing place important limits on each other, and by studying both simultaneously, I believe I can add greater depth to theories of language processing.

One demonstration of the usefulness of this approach comes from my work on phonemic restoration. When listening to speech in the presence of background noise, some parts of the target signal can become masked. Adults use their prior knowledge of the language to "restore" these gaps in the signal. Children, however, do not have as much lexical knowledge as adults. Even words children know will typically have much weaker representations than the words would for adults. As a result, children may rely less heavily upon their lexical knowledge. I explored this interaction between lexical knowledge and speech perception, and found that while school-aged children are similar to adults in their restoration, toddlers are not.<sup>12</sup> Instead, toddlers place more reliance on their speech perception skills (and less on lexical knowledge) than do adults or older children, even in those cases in which they have appropriate prior knowledge.

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<sup>6</sup> Newman, Sawusch & Luce, 1997, 1999, 2005; Newman & German, 2002, 2005; German & Newman, 2004.

<sup>7</sup> Newman & German, 2005.

<sup>8</sup> Newman & German, 2002; German & Newman, 2004, & accepted; Newman & Bernstein Ratner, in press.

<sup>9</sup> Newman & Bernstein Ratner, in press.

<sup>10</sup> Newman & German, 2002, 2005; Samuelson, Newman & Gupta, in progress; Streckas, King, Newman & Ratner, in progress.

<sup>11</sup> Newman & German, 2005.

<sup>12</sup> Newman, 2004; Newman, in press.

Exploring the interactions between speech perception and the lexicon allowed me to identify an important pattern of developmental change, adding to our knowledge of language acquisition.

Another example of the benefits of studying both areas simultaneously comes from research examining how infants' ability to process speech influences their later acquisition of new words. We found that infants who were slightly better at finding the individual words in a fluent speech stream at 7 months of age demonstrated superior vocabularies and superior syntactic skills years later.<sup>13</sup> The ability to process the speech signal appears to be a necessary prerequisite for later language learning, such that delays in the earlier-learned skill translate into difficulties learning other skills later in life. While this makes sense on an intuitive level, it was an unexpected finding since differences in infant performance were often thought to be a result of random variation. This work has been highlighted by the American Psychological Association as one of the first studies to link an aspect of infant speech processing with variability in later language performance.

These findings led me to design a multi-investigator project examining a wide range of infant abilities that might relate to eventual language outcomes. These include both speech perception skills (such as the ability to segment speech into individual words), and more general cognitive skills (such as working memory and attention). The project explores how these different abilities build upon one another over time, and how they interact during development. This is an important question theoretically, and also has wide-reaching clinical implications. If we find that some infant tasks are good predictors of which children will later develop a language impairment, this could lead to earlier screening tests for those impairments. Similarly, if we find that particular skills are necessary prerequisites for later development, we could intervene to enhance those necessary early skills.

## **Conclusions**

Speech perception and lexical access are intertwined. My research, to date, has explored each of these areas. By studying the two domains in combination, I seek to develop a more nuanced model of how humans process language. Such work will contribute substantially to our understanding of how listeners across the lifespan perceive and comprehend speech in the complex world surrounding them.

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<sup>13</sup> Newman et al., 2006.