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Short-term memory for serial order supports vocabulary development: New evidence from a novel word learning paradigm

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ABSTRACT

Although recent studies suggest a strong association between short-term memory (STM) for serial order and lexical development, the precise mechanisms linking the two domains remain to be determined. This study explored the nature of these mechanisms via a microanalysis of performance on serial order STM and novel word learning tasks. In the experiment, 6- and 7-year-old children were administered tasks maximizing STM for either item or serial order information as well as paired-associate learning tasks involving the learning of novel words, visual symbols, or familiar word pair associations. Learning abilities for novel words were specifically predicted by serial order STM abilities. A measure estimating the precision of serial order coding predicted the rate of correct repetitions and the rate of phoneme migration errors during the novel word learning process. In line with recent theoretical accounts, these results suggest that serial order STM supports vocabulary development via ordered and detailed reactivation of the novel phonological sequences that characterize new words.

Introduction

An increasing literature is showing that verbal short-term memory (STM), and especially STM for serial order, is closely associated with lexical development. The underlying hypothesis is that short-term retention abilities for sequential information support vocabulary development by facilitating

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learning of the phonological forms of new words during the initial learning stage, when the novel word form is first encountered. However, evidence for this mainly comes from studies correlating performance on STM tasks with general estimates of receptive vocabulary knowledge that confound phonological, lexical, and semantic levels of knowledge. The aim of this study was to provide direct evidence for a link between serial order STM capacities and learning abilities for novel word forms in children and to gain a deeper insight into the mechanisms that determine this link.

A number of studies have explored the link between verbal STM capacity and vocabulary development, showing a consistent association between estimates of verbal STM, as measured by nonword repetition tasks, and vocabulary knowledge, especially in younger children (e.g., Avons, Wragg, Cupples, & Lovegrove, 1998; Gathercole, Willis, Baddeley, & Emslie, 1994; Gathercole, Willis, Emslie, & Baddeley, 1992; Service, 1992). The difficulty, however, is to clearly understand the factors that drive this association. Typically, a verbal STM task requires immediate repetition of sequences of familiar or unfamiliar verbal information, with the sequences containing either multiple items (e.g., word list immediate serial recall) or single items of variable length (e.g., multisyllabic nonword repetition). In the framework of the phonological loop model, the association between performance on STM tasks and vocabulary development is considered to reflect the importance of temporary phonological storage capacity for forming new long-term phonological lexical representations (e.g., Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1989). Studies showing that performance in nonword repetition tasks predicts performance on novel word learning tasks in young children are supportive of this assumption (Gathercole, Hitch, Service, & Martin, 1997). However, the difficulty here is that verbal STM tasks do not simply reflect the capacity of a specialized STM system but also are, at the same time, influenced by language knowledge. Immediate serial recall tasks using word stimuli lead to higher performance levels than tasks using nonwords, suggesting that lexical knowledge contributes to short-term recall, either indirectly via redintegration processes of the decayed STM trace during retrieval (e.g., Hulme, Maughan, & Brown, 1991; Schweickert, 1993) or directly via stabilizing feedback activation between language and STM systems during all STM stages (e.g., Baddeley et al., 1998; Martin, Lesch, & Bartha, 1999). Similarly, at the sublexical level, subtle knowledge about statistical properties of sound co-occurrences for the native language phonology leads to a recall advantage for nonwords containing frequent phonotactic patterns relative to nonwords with less frequent phonotactic patterns (Gathercole, Frankish, Pickering, & Peaker, 1999; Majerus & Van der Linden, 2003; Majerus, Van der Linden, Mulder, Meulemans, & Peters, 2004; Thorn & Frankish, 2005). Finally, at a semantic level, it has also been shown that semantic knowledge supports immediate serial recall of word lists (Majerus & D'Argembeau, 2011; Poirier & Saint-Aubin, 1996; Walker & Hulme, 1999). This implies that traditional STM tasks reveal at least as much about language processing as they do about STM processing; thus, the association between performance on STM and performance on vocabulary measures could be a by-product of the fact that both measures reflect the level of development of the language system (see also Fowler, 1991; Metsala, 1999).

Therefore, it is important to ensure that the impact of language knowledge on verbal STM tasks is controlled for when studying links between verbal STM and lexical development. It has recently been shown that this can be achieved by distinguishing between item and serial order components in verbal STM tasks. The item component refers to the phonological and lexico-semantic characteristics of the items within a list of memoranda, whereas the serial order component refers to the serial position of the items within the list. Importantly, item recall is known to be affected by lexical and semantic variables, but recall of serial order information is much less affected by these (e.g., Majerus & D'Argembeau, 2011; Nairne & Kelley, 2004; Poirier & Saint-Aubin, 1996; Saint-Aubin & Poirier, 2005). Similarly, impaired language representations in patients with acquired brain lesion lead to poor item recall but not to poor serial order recall (Attout, Van der Kaa, George, & Majerus, 2012; Majerus, Norris, & Patterson, 2007). Finally, neuroimaging studies also show that temporary maintenance of verbal item information actively recruits language processing neural networks in bilateral temporal gyri, whereas temporary maintenance of serial order information recruits a distinct neural network involving the intraparietal sulci (Fiebach, Friederici, Smith, & Swinney, 2007; Majerus, Poncelet, Van der Linden, et al., 2006; Majerus et al., 2010; Marshuetz, Smith, Jonides, DeGutis, & Chenevert, 2000). These data suggest that short-term storage of item information involves temporary activation of long-term verbal representations in the language network, whereas this is not the case for