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The episodic buffer in children with intellectual disabilities: An exploratory study

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ABSTRACT

Performance on three verbal measures (story recall, paired associated learning, category fluency) designed to assess the integration of long-term semantic and linguistic knowledge, phonological working memory and executive resources within the proposed 'episodic buffer' of working memory (Baddeley, 2007) was assessed in children with intellectual disabilities (ID). It was hypothesised that children with ID would show equivalent performance to typically developing children of the same mental age. This prediction was based on the hypothesis that, despite poorer phonological short-term memory than mental age matched peers, those with ID may benefit from more elaborate long-term memory representations, because of greater life experience. Children with ID were as able as mental age matched peers to remember stories, associate pairs of words together and generate appropriate items in a category fluency task. Performance did not, however, reach chronological age level on any of the tasks. The results suggest children with ID perform at mental age level on verbal 'episodic buffer' tasks, which require integration of information from difference sources, supporting a 'delayed' rather than 'different' view of their development.

The episodic buffer of working memory (Baddeley, 2000; Baddeley, 2007) is proposed as a limited capacity storage system responsible for integrating information from several sources to create a unified memory, sometimes referred to as a single 'episode'. The episodic buffer does this by "binding" information from the various systems of working memory (e.g. phonological loop, visuospatial sketch pad) and relevant activated long-term semantic and linguistic knowledge, into a coherent whole. The episodic buffer can also act as a "mental modelling space, allowing one to set up representations that might guide future actions" (Baddeley & Wilson, 2002, p. 1738).

The current paper is concerned with the integration/binding of linguistic and semantic long-term knowledge with information from the "slave" verbal storage system, the phonological loop, during verbal episodic remembering and thinking tasks. It provides an exploratory investigation of whether the functioning of the episodic buffer in children with intellectual disabilities (IQ below 70, associated adaptive and daily living difficulties) is at a level commensurate with their mental age. Children with ID were compared to comparison groups of typically developing children matched for chronological and mental age. Such groups allow the evaluation of three competing cognitive accounts of ID: (1) according to the 'developmental' model, children with mixed aetiology familial ID should obtain mental age-appropriate levels of performance on cognitive tasks, as their cognitive development is delayed rather than different in comparison with typical controls (Zigler, 1969); (2) evidence for below mental age level performance on cognitive tasks supports the 'difference' model, that cognitive development in those with ID is different to those with typical development (Ellis, 1969; Milgram,

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1973); and (3) evidence for 'optimal performance' is found when levels of performance in those with ID approach chronological age level (Burack & Zigler, 1990).

A small literature is developing on the episodic buffer in typically developing children. For example, it has been claimed that the episodic buffer is a separate component of working memory that can be reliably identified. Alloway, Gathercole, Willis, and Adams (2004) used 'recall of spoken sentences' to assess integration of phonological short-term memory representations with relevant long-term language knowledge. They argued that this measure tapped a distinct component of working memory in 4–6-year-old children (i.e. the episodic buffer), which was separable from the phonological loop and the central executive; although the three components were somewhat related. Others have suggested that the proposed *automatic* binding mechanisms in the episodic buffer, responsible for integrating information from different sources, may mature relatively early in typically developing children (possibly as young as 6 years, Sluzenski, Newcombe, & Kovacs, 2006). Experimental work in support of this conclusion has concerned tasks such as the binding of visual object and spatial information (Cowan, Naveh-Benjamin, Kilb, & Saults, 2006), verbal paired associate recognition (Shing, Werkle-Bergner, Li, & Lindenberger, 2008), and memory for combinations of complex photographs of animals in variable backgrounds (Sluzenski et al., 2006). There is also evidence that different tasks assessing episodic buffer functioning may assess common processes. Sluzenski et al. (2006) looked at the relationship between picture association and story remembering, finding modest correlations between the two tasks (about .40). This could be interpreted as evidence in favour of a general episodic buffer component which binds information from different sources together, regardless of exact content.

Although many authors investigating memory performance generally in children with ID (Weiss, Weisz, & Bromfield, 1986) and phonological short-term memory, in particular, have reported *below mental age level* abilities (Henry & MacLean, 2002; Henry & Winfield, 2010; Hulme & Mackenzie, 1992; Van der Molen, Van Luit, Jongmans, & Van der Molan, 2007), episodic buffer functioning may be *as good as* children matched for mental age in children with ID. If automatic binding processes mature early in typically developing children, this implies that these skills are not greatly influenced by developmental factors and may be relatively spared in children with ID. Perhaps more importantly, children with ID are likely to have *greater* levels of semantic and linguistic long-term knowledge to support episodic remembering, than children matched for mental age, who are necessarily younger and have less life experience. It is proposed that greater long-term knowledge might compensate children with ID for their weaker phonological short-term memory on tasks which require the integration of information from both of these sources in the proposed episodic buffer of working memory. There is some corroborating evidence that the knowledge base of individuals with ID is more extensive than that of typically developing mental age matched controls (Lukose, 1987; Numminen, Service, & Ruoppila, 2002).

Therefore, three verbal recall/thinking tasks, hypothesised to require the binding of information from phonological short-term memory with activated semantic and linguistic knowledge from long-term memory were employed in the present study. All tasks were necessarily indirect measures of the proposed episodic buffer, as no clearly agreed methodologies exist for assessing the episodic buffer independently.

The first task was *prose recall*. In order to recall a passage of text coherently, it is necessary to utilise long-term knowledge about the structure of language, vocabulary, content of the passage and the structure of typical narratives or scripts. This information must be integrated with memory traces from the phonological loop, and "modality free" representations held in the episodic buffer. Storage in the phonological loop alone is insufficient to support prose recall. The episodic buffer is hypothesised to create a "novel episode", by combining primed or activated representations from long-term memory with information in the phonological loop, drawing on executive resources to maintain this new representation (Baddeley & Wilson, 2002). Therefore, all participants recalled short, but coherent, stories from a standardised children's memory battery (Test of Memory and Learning, TOMAL, Reynolds & Bigler, 1994). This immediate story recall task is directly analogous to that used by Baddeley and Wilson (2002) in their study of densely amnesic patients (i.e. 'logical memory' from the Wechsler Memory Scale).

The second task was *paired associate learning* from the TOMAL (Reynolds & Bigler, 1994). Participants were asked to learn to associate pairs of words over several trials (e.g. bite-name); and half of the items were already associated (e.g. stove-cook), so long-term knowledge should have been even more likely to aid learning. Performance on this task can be hypothesised to reflect the capacity of the phonological store, activated long-term knowledge about the meanings of words and potential associations between them, the quality of the integrated "novel episode" created by the episodic buffer, and the efficiency the relevant executive processes recruited to maintain this representation. Some earlier papers on paired associate learning in ID provide relevant background to the current study. For example, Winters, Attlee, and Harvey (1974) found that teenagers with ID (provided they were non-institutionalised) were as able to use long-term knowledge as typically developing children of the same mental age in picture paired associate task (see also Cantor & Ryan, 1962). However, the IQs of participants in the Winters et al. (1974) study were only assessed with a receptive vocabulary test, and those with IQs over 70 do not appear to have been excluded. The current study employed two of the three full subscales from the British Ability Scales II (Elliott, 1996) to obtain more reliable estimates of IQ, and only included children with ID who had IQs of 70 and below.

The final task was category fluency. Fluency or 'generation' tasks are often discussed in the context of executive processing (e.g. Bishop & Norbury, 2005), but in addition to requiring executive skills to coordinate the search for relevant exemplars and inhibit items that have already been selected, category fluency relies on lexical access: specifically, accessing stored long-term semantic knowledge about which items belong to particular categories (Fisk & Sharp, 2004). Category fluency, therefore, may be a good example of the interface between central executive resources and links to semantic memory via the episodic buffer. Existing evidence suggests that verbal fluency may be at mental age level in those with ID,