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Word learning by children with phonological delays: Differentiating effects of phonotactic probability and neighborhood density

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Abstract

This study examined the ability of 20 preschool children with functional phonological delays and 34 age- and vocabulary-matched typical children to learn words differing in phonotactic probability (i.e., the likelihood of occurrence of a sound sequence) and neighborhood density (i.e., the number of words that differ from a target by one phoneme). Children were exposed to nonwords paired with novel objects in a story and learning was measured by a picture naming task. Results showed that both groups created lexical representations for rare sound sequences from sparse neighborhoods. However, only children with typical development appeared to build on this initial lexical representation to create a full representation of the word (i.e., lexical–semantic connection and semantic representation). It was hypothesized that creating a lexical representation may be too resource demanding for children with phonological delays, leaving few resources available to create a lexical–semantic connection and/or a semantic representation.

Learning outcomes: The reader will be able to (1) define phonotactic probability; (2) define neighborhood density; (3) identify how these variables impact the word learning process in general; (4) identify potential areas of deficit in the word learning process for children with functional phonological delays.

1. Introduction

Children with functional phonological delays experience significant deficits in acquiring the sound system of their native language in the absence of any concomitant deficits in motor, sensory, cognitive, or social abilities (Shriberg, Kwiatkowski, Best, Hengst, & Terselic-Weber, 1986). A full understanding of the nature of this disorder, in terms of the language representations and processes affected, has remained elusive. Hypothesized deficits include poor speech perception, poor oral-motor control as revealed by acoustic and kinematic measures, and poor higher level phonological knowledge, such as understanding how sounds are used to contrast meaning as well as how sounds can be combined to create words (see Munson, Edwards, & Beckman, 2005a for review). Thus, hypothesized deficits focus on deficits to motor and/or *phonological representations*, specifically representations of individual sounds in long-term

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memory. Moreover, the impact of these different hypothesized deficits on other areas of language acquisition has been relatively unexplored. It generally has been assumed that other areas of language are intact in children with functional phonological delays. However, more recent research has suggested that this assumption may be false. One language area that may be affected by phonological delay is word learning. Word learning involves *lexical representations*, the representation of the whole-word sound form in long-term memory, and *semantic representations*, the representation of the meaning or referent of a word in long-term memory.

To learn a word, a child must first recognize that a novel word was encountered, thereby triggering learning processes. It has been hypothesized that two characteristics contribute to this aspect of word learning. The first is the novelty of the word in the language as measured by *phonotactic probability*, the likelihood of occurrence of a sound sequence. That is, words that are more unique are more likely to be identified as novel, triggering learning processes (Storkel, Armbruster, & Hogan, 2006). Specifically, rarer sound sequences trigger learning more efficiently than more common sound sequences (Storkel et al., 2006). The second characteristic is similarity to other known words, termed *neighborhood density* for phonological similarity or *semantic set size* for semantic similarity. Here, presentation of a word activates representations of known words in long-term memory. For a novel word, none of the existing lexical or semantic representations in long-term memory will exactly match the novel word. This mismatch between the input and the child's representations in long-term memory is thought to trigger learning processes (Storkel & Adlof, 2009). When a novel word is similar to few other known words, as in a sparse neighborhood or small set size, the mismatch will be greater than when a novel word is similar to many other known words, as in a dense neighborhood or large set size, thereby facilitating initiation of learning (Storkel & Adlof, 2009). Once learning is initiated, the child must create a lexical and semantic representation of the word in long-term memory. This does not mark the end of word learning. Rather, the new lexical and semantic representations in long-term memory must form connections with existing lexical and semantic representations. This period of integration appears to occur separately from the creation of the representation and may be more protracted (Gaskell & Dumay, 2003; Leach & Samuel, 2007). Moreover, forming connections with many existing representations, as in a dense neighborhood or large set size, may serve to strengthen the new representation relative to forming connections with few existing representations, as in a sparse neighborhood or small set size (Storkel et al., 2006).

What is known about word learning by children with phonological delays? Edwards, Fox and Rogers (2002) provided evidence that children with phonological delays are less accurate discriminating words differing by a final consonant than children with typical phonological development (see also Edwards, Fourakis, Beckman, & Fox, 1999). Interestingly, this deficit was not tied to a specific error pattern in production (i.e., children showed this difficulty regardless of their production accuracy for final consonants). Poor discrimination could impact word learning by affecting the ability to identify that a novel word does not exactly match any existing lexical representations in long-term memory, resulting in a failure to trigger learning. Alternatively, poor discrimination may lead to misperception of the novel sound sequence, leading to inaccuracies in the newly created lexical representation. Importantly, Edwards and colleagues provide initial support for a relationship between speech perception and word learning. Specifically, they found a relationship between discrimination accuracy and vocabulary size (as well as articulatory accuracy). Moreover, previous research has demonstrated that children with phonological delays have lower receptive and expressive vocabulary scores on standardized tests than children with typical phonological development and that this difference persists into adulthood even after the production deficit has apparently resolved (Felsenfeld, Broen, & McGue, 1992; see also Shriberg & Kwiatkowski, 1994 for similar child findings).

Storkel (2004a) provided a more detailed picture of word learning by children with phonological delays. In this study, children with phonological delays and children with typical development learned nonwords that varied in phonotactic probability/neighborhood density. Phonotactic probability is positively correlated with neighborhood density in English (Storkel, 2004b; Vitevitch, Luce, Pisoni, & Auer, 1999). Specifically, rare sound sequences tend to have few neighbors (i.e., sparse neighborhoods) and common sound sequences tend to have many neighbors (i.e., dense neighborhoods). Thus, children in Storkel (2004a) were exposed to rare sound sequences from sparse neighborhoods (e.g., /gaʊb/) and common sound sequences from dense neighborhoods (e.g., /mæb/). Results of Storkel (2004a) showed differing effects of correlated phonotactic probability/neighborhood density based on phonological development.

In Storkel (2004a), children with phonological delays learned novel words composed of rare sound sequences in sparse neighborhoods more readily than novel words composed of common sound sequences in dense neighborhoods. In contrast, children with typical development showed the opposite pattern, learning novel words composed of common sound sequences in dense neighborhoods more readily than those composed of rare sound sequences in sparse neighborhoods (Storkel, 2004a). Moreover, error analyses provided evidence that common-dense sound