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Visuospatial support for verbal short-term memory in individuals with Down syndrome

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ABSTRACT

Individuals with Down syndrome (DS) tend to have impaired verbal short-term memory (STM), which persists even when visual support is provided for carrying out verbal tasks. *Objective*: The current study aims to investigate whether visuospatial support, rather than just visual, can compensate for verbal STM deficits in these individuals. The performance of 25 children and adolescents with DS (mean age = 12.5, SD = 3.8) on five word span tasks was compared with that of two groups of typically developing children, matched for mental age ($N = 25$; mean age = 6.0, SD = .2) and for receptive vocabulary ($N = 25$; mean age = 4.0, SD = .8). Four of the five tasks varied in terms of input and output – verbal and/or visual – and the fifth task included a spatial component in addition to visual input and output. DS individuals performed equally bad in the pure verbal task and in those with visual components; however, there was a significant improvement when the spatial component was included in the task. The mental age matched group outperformed DS individuals in all tasks except for that with the spatial component; the receptive vocabulary matched group, outperformed DS individuals only in the pure verbal task. We found that visuospatial support improves verbal STM in individuals with DS. This result may have implications for intervention purposes.

1. Introduction

Short-term memory (STM) refers to the ability to maintain a limited amount of information activated in mind for a short period of time. It is the memory that we use, for example, when we are to make a phone call; the numerical sequence is activated in our mind until we reach the telephone and dial the number, and then, the information fades away.

Separate systems are thought to deal with short-term storage of verbal and visuospatial information (Baddeley & Hitch, 1974). Individuals with Down syndrome (DS), for instance, tend to have impaired verbal STM with relatively preserved visuospatial STM (Baddeley & Jarrold, 2007; Jarrold & Baddeley, 2001).

In general, verbal STM is assessed by means of a digit span (or word span) task, in which the examinee must repeat a list of numbers (or words) in the same order provided by the examiner. Visuospatial STM, on the other hand, is commonly assessed by the Corsi span task, in which the examiner taps blocks arranged visuospatially in random sequence and participants must reproduce the block tapping in the same order. DS children and adolescents show impairment in digit span but not in Corsi

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span tasks, when compared to typically developing children (Azari et al., 1994; Jarrold & Baddeley, 1997; Jarrold, Baddeley, & Hewes, 2000).

DS individual's impairment in digit span tasks persists even when visual support is provided to complete the task. In other words, verbal STM deficits are not reduced when digits or words are presented visually (Broadley, MacDonald, & Buckley, 1995; Marcell, Harvey, & Cothran, 1988), or when response to the task is given by pointing numbers or pictures representing the digits or words listened, eliminating the need to provide a verbal response (Brock & Jarrold, 2005; Marcell & Weeks, 1988).

On dealing with nameable pictures, e.g. drawings, typically developing children between the ages of 5 and 8 progress from using no obvious strategy to using visual encoding, then to the use of both visual and verbal codes, and finally to a mature state where more efficient verbal encoding is preferred (Palmer, 2000). However, there are no similar studies on individuals with DS. One might expect that visual strategies could be used to compensate for the marked verbal STM deficit; however, the above mentioned studies do not support this hypothesis whereas performance in verbal tests does not improve when either input or output is visual.

To our knowledge, no study has investigated whether spatial strategies can compensate for verbal STM deficits in DS. Recent studies show that this might be the case: Laws (2002) demonstrated that visual STM is only minimally preserved in individuals with DS, and discussed that the unimpaired Corsi span performance found in this population might be due to the spatial component of the task, rather than the visual one. Moreover, there are indications that the visuospatial ability preserved in DS individuals is their capacity for spatial sequencing (Lanfranchi, Carretti, Spanò, & Cornoldi, 2009).

Verbal STM is crucial for language development and vocabulary acquisition (Baddeley, Gathercole, & Papagno, 1998) and is important for day-to-day activities by keeping task goals actively in mind (Miyake, Emerson, Padilla, & Ahn, 2004). Intervention programs for individuals with DS commonly focus on training verbal STM in order to increase verbal span (Broadley & MacDonald, 1993; Conners, Rosenquist, Arnett, Moore, & Hume, 2008; Conners, Rosenquist, & Taylor, 2001).

Therefore, finding ways to improve verbal span can be useful for efficient intervention. This study investigated whether visuospatial support, rather than just visual support, could compensate for the verbal STM deficits encountered in individuals with DS. Five word span tasks, using the same words – or drawings to represent the words – were created. Four of the five tasks varied in terms of input and output, which could be either verbal and/or visual; the fifth test contained a spatial component in addition to the visual input and output.

The aim of this experiment was to understand the interaction among different input/output modalities in verbal STM tasks for each group of individuals, with and without DS.

2. Method

2.1. Participants

Twenty-five individuals (9 girls) diagnosed with Down syndrome (DSGROUP), who used verbal language as means of communication, were evaluated and compared with two different groups of typically developing children (MENTALAGE and VOCAB), containing 25 individuals each.

Sixteen participants from the DSGROUP were enrolled in regular schools and nine in special-needs schools. DSGROUP and MENTALAGE were paired by mental age, as derived from their intelligence quotient (IQ) and chronological age; DSGROUP and VOCAB were paired by receptive vocabulary, as measured by their scores on the Peabody picture vocabulary test (PPVT – Brazilian version).

Participant's ages ranged from 7 to 18 years old (mean = 12.5, SD = 3.8) in the DSGROUP, from 6 to 7 years old (mean = 6.0, SD = .05) in the MENTALAGE and from 3 to 5 years old (mean = 4.0, SD = .8) in the VOCAB group.

2.2. Instruments

2.2.1. IQ

The Wechsler Intelligence Scale for Children (WISC-III) (Wechsler, 2002) and the Wechsler Adult Intelligence Scale (WAIS-III) (Wechsler, 2004) were used to measure IQ for individuals from DSGROUP and MENTALAGE groups according to their age. Mental age calculus derived from each participant's IQ and chronological age, i.e. mental age = (IQ * chronological age)/100.

2.2.2. Vocabulary

The Brazilian version of the PPVT (Dunn & Dunn, 1981) was used to assess receptive vocabulary. In this test, four pictures are shown, the examiner states a word describing one of the pictures and participants must point to the correct one. Score was given in terms of number of correct responses.

2.2.3. Short-term memory

Standard verbal and visuospatial short-term memory tasks and other five novel tasks, created specifically for this study, were applied.

2.2.3.1. Standard short-term memory tasks. Forward digit span (Wechsler, 2002) and forward Corsi span tasks (Lezak, 1995) were used to asses verbal and visuospatial STM, respectively. In the digit span test, subjects must repeat a series of digits