Specific Aims

In 1997 Congress requested that NICHD create a National Reading Panel to provide guidance on how to approach reading instruction and difficulties in school children, following extensive review of the literature, public hearings, and expert consultation (NICHD/NRP, 2000a). One conclusive finding was the high correlation between phonemic awareness (PA) and reading (cf. Schuele and Boudreau, 2008). Less clear is the nature of this interaction, namely, what does the correlation measure? Does poor phonemic awareness cause poor reading or vice versa (Goswami, 2010)? What is needed is a clear understanding of: why children with reading disability (RD) have poor PA scores, what PA measures, and what can be done to rectify the situation.

Our proposed work has **two aims: (1) to investigate abilities less linguistic and central than PA in children with RD, that may underlie PA and RD, namely more sensory and peripheral abilities of children with RD to aurally perceive speech sounds; and (2) to carefully map individual differences in perceptual confusions.** Recent theorists have provided evidence of auditory processing difficulties in RD and argued that it is essentially an auditory (or phonological) disorder (Dawes and Bishop, 2009; Goswami, 2010; Rosen, 2003; Snowling, 2000, 2001; Tallal, 1980; Vandewalle et al., 2012; Ziegler and Goswami, 2005; see also Merzenich et al., 1996; Tallal et al., 1996; and Ziegler et al., 2005, for a similar argument for children with Specific Language Impairment). Perceptual confusion is suggestive of children with hearing loss or deaf children who receive cochlear implants. Namely, if there are early hearing related problems in RD (perhaps due middle ear pathology that goes undetected but eventually resolves), the child might be unable to discern critical features in the speech signal even in late elementary school. If so, speech perception training for the child's particular observed confusions could lead to improved assessment and intervention for RD.

This basic exploratory study will evaluate four intertwined hypotheses related to reading disabilities. **H1 *Consonant (C) and vowel (V) perception***: *Auditory perceptual deficits for speech sounds contribute to RD.* If true, children with RD do not spontaneously perceive certain speech sound distinctions, similar to participants who use hearing aids and claim to hear the amplified speech but cannot understand it. Alternatively, if children with RD perceive all Cs and Vs as good readers do, we may assume that sensory aspects of the auditory system do not contribute to reading problems. **H2 *Short-term auditory memory***: *Short-term auditory memory difficulties for speech sounds contribute to RD.* If both H1 and H2 are true, children with RD would eventually reach cognitive overload when asked to perceive sounds they tend to confuse, in increasingly longer strings of nonsense syllables. Their error rate should increase as a function of the number of the sounds in the syllable sequence. Alternately, given no memory disorder, children with RD should perform like good readers in repeating back long sequences of nonsense syllables. Note, in our reasoning, H2 is contingent on H1. (We have **Preliminary Data** consistent with both H1 and H2.) **H3**. ***Integration of visual and auditory streams****: Processing of the auditory and visual streams is not well integrated in children with RD***.** Here we ask if auditory information is used well by children with RD for decoding and reading fluency with novel print. Participants will view a printed random string of four nonsense syllables (decoding) while listening to an auditory version that differs by only one speech sound, and detect the point of mismatch. Then participants will read the printed sequence aloud (reading fluency). We predict that children with RD will have difficulty detecting mismatches and will produce read-aloud errors for sounds they confused on the H1 task. **H4 *Auditory plasticity***: *Reading disabilities are plastic, and thus will respond to training focused on a child's observed speech sound confusions.* We will test this hypothesis with extensive listening training, with feedback, concentrating on specific Cs and Vs in whole nonsense syllables that a child had difficulty perceiving for H1. Unlike the *FastForWord* program (Merzenich et al., 1996; Scientific Learning Corporation, 1998; Tallal et al., 1996), our training will involve only unmodified syllables from the natural speech of multiple talkers and thus remain closer to real-life listening experience. If the plasticity hypothesis is true, children with RD should learn to accurately perceive the difficult syllables, leading to a measurable improvement in their global skill set for print decoding, reading comprehension, and reading fluency. Such plasticity has previously been observed for phonemic awareness (Ehri et al., 2001).

In combination, these four hypotheses are designed to test a hierarchical model of auditory speech perception in children with RD and assess the nature of each child's disability. If improper phonetic perception (in the more peripheral auditory system) contributes to RD (H1 true), we should see abnormal performance on all the tasks (perhaps due to early diminished auditory exposure from middle ear fluid and undetected hearing loss, as suggested by patterns seen in our Preliminary Data). Having detected a child's specific misperceived phones, we can potentially retrain those, possibly resulting in dramatic and permanent gains in speech perception and reading (H4 true). If on the other hand the child with RD has a more central, cognitive disorder, errors will appear in the later tests (only H2 and H3 true), but phonetic perception will be normal (H1 false).