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Individual differences in online spoken word recognition: Implications for SLI

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ABSTRACT

Thirty years of research has uncovered the broad principles that characterize spoken word processing across listeners. However, there have been few systematic investigations of individual differences. Such an investigation could help refine models of word recognition by indicating which processing parameters are likely to vary, and could also have important implications for work on language impairment. The present study begins to fill this gap by relating individual differences in overall language ability to variation in online word recognition processes. Using the visual world paradigm, we evaluated online spoken word recognition in adolescents who varied in both basic language abilities and non-verbal cognitive abilities. Eye movements to target, cohort and rhyme objects were monitored during spoken word recognition, as an index of lexical activation. Adolescents with poor language skills showed fewer looks to the target and more fixations to the cohort and rhyme competitors. These results were compared to a number of variants of the TRACE model (McClelland & Elman, 1986) that were constructed to test a range of theoretical approaches to language impairment: impairments at sensory and phonological levels; vocabulary size, and generalized slowing. None of the existing approaches were strongly supported, and variation in lexical decay offered the best fit. Thus, basic word recognition processes like lexical decay may offer a new way to characterize processing differences in language impairment.

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1. Introduction

The incoming speech signal is variable and noisy, arrives at a high rate of input, and maps onto a potentially vast number of lexical candidates. The question of how listeners recognize words given these challenges represents an important problem in the language sciences. Research over the last 30 years has led to a remarkable consensus for several principles that broadly characterize the processing architecture underlying spoken word recognition. These include immediate incremental processing, graded activation, parallelism, and competition.

These core principles provide descriptions of average performance in a variety of word recognition tasks and represent fundamental commonalities across listeners. However, there has been little work addressing differences between listeners. Such research has the promise for refining current models of word recognition by revealing which aspects vary freely, which are more constant, and which may be important for language processes beyond word recognition. It may also help diagnose and treat listeners at the low end of the language ability scale, listeners commonly characterized as specific- or non-specific-language-impaired (SLI or NLI).

The present paper begins to address this by using fine-grained measures of the temporal dynamics of word recognition, and testing hypotheses for underlying causes of these differences using a current model of word recognition, TRACE (McClelland & Elman, 1986). We start by reviewing the research that established the current consensus on word recognition. We then motivate the individual differences that we chose to study here: gradations in overall language ability that are commonly associated with language impairment. Next, we present an experiment that uses the visual world paradigm (Allopenna, Magnuson, & Tanenhaus, 1998; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) to assess online word recognition. Finally, we use variants of the TRACE model (McClelland & Elman, 1986) to test hypotheses about the underlying processing dimension(s) that may account for the individual differences we observed.

1.1. Principles of spoken word recognition

There is considerable consensus for several core principles that characterize the processes of real-time spoken word recognition: (1) words are activated *immediately* upon the receipt of the smallest amount of perceptual input; (2) activation is updated *incrementally* as the input unfolds; (3) activation is *graded*; (4) multiple words are activated in *parallel*; and (5) these words actively *compete* during recognition.

Immediacy was initially revealed by gating paradigms (Grosjean, 1980; Tyler, 1984) and later by priming and eye-movement measures (Allopenna et al., 1998; Marslen-Wilson & Zwitserlood, 1989; McMurray, Clayards, Tanenhaus, & Aslin, 2008; Zwitserlood, 1989). Given a minimal amount of information at word onset, listeners activate the set of all words compatible with this partial information. These words are maintained in *parallel*, until they can be ruled out by additional acoustic material as it accumulates *incrementally* (Dahan & Gaskell, 2007; Frauenfelder, Scholten, & Content, 2001; Marslen-Wilson, 1987). Early work focused on the kinds of words that are considered during processing, showing specifically that onset-competitors (or cohorts, such as *beetle* when hearing *beaker*) receive significant activation early, but that offset-competitors (rhymes, e.g. *speaker*) are also active (Allopenna et al., 1998; Connine, Blasko, & Titone, 1993; Marslen-Wilson, Moss, & Van Halen, 1996).

Lexical activation is clearly a *graded* phenomenon: frequency affects activation (Dahan, Magnuson, & Tanenhaus, 2001; Marslen-Wilson, 1987), as does phonetic match (Marslen-Wilson et al., 1996). Words that match at onset (but mismatch later in the word) receive more activation than those that mismatch at onset but match later (e.g. rhymes) (Allopenna et al., 1998). Moreover, activation is a function of the lexicon as a whole (not just a word's match to the input). The number of similar words (to the target word) affects recognition (Luce & Pisoni, 1998) and specific competitor words can delay activation to a target (Dahan, Magnuson, Tanenhaus, & Hogan, 2001; Marslen-Wilson & Warren, 1994). Thus, there is an active process by which lexical items *compete* with other items. This is underscored by the fact that well after a word's uniqueness point (the point where there is sufficient