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Evaluating the developmental trajectory of the episodic buffer component of working memory and its relation to word recognition in children

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ABSTRACT

The creation of temporary bound representation of information from different sources is one of the key abilities attributed to the episodic buffer component of working memory. Whereas the role of working memory in word learning has received substantial attention, very little is known about the link between the development of word recognition skills and the ability to bind information in the episodic buffer of working memory and how it may develop with age. This study examined the performance of Grade 2 children (8 years old), Grade 3 children (9 years old), and young adults on a task designed to measure their ability to bind visual and auditory–verbal information in working memory. Children's performance on this task significantly correlated with their word recognition skills even when chronological age, memory for individual elements, and other possible reading-related factors were taken into account. In addition, clear developmental trajectories were observed, with improvements in the ability to hold temporary bound information in working memory between Grades 2 and 3, and between the child and adult groups, that were independent from memory for the individual elements. These findings suggest that the capacity to temporarily bind novel auditory–verbal information to visual form in working memory is linked to the development of word recognition in children and improves with age.

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Introduction

Working memory provides temporary maintenance of information necessary to support complex cognitive processing. There is now considerable evidence that working memory abilities develop throughout childhood (Case, Kurland, & Goldberg, 1982), with potentially important implications for academic attainment (Gathercole & Alloway, 2008; Gathercole, Brown, & Pickering, 2003; Jarvis & Gathercole, 2003) and, more specifically, for reading development (e.g., Swanson & Ashbaker, 2000; Swanson, Zheng, & Jerman, 2009; Wang & Gathercole, 2013). Alloway, Gathercole, and Pickering (2006); see also Bayliss, Jarrold, Gunn, & Baddeley, 2003) found that children's performance on working memory tasks was best captured by the Baddeley and Hitch (1974) tripartite model that sets out phonological and visuospatial short-term stores and a central executive control resource, with each of these components showing clear improvements from 4 years of age. Storage capacity and central executive control are classically measured by simple and complex span tasks. Whereas simple span tasks require only the passive retention of information, complex span tasks involve simultaneous storage and processing of information. As indexed by such measures, close links between working memory capacity and development of different aspects of reading skills have been well established, including visual word recognition (e.g., Swanson & Ashbaker, 2000; Wang & Gathercole, 2013) and text comprehension (e.g., Cain, Oakhill, & Bryant, 2004; Daneman & Carpenter, 1980).

More recently, Baddeley (2000) argued for a fourth component of working memory, termed the episodic buffer, that was intended to capture the binding of information from different sources, both within and between modalities. Although this component has recently been investigated in young adults (e.g., Allen, Hitch, & Baddeley, 2009; Baddeley, Allen, & Hitch, 2011; Baddeley, Hitch, & Allen, 2009) and clinical populations (e.g., Allen, Vargha-Khadem, & Baddeley, 2014; Jeneson, Mauldin, & Squire, 2010), it is less clear how the ability to effectively bind together different types of information might relate to reading development and how it develops with age. For current purposes, our specific focus is on the development of visual word recognition skills as a factor that is closely associated with reading development. Examining this issue is of considerable value, particularly given that learning visual to phonological mappings has previously been suggested to be important in developing word recognition abilities (e.g., Hulme, Goetz, Gooch, Adams, & Snowling, 2007). The current study, therefore, attempted to explore how the ability to create temporary bound representation in working memory may be associated with the development of word recognition skills in children and how this ability develops throughout childhood and into young adulthood.

The episodic buffer component was assumed by Baddeley (2000) to comprise a storage capacity based on a multidimensional code that can be used to integrate information from specialized phonological and visuospatial subsystems and to interface with long-term memory. This buffer may serve as a storage and modeling space that is informed by, but is separable from, the specialized subsystems and long-term memory (e.g., Allen, Havelka, Falcon, Evans, & Darling, in press; Baddeley, 2012; Langerock, Vergauwe, & Barrouillet, 2014) and may form an important stage in long-term episodic learning (Baddeley, 2003). Consistent with this, children's performance on short-term feature-binding tasks intended to index the episodic buffer have been found to associate with their development of long-term episodic memory (Picard, Cousin, Guillery-Girard, Eustache, & Piolino, 2012). A range of either conjunctive or relational binding tasks that require participants to make recognition or recall judgments concerning simple combinations of features within domains (Allen, Baddeley, & Hitch, 2006, 2014), between verbal and spatial domains (Langerock et al., 2014; Morey, 2009), and across modalities (Allen et al., 2009) have been intensively used to investigate this component. Conjunctive or intrinsic binding (e.g., of shape and color within an object) may be relatively low level and perceptual in nature, possibly accomplished by specialized visuospatial processing before being consciously retained within the episodic buffer. In contrast, relational or extrinsic binding (Ecker, Maybery, & Zimmer, 2013; Parra et al., 2015) of elements from different domains or modalities may particularly require the episodic buffer for their formation and retention, as implied by Baddeley's (2000) original proposal. Therefore, for current purposes, episodic buffer capacity was indexed by a task in which temporary creation and maintenance of bound visual and phonological information were needed.