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The role of phonological storage deficits in specific language impairment: A reconsideration

In her Keynote Article, Gathercole (2006) presents a theoretical framework intended to account for evidence regarding the relation between nonword repetition and word learning. This framework stems from an impressive amount and breadth of research on this topic, including findings from adults and children with typical language abilities as well as language learning disorders. In this commentary we focus on claims relative to the interpretation of nonword repetition deficits in
children with specific language impairment (SLI). One issue we address pertains to the nature of the proposed model of nonword processing and word learning, particularly with respect to phonological sensitivity and storage. The second issue we address relates to the assumption that a phonological storage deficit, although not sufficient, is necessary for SLI.

Gathercole (2006) asserts that phonological storage is central to both nonword repetition and word learning, and that both of these abilities are additionally constrained by auditory, phonological, and speech–motor output processes. She systematically lays out the evidence to demonstrate that problems with nonword repetition in SLI are not primarily attributable to each of these additional constraining processes. In doing so, the overall impression is one of a relatively simple serial information processing mechanism, especially with respect to the dichotomy of the debate about phonological storage versus phonological sensitivity. Her figure 4 shows unidirectional arrows from auditory processing to phonological analysis to phonological storage to both speech–motor planning/output and phonological learning. However, there are alternative models supported by empirical data indicating that these cognitive processes are, in fact, interactive (e.g., Christiansen & Chater, 2001; Elman, Hare, & McRae, 2005; Plaut & Kello, 1999; Seidenberg & MacDonald, 1999).

Given that Gathercole (2006) acknowledges that deficits in cognitive processes besides phonological storage may be necessary to account for SLI, it seems curious to take such a strong position on minimizing the role of phonological analysis and representation. Although studies conducted by Gathercole and colleagues support the claim that the source of the difficulty is with phonological storage rather than with earlier aspects of phonological analysis, other evidence, as discussed below, is more consistent with the phonological sensitivity explanation.

Gathercole (2006) argues that the phonological storage hypothesis (namely, that children with SLI have a deficit in phonological storage) best accounts for empirical data regarding nonword repetition in children with SLI relative to age peers. Gathercole contrasts the phonological storage hypothesis with the phonological sensitivity hypothesis, a term she uses to describe the theoretical framework of Beckman, Edwards, and Munson (Beckman & Edwards, 2000a; Edwards, Beckman, & Munson, 2004; Munson, 2001; Munson, Edwards, & Beckman, 2005; Munson, Kurtz, & Windsor, 2005). These authors argue for an account of phonological acquisition in which phonological representations are highly tied to words the child knows in early language learning and gradually become more independent of context as vocabulary size increases. In this view, difficulties with nonword repetition in SLI are more readily interpreted as a consequence of small vocabulary size rather than as a causal factor (Beckman & Edwards, 2000b).

In particular, Gathercole (2006) argues that the phonological storage hypothesis better explains the finding that the accuracy differences in nonword repetition between children with SLI and their age peers increase as word length increases because of decay. However, there are also findings that are better explained by the phonological sensitivity hypothesis. Edwards et al. (2004) examined 104 typically developing children aged 3 through 9 years, and found that accuracy differences between children with smaller vocabularies and those with larger vocabularies
were greater for low-frequency phoneme sequences compared to high-frequency sequences. Furthermore, in a similar experiment with different stimuli, Munson, Kurz, et al. (2005) found that accuracy differences in nonword repetition between children with SLI and their typically developing age peers were greater for low-frequency phoneme sequences compared to high-frequency sequences. Moreover, children with SLI performed similarly to younger typically developing peers, matched for vocabulary size. Given that the words containing the low-frequency and high-frequency phoneme sequences were of the same length, this finding is difficult for the phonological storage hypothesis to explain. The phonological sensitivity hypothesis can readily explain this result: namely, as the size of the lexicon increases, phonological representations become less context sensitive so that nonword repetition accuracy is less dependent on whether the child has encountered a similar sequence in a known word. The fact that an interaction between vocabulary size and phonotactic probability was not observed in Gathercole, Frankish, Pickering, and Peaker (1999) may be due to the different nature of the task (serial recall) or to the more limited age range tested (7- and 8-year-olds only).

Another concern with Gathercole’s (2006) account is that it appears to conflate wordlikeness and phonotactic probability. Bailey and Hahn (2001) found that adult wordlikeness judgments consist of two independent components: neighborhood density and phonotactic probability. In a study of monosyllabic nonwords, neighborhood density and phonotactic probability both contributed independently to adults’ wordlikeness judgments. Adults rated a nonword as more wordlike as its neighborhood density and its phonotactic probability increased.

This finding is relevant in that longer nonwords differ from shorter nonwords in neighborhood density. Neighborhood density is inversely correlated with word length: the longer the word, the fewer lexical neighbors it will have (Storkel, 2004). For example, two-syllable words on the Children’s Test of Nonword Repetition (CNRep; Gathercole, Willis, Baddeley, & Emslie, 1994) have a number of lexical neighbors. For example, *ballop* rhymes with *gallop*, *sladding* is a lexical neighbor of both *sliding* and *sledding*, and so on. However, none of the five-syllable words on the CNRep have any lexical neighbors. Thus, longer words on the CNRep differ from shorter words in two respects: they contain more syllables and they have fewer lexical neighbors. Just as low phonotactic probability resulted in a greater decrement in performance for children with SLI relative to peers, it may be that low neighborhood density also results in a greater decrement in performance for children with SLI. Perhaps the finding of Gathercole and Baddeley (1990) that there is a greater decrement in performance for children with SLI relative to age peers on longer nonwords is more related to neighborhood density rather than to word length per se. This is an empirical question that can be answered only by contrasting nonwords of the same length with different neighborhood densities.

As suggested above, the framework represented in Gathercole’s (2006) figure 4 does not adequately represent the highly interactive and multidimensional nature of phonological representations and phonological processing. Within a more complex model, one might assume that different levels of processing (or representation) are influencing each other such that phonological analysis and storage would interact
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in a dynamic fashion. According to this type of model, one would expect that it would be more difficult to analyze phonological representations that are poorly stored and that it also would be more difficult to store poorly specified phonological representations. As noted by Gathercole (2006), it typically takes multiple passes (exposures) to learn a word. If a child has a deficit in phonological analysis, then getting the word stored might be difficult. The child may not arrive at the same phonological analysis each time, thereby amassing conflicting information such that he/she must suppress or override prior representations that were stored incorrectly.

Given such a complex system, it may be that some children with SLI have a primary deficit in phonological storage, other children have a primary deficit in phonological analysis, and some children have neither. Although some research supports the phonological storage hypothesis (e.g., Gathercole & Baddeley, 1990) and some research supports the phonological sensitivity hypothesis (e.g., Edwards et al., 2004; Munson, Kurtz et al., 2005), most studies of nonword repetition in children with SLI relative to typically developing peers have found much variability in performance, especially among the children with SLI. Many of these studies (e.g., Edwards & Lahey, 1998; Ellis Weismer et al., 2000) have found overlap in performance between children with SLI and their age peers.

Ellis Weismer et al. (2000) investigated nonword repetition in second grade children as measured by the task developed by Dollaghan and Campbell (1998). Using an odds ratio analysis, they found that nonword repetition performance, although helpful, was not sufficient by itself to classify children on the basis of language diagnosis or intervention status. This large (N = 581) population-based sample of children had been diagnosed according to the EpiSLI criteria established by Tomblin, Records, and Zhang (1996). Although it was the case that the SLI group and nonspecific language impairment groups both performed significantly worse than the normal language and low cognitive (normal language) groups, there was considerable overlap across the groups. The total percentage phonemes correct (PPC) for the children diagnosed as having normal language ranged from 48 to 99%, and the PPC for the longest nonwords (four syllables) ranged from 8 to 99%. A substantial minority of children with SLI performed at or above the mean for the control group on total PPC and four-syllable PPC (33 and 25% of the SLI group, respectively).

Gathercole (2006) explicitly states that limitations in phonological storage may not be sufficient to cause substantial language deficits. This explains how some children with poor nonword repetition skills can still have normal range word learning/vocabulary skills. Within Gathercole’s framework, it is poor phonological storage plus restrictions in supporting cognitive resources, most notably working memory, that are posited to lead to language learning difficulties. As she notes, there is empirical support for the notion that children with SLI display deficits in verbal working memory compared to normal language peers, as measured by a variety of tasks (e.g., Ellis Weismer, Evans, & Hesketh, 1999; Montgomery, 2000). Ellis Weismer and Thordardottir (2002) reported that nonword repetition and listening span (working memory task) were significant unique predictors of language abilities (as measured by a standardized language test) in a group of second
graders who had a wide range of nonverbal cognitive and language abilities. It is noteworthy that the listening span measure accounted for substantially more variance in language scores than nonword repetition performance in this sample. Despite the fact that children with SLI, as a group, demonstrate both phonological storage and working memory difficulties, not all children with SLI display poor nonword repetition (Ellis Weismer et al., 2000), nor do all children with SLI exhibit verbal working memory deficits on other measures (Ellis Weismer et al., 1999; Ellis Weismer & Thordardottir, 2002).

Several investigators have discussed the heterogeneity of SLI and hypothesized that there may be different underlying causal factors for various subgroups of children (Bishop, Carlyon, Deeks, & Bishop, 1999; Ellis Weismer, 2004, 2005; Tomblin, Zhang, Weiss, Catts, & Ellis Weismer, 2004). For instance, research suggests speech perception deficits (Stark & Heinz, 1996) and slowed processing speed (Miller, Kail, Leonard, & Tomblin, 2001; Windsor & Hwang, 1999) are primarily linked to receptive–expressive SLI rather than expressive-only SLI. In a recent longitudinal investigation, Catts, Adolf, Hogan, and Ellis Weismer (2005) examined the relationship between SLI and dyslexia in a population-based sample of school-age children. Findings from that study suggest that comorbidity with dyslexia may account in large part for the poor nonword repetition performance displayed by most children with SLI. Children diagnosed with SLI who did not also meet the criteria for dyslexia displayed only mild problems with nonword repetition. Rather than attempting to identify one primary cognitive process that is believed to be implicated in language learning deficits, it may be important to consider the possibility that there are different underlying factors for different subgroups.

In conclusion, this seminal paper by Gathercole (2006) brings together many different strands of research on nonword repetition. It points the way to further empirical work, as well as to the need for more explicit and complex models of the processes involved in both nonword repetition and word learning, particularly in relation to SLI.

REFERENCES


Our understanding of the relationship between verbal short-term memory as indexed by nonword repetition and word learning must now incorporate myriad factors that were not as apparent 17 years ago when Gathercole and Baddeley (1989) proposed that “the phonological memory skills tapped by nonword repetition play a causal role in vocabulary development” (p. 211). In particular, successful nonword repetition involves more than the phonological loop, word learning happens by degrees and is influenced by many factors other than phonology, and children with specific language impairment (SLI), who have served as test cases by virtue of consistently demonstrating phonological memory deficits, often exhibit other deficits with the potential to negatively impact word learning. Gathercole (2006) still makes the case for temporary phonological storage playing an important role in word learning, but with several caveats. I would like to add two.

First, when assessing the relationship between the ability to repeat nonwords and vocabulary acquisition, it is important to distinguish between studies using extant vocabulary and those teaching new words to children. Our research examining the initial stage of word learning, known as fast mapping, has generally not found a significant relationship between nonword repetition and fast mapping in young children with SLI. Gray (2004) assessed fast mapping comprehension and production in 20 preschoolers with SLI who were age and gender matched to children with typical development (TD). On the nonword repetition task (Dollaghan & Campbell, 1998) the TD group repeated significantly more nonwords than the SLI group, and comprehended significantly more words on the fast mapping task, but receptive vocabulary and expressive phonology predicted fast mapping comprehension. Similarly, Gray (in press) studied fast mapping in 53 young children (3–6 years) diagnosed with SLI and 53 children with TD matched for age and gender to the SLI group. The TD group scored significantly higher than the SLI group on nonword repetition at ages 3, 4, 5, and 6; but only the 5-year-old TD group outperformed the SLI group on fast mapping comprehension and production. Age