



## Grouping, semantic relation and imagery effects in individuals with Down syndrome



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### ABSTRACT

Down syndrome (DS) is associated with a specific verbal short-term memory (STM) deficit. This study explored the effects of grouping, semantic relations and visual presentation upon verbal STM recall performance in a group of 15 individuals with DS and 15 vocabulary-matched typically developing (TD) children. Participants were presented with memoranda in either a temporally grouped schedule, such that items were grouped as pairs, or in an equally spaced presentation schedule. The two items constituting each pair were either semantically related or unrelated. Performance across these conditions was compared in verbal or verbal plus visual presentation modes. Significant memory recall benefits were observed across populations as a result of temporal grouping, semantic relations and verbal and visual combined presentation. However, a reduced benefit of semantic relation in the DS group compared to the TD group indicated that those with DS were less influenced by LTM relational knowledge. In addition, those with DS only experienced a grouping benefit during verbal and visual combined presentation, in contrast to the TD group who experienced grouping benefits throughout. This indicates that individuals with DS are poorer at encoding temporal context for purely verbal memoranda. These findings were replicated in a follow-up experiment, aimed at aligning baseline performance in the two populations. This study provides encouraging evidence that, despite their difficulties in some areas, individuals with DS can benefit from the use of grouping and LTM knowledge to assist their verbal STM performance under certain circumstances.

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Verbal short-term memory (STM) is responsible for the short-term storage and maintenance of verbal input such as words and digits. Associations between individuals' verbal STM performance and the development of vocabulary acquisition, comprehension and syntax are well established (Baddeley, Gathercole, & Papagno, 1998; Baddeley, Papagno, & Vallar, 1988; Ellis & Sinclair, 1996; Vallar & Baddeley, 1984). In turn, this has driven research seeking training routes to enhance memory performance. Recent memory training programmes have primarily aimed at improving the broader concept of working memory, e.g., CogMed ([www.cogmed.com](http://www.cogmed.com)), that is, individuals' ability to store and simultaneously process information, be it verbal or visual. The relevance of such work follows from the fact that working memory is implicated in various wider abilities such as mathematics and reading ability (Gathercole, Pickering, Knight, & Stegmann, 2004; Leather & Henry, 1994). Nevertheless, given the role of verbal STM in driving aspects of language development, understanding how one might

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improve verbal STM performance specifically is also extremely relevant for populations known to experience particular problems in the language domain.

One population among whom verbal STM tends to be specifically poor is those with Down syndrome (DS). Individuals with DS experience varying degrees of general learning difficulties. Nonetheless, verbal STM is a domain in which, as a group, specific difficulty is consistently displayed, with performance on verbal STM tasks being significantly poorer to that observed in comparable visual STM tasks, as well as significantly poorer than the performance of matched control groups, be they typically developing, or individuals with other learning difficulties (Brock & Jarrold, 2005; Hulme & Mackenzie, 1992; Jarrold & Baddeley, 1997; Jarrold, Baddeley, & Hewes, 2000; Jarrold, Cowan, Hewes, & Riby, 2004; Laws & Bishop, 2003; Vicari, Marotta, & Carlesimo, 2004).

Verbal STM has a limited capacity (Cowan, 2001; Miller, 1956), according to Cowan (2010) this capacity is limited to around 3–5 chunks in typical adults. However, the amount individuals are able to recall during STM tasks can also vary according to other factors regarding the given recall circumstances, one being the structure or organisation of the items presented for recall. For example, it has long been known that presenting memoranda with grouping imposed on the items using perceptual separation, such as by separating items by temporal pauses, results in benefits to recall in typically developing groups. Such perceptual grouping effects are observed in both adults (Bower & Winzenz, 1969; Frankish, 1995; Maybery, Parmentier, & Jones, 2002; Melkman, Tversky, & Baratz, 1981; Ryan, 1969), and children (Harris & Burke, 1972), including pre-schoolers (Calfee, 1969). It has been suggested by Farrell (2012) that clusters (or groups) provide a hierarchical temporal context; recalling the context consequently helps an individual to recall the items within that group context. In this sense, grouping divides the verbal sequence into separate sub-sequences, such that individuals can process coarse temporal context for each cluster and a finer temporal context for the items constituting each cluster. Such a hierarchical structure allows for organised encoding and retrieval of items. This notion is also compatible with working memory models such as Burgess and Hitch's (1992) connectionist model, which invokes the concept of a context timing signal (see also Burgess, 1995). In Burgess' (1995) model the 'context' is defined using the metaphor of a moving window, with item nodes forming temporary associations with other items nodes in that same window (shared context). Hence, temporally grouping items at presentation may lead to enhancements in performance, as discussed above, as a result of structured, hierarchically organised encoding and recall of items.

Grouping may be a useful strategy for individuals with DS to adopt given that they experience verbal STM difficulties and appear to have a reduced verbal STM capacity (Purser & Jarrold, 2005). One possibility is that a lack of strategic grouping may be a contributing factor to the consistent finding of poor verbal STM performance in this population. Spontaneous grouping tendencies for memoranda (that are not readily grouped at presentation), do not appear to develop in typically developing children until they reach around 8 or 9 years of age (Towse, Hitch, & Skeates, 1999). It is possible that similarly, without instruction, individuals with DS may not develop spontaneous grouping strategies for unstructured verbal input, given their mental age. Thus, for young children (and possibly individuals with DS) who would otherwise struggle to spontaneously group verbal memoranda it may be particularly useful to provide grouped structure at input. As such, temporally structured presentation of input may induce organised encoding and recall. Previous studies have attempted to actively train individuals with DS to enhance their organisational memory strategies, observing subsequent benefits (Broadley & MacDonald, 1993; Broadley, MacDonald, & Buckley, 1994), with skills maintained at a later date, but appearing to be gains only on the specifically trained tasks. While individuals with DS therefore appear to benefit from organisational instructions, to our awareness, no existing studies have explored the nature of possible grouping benefits in individuals with DS simply by presenting memoranda in a format that can be readily organised into perceptual groups.

The first aim of the current study was therefore to explore whether individuals with DS benefit from grouped presentation of memoranda. This was done by measuring recall performance for lists of items presented at a temporally grouped rate, such that pairs (groups) were presented with the temporal interval between each pair being longer than the interval occurring between the two items constituting the pair. Recall for such stimuli was compared to that for items presented within a non-temporally grouped (equal) schedule. A benefit of grouped presentation would indicate that individuals with DS spontaneously make use of the pre-grouped format of the memoranda, storing and retrieving the items in memory according to the temporally grouped organisation. If recall performance is enhanced for those with DS, then this would have implications for the presentation of materials in educational settings.

The effect of temporal grouping upon those with DS was therefore compared to that seen in a typically developing (TD) matched control group of children. If individuals' encoding and recall potential reflects a developmental progression, then one might expect that individuals with DS will benefit from temporal grouping to a similar degree to that of a vocabulary matched control group of TD children. However, given the specific verbal STM problems experienced by those with DS, whereby they tend to perform poorer on tests of verbal serial recall than matched controls, it may be that the temporally grouped presentation does not enhance recall for those with DS to the extent expected for their mental age. For example, the specific verbal STM deficit observed in those with DS may be due to differential processing of the verbal input, such that temporal structure is processed or encoded in a way that is not equivalent to their TD peers.

Another factor that supports verbal STM span performance in TD groups is the top-down influence of existing knowledge of the memoranda held in long-term memory (LTM). For instance, in immediate serial recall tasks concrete words are recalled better than abstract words (Paivio, Clark, & Khan, 1988), and high frequency words better than low frequency words (Roodenrys, Hulme, Lethbridge, Hinton, & Nimmo, 2002). Typically, individuals are able to remember more items during STM tasks when the items are meaningful (Caza & Belleville, 1999; Graf & Schacter, 1989; Poirier, Dhir, Saint-Aubin, Tehan, &

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