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Working memory studies among individuals with intellectual disability: An integrative research review

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ABSTRACT

Background: Integrative research review infers generalizations about a substantive subject, summarizes the accumulated knowledge that research has left unresolved and generates a new framework on these issues. Due to methodological issues emerging from working memory (WM) studies in the population with non-specific intellectual disability (NSID) (N = 64) between 1990–2014, it is difficult to conclude on WM performance in this population.
Aim: This integrative research review aimed to resolve literature conflicts on WM performance among individuals with NSID and to identify the conditions/moderators that govern their WM performance compared to controls with Typical development.
Method/procedure: We used the six stages of integrative research review: problem formulation, data collection, evaluation, data analysis, results, interpretation and discussion.
Outcomes and results: The findings indicate two types of moderators that determine WM performance in the population with NSID: Participants' moderators (criteria for matching the ID and TD groups, CA and MA), and **task** moderators [the three WM components of Baddeley and Hitch's (1974) model and task load]. Only an interaction between the two moderators determines WM performance in this population. The findings indicate a hierarchy (from more to less preserved) in WM performance of individuals with NSID: The visuospatial tasks, then some of the executive functions tasks, and the phonological loop tasks being less preserved. Furthermore, at a low level of control, the performance of participants with NSID was preserved beyond the modality and vice versa.
Conclusions and implications: Modality and MA/intelligence determine WM performance of individuals with ID. Educators should prepare intervention programs take the impact of the two moderators into account.

1. Introduction

"Working memory refers to a broad framework of interacting processes that involve the temporary storage and manipulation of information in the service of performing complex cognitive activities" (Baddeley, Allen, & Hitch, 2011, p. 1393).

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It evolved from the earlier concept of short-term memory (STM), from which it differs by emphasizing the functional importance of the system and by replacing a unitary store with a multicomponent system (Baddeley & Hitch, 1974).

Scientists are in disagreement on whether WM per se explains fluid intelligence (Garlick & Sejnowski, 2006) and whether the working memory (WM) capacity is associated with fluid intelligence (*g*) (Conway et al., 2005; Garlick & Sejnowski, 2006; Kane & Engle 2002). Baddeley (2000) (and in Baddeley et al., 2011) claimed that "Attention and temporary storage, are themselves unchanged by learning, other than indirectly via the crystallized systems". Kane and Engle (2002) stated that the "Executive attention, is the psychological core of the statistical construct of general fluid intelligence, or psychometric Gf (page 638)".

It has been documented that WM is associated with cognitive skills such as problem solving, reasoning and academic achievements (Bayliss, Jarrold, Baddeley, & Leigh, 2005; Hitch & McAuley, 1991) as well as with everyday life skills such as reading, writing, arithmetic, and language (Gathercole, Alloway, Willis, & Adams, 2004; Numminen, Service, & Ruoppila, 2002) which enable an independent life. Thus, the importance of WM in the population with intellectual disability) is thus self-evident (Van der Molen, Luit, Van de Molen, & Jengmans, 2011).

The most widely recognized model of WM is that of Baddeley and Hitch (1974) and Baddeley (2003, 2008). This model assumes a limited capacity controller, the central executive, supported by two temporary slave systems, the phonological loop and the visuospatial sketchpad. *The phonological loop* involves the temporary storage of phonological auditory information and is comprised of two sub-systems: The phonological store and the sub-vocal rehearsal process (Schuchardt, Maehler, & Hasselhorn, 2011). The *visuospatial sketchpad* is assumed to be capable of holding and manipulating visual and spatial information. The use of spatial imagery in immediate recall is disrupted by tasks such as tracking a moving object (Baddeley, Thomson, & Buchanan, 1975), while memory for pattern and shape is disrupted by the passive processing of line drawings, or even colour patches (Logie & Pearson, 1997; Logie, 1986). *The central executive* is involved in conditions of high level processing, including a set of high level attentional cognitive abilities such as planning, attention, inhibition and shifting (Baddeley et al., 2011; Camos & Barrouillet, 2014). A neutral modality storage, the episodic buffer, has recently been proposed (Baddeley et al., 2011), which is assumed to be a temporary multidimensional store that forms an interface between the subsystems of WM, long-term memory (LTM) and the central executive. Its major function is to bind different sources of information into integrated chunks (Baddeley et al., 2011). The phonological loop, the visuospatial sketchpad and the central executive were examined broadly in the population with ID, whereas the episodic buffer was examined in only one study (Henry, 2010), and will therefore not be included in the present review.

Cornoldi, Rigoni, Venneri, and Vecchi (2000) argued that Baddeley's model cannot by itself explain WM performance patterns of individuals with ID. Cornoldi and Vecchi (2003) suggested a double '*Horizontal and vertical continuum*' model. The *horizontal continuum* relates to the above-mentioned components of Baddeley et al.'s (2011) model. The *vertical continuum* reflects the required degree of control which is defined by the amount of active processing necessary for manipulating the information maintained in a temporary memory system ranging from passive to active tasks (Cornoldi & Vecchi, 2003), i.e. the cognitive load inherent in the task. Some tasks that measure the articulatory loop or visuospatial sketchpad simply require remembering the material as it was presented, and involve a low level of control, while other tasks require a high level of control. The concept of cognitive load raised by Cornoldi and Vecchi (2003) parallels the concept of attention and cognitive load suggested by Camos and Barrouillet (2014). They define cognitive load as the duration of attentional capture divided by the total time of performing the task.

Scientists are interested in the question of whether WM is domain-specific or domain-general (Baddeley & Logie, 1999). In their time-based resource-sharing model, Camos and Barrouillet (2014) argue that domain-general resources are responsible for processing and storage and that attention is involved in both. They claim two systems that are involved in the maintenance of verbal information: the phonologica loop and the executive loop. The phonological loop is less attention-demanding (primary memory according to Unsworth & Engel, 2007) and involves the recalling of simple verbal tasks (i.e., digit span forward). The executive loop involves manipulation of the task in addition to just recalling, and demands a higher level of attention according to the tasks (inhibition, selecting, etc.).

Use of the phonological loop makes recall sensitive to the phonological characteristics of the material to be maintained, whereas the phonological nature of the memory items does not affect recall performance under the use of the executive loop. This does not imply that the executive loop is a "better" system of maintenance that should always be favored for verbal information. Because attentional refreshing is more attention-demanding than sub-vocal rehearsal, the former is very sensitive to the availability of attention and the presence of concurrent attention-demanding tasks. Attention is involved in both the retention of information and in processing activities. The capacity of the focus of attention appears clearly when verbal rehearsal is prevented, suggesting that maintenance of verbal information through attentional focusing and verbal rehearsal must be distinguished. Brain imaging studies reported distinct neural structures supporting the separation of these two loops.

As far as we know, only one study tapped the effect of cognitive load on WM performance among individuals with Down syndrome versus peers with typical development (TD) with the same mental age (MA) (Lanfranchi, Cornoldi, & Vianello, 2004). It was found that in tasks requiring a low level of control, children with Down syndrome showed impairment of verbal but not visuospatial WM tasks. As the requirement for control increased, they showed greater impairment on both tasks. The above study implies the need to examine the effect of cognitive load in WM tasks among individuals with non-specific

ID (NSID). In this integrative review we examined the effect of the level of control on WM performance among individuals with NSID beyond modality.

1.1. Cognitive profile of individuals with NSID

Individuals with ID are a heterogeneous group in their IQ level, etiology and associated disorders. Poor language competence (Fink & Cegelka, 1982), lack of verbal rehearsal and reduced ability to retrieve stored information (Hulme & Mackenzie, 1992) are common. They exhibit lack of cognitive strategies in dealing with problems, as well as in the use of meta-cognitive strategies (Borkowski, Carr, & Pressley, 1987), difficulties in shifting flexibly from one strategy to another (Campione & Brown, 1984), attention deficit (Reed, 1996), and lack of automatic identification of presented stimuli (Ellis, 1978). They also exhibit inefficient STM (Ellis, 1978). Some of the studies found equal WM performance in the population with ID compared to participants with TD (Danielsson, Henry, Rönnberg, & Nilsson, 2010; Henry, 2001; Van der Molen, Van Luit, Jongmans, & Van der Molen, 2007), whereas others found lower WM performance (Alloway, 2010; Conners, Carr, & Willis, 1998; Hartman, Houwen, Scherder, & Visscher, 2010; Hasselhorn & Mähler, 2007; Henry & MacLean, 2002; Van der Molen, Van Luit, Jongmans, & Van der Molen, 2009; Van der Molen, Van Luit, Van der Molen, & Jongmans, 2010; Willner, Bailey, Parry, & Dymond, 2010). The question is whether there is a general "law" which dictates the equal or lower performance of the population with ID compared to the population with TD.

1.2. Integrative research review

"Integrative research review infers generalizations about a substantive subject from a set of studies bearing on the same issues" (Cooper, 1982, p. 438; Randolph, 2009; Torraco, 2005). "Its goal is to summarize the accumulated knowledge regarding the relation (s) of interest, highlight important issues, critiques, synthesize representative literature that research has left unresolved and generate a new framework on these issues" (Torraco, 2005; p. 3). Several methodological issues emerge from the WM studies we reviewed, which make it difficult to draw definitive conclusions. Some focus on the phonological loop, some on the visuospatial sketchpad and others on executive function tasks. Furthermore, different intelligence tests were used for matching between groups. There is also a lack of distinction between ID levels, and different WM tests were used for measuring the same skills. The goal of this review was to resolve literature conflicts on WM performance among individuals with ID and to identify the conditions/moderators that govern their WM performance compared to controls with TD.

One might argue that conducting a meta-analysis on WM studies in the population with ID is the best method for answering this question. Lifshitz, Stein, Weiss and Vakil (2011) published a meta-analysis of 40 explicit memory studies of three etiologies with ID. The explicit memory of individuals with ID was found to be poorer than in controls with TD with the same chronological age (CA) or mental age (MA). Relatively preserved explicit memory performance was found among individuals with Williams syndrome compared to Down syndrome. Cohen (1988, 1992) argued that a 'summary effect' could mask findings that are insufficient to alter the generalizations, but might hold important qualitative data that are potentially significant for rehabilitational and educational purposes. The meta-analysis revealed poorer performance in recall and recognition in verbal and visual tasks. However, examining each study separately revealed that recognition and free recall in the visual modality were preserved in some of the studies (Dulaney & Ellis, 1991; Perrig & Perrig, 1995). Using a different methodology – an integrative research review (Lifshitz-Vahav & Vakil, 2014), we elucidated the underlying moderators of preserved/impaired explicit memory studies. We suggested a taxonomy of moderators related to the participants and the tasks, where only an interrelation between the two dictates memory performance in the population with ID.

We shall review WM studies in the population with NSID from 1990. Until that time, memory studies in the population with ID focused only on STM (Atkinson & Shiffrin, 1968, 1971; Baddeley, 2000). The concept of WM was introduced to the field of ID only in the 1990s. The theoretical foundations of this integrative review were the vertical and horizontal WM models (Cornoldi & Vecchi, 2003). The **horizontal** model relates to the components of Baddeley's model: The phonological loop, the visuospatial sketchpad, and the executive function, whereas the **vertical** model relates to the level of control required in the task from passive to active manipulation in each component (Baddeley et al., 2011).

The operative goals were: (a) To find the WM phenotype in each component of Baddeley's model among participants with NSID. Put differently, we aimed to find the moderators that influence WM performance in Baddeley's model. Lifshitz and Vakil (2014) found the "picture superiority effect" in explicit memory studies among individuals with ID. That is, none of the verbal explicit tasks yielded equal performance of individuals with ID compared to those with TD. Based on the above we hypothesized that participants with NSID would exhibit relatively more preserved visual WM tasks compared to phonological loop tasks. (b) To examine the effect of cognitive load in WM tasks beyond modality. We hypothesized that WM performance in the population with NSID would vary according to the cognitive load of the task. Performance would decrease with increasing cognitive load.

2. Method

We conducted a computerized search of articles on ID published between 1990 and 2014 in journals that focus on memory and cognition and in journals that focus on ID, using the PsycNET database, Dissertation Abstracts International, the

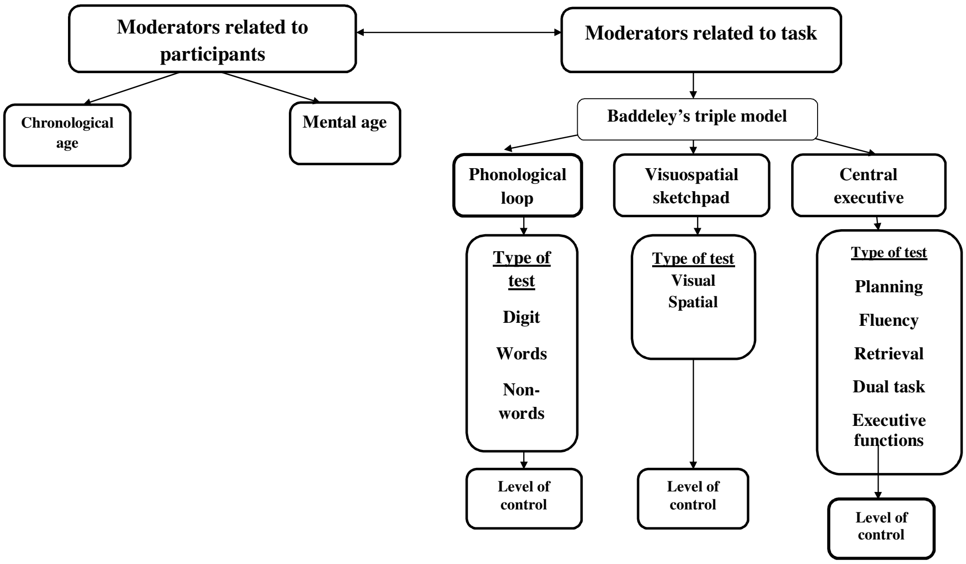


Fig. 1. Taxonomy of moderators that influence working memory in a population with ID.

Social Science Citation Index, ERIC, Webspires, Proquest, Ebsco, and Google Scholar. Keywords were "short term memory," "working memory," "phonological loop," "visuospatial sketchpad," "executive function," "mental retardation" or "intellectual disability"; and "non-specific ID or etiology." Inclusion criteria were: studies of individuals with ID without other disabilities such as autism or mental illness; IQ ranging from mild to moderate ID; samples larger than a case study; a control group of individuals with TD; studies that included statistical analyses or presented means and standard deviations.

The search yielded 64 studies (157 experiments) of WM in the population with NSID, which were conducted between 1990 and 2014. Only 15% ($n = 10$) were conducted in 1990–1999, while 85% ($n = 54$) were conducted in 2001–2011. Thus, WM research in this population is still relatively young.

Some of the studies conducted several experiments in the same study using different modalities and tests. Each of these was considered an experiment. Table 1 presents the distribution of WM experiments in the population with NSID according to Baddeley and Hitch (1974) and Baddeley et al.'s (2011) model.

The following conclusions emerge from the table: 15% ($n = 10$) of the studies focused on children aged 5–12; 70% ($n = 44$) on adolescents aged 12–21; and only 15% ($n = 10$) on adults aged 21–50. Thus, adolescents are currently at the focus of WM studies in the population with NSID. 43% ($n = 68$) of the experiments focused on the phonological loop; 21% ($n = 32$) on the visuospatial sketchpad; and 37% ($n = 57$) on the central executive.

2.1. Procedure

An integrative research review includes six stages (Cooper, 1982; Randolph, 2009; Torraco, 2005): (1) problem formulation; (2) data collection; (3) data evaluation; (4) data analysis; (5) presentation of results; and (6) interpretation and discussion. We used a double factor model that we used previously for examining explicit LTM studies in the population with ID (Lifshitz & Vakil, 2014), albeit with adaptation to WM studies: Moderators related to **background characteristics of participants** (criteria for matching the ID and TD groups, CA and MA), and moderators related to the **task** (the three components of Baddely et al.'s (2011) model: the phonological loop, the visuospatial sketchpad and executive function). The tentative moderators used in this integrative review are presented in Fig. 1. We triangulated (Randolph, 2009) between the moderators in order to find their involvement when memory was preserved or impaired. In cases of contradictory results for the same moderators, we re-read the articles to find other moderators that might influence performance. In addition, we counted the number of preserved/impaired experiments in each component. Based on the above, we constructed a table which relates to the hierarchy of the WM tasks in the components in Baddeley's model (Baddeley & Hitch, 1974) (from more to less preserved). It should be noted that the content of the tasks is different in each component, but we compared the number of preserved/impaired performances in each component beyond type of task. Furthermore, this is an integrative research review which is a kind of qualitative study (Randolph, 2009; Torraco, 2005) with different goals than a meta-analysis. As stated earlier (p. 7), a 'summary effect' could ignore findings that which might hold important qualitative data that are potentially significant for rehabilitation and educational purposes (Cohen, 1988; 1992). Therefore, our WM hierarchy tasks table does not take the sample size and effect size into account, but is based on percentage which was found to be a reliable measure in our previous integrative research review (Lifshitz-Vahav & Vakil, 2014). We then attempted to integrate the results. In the discussion we interpreted the results and placed them in a theoretical framework.

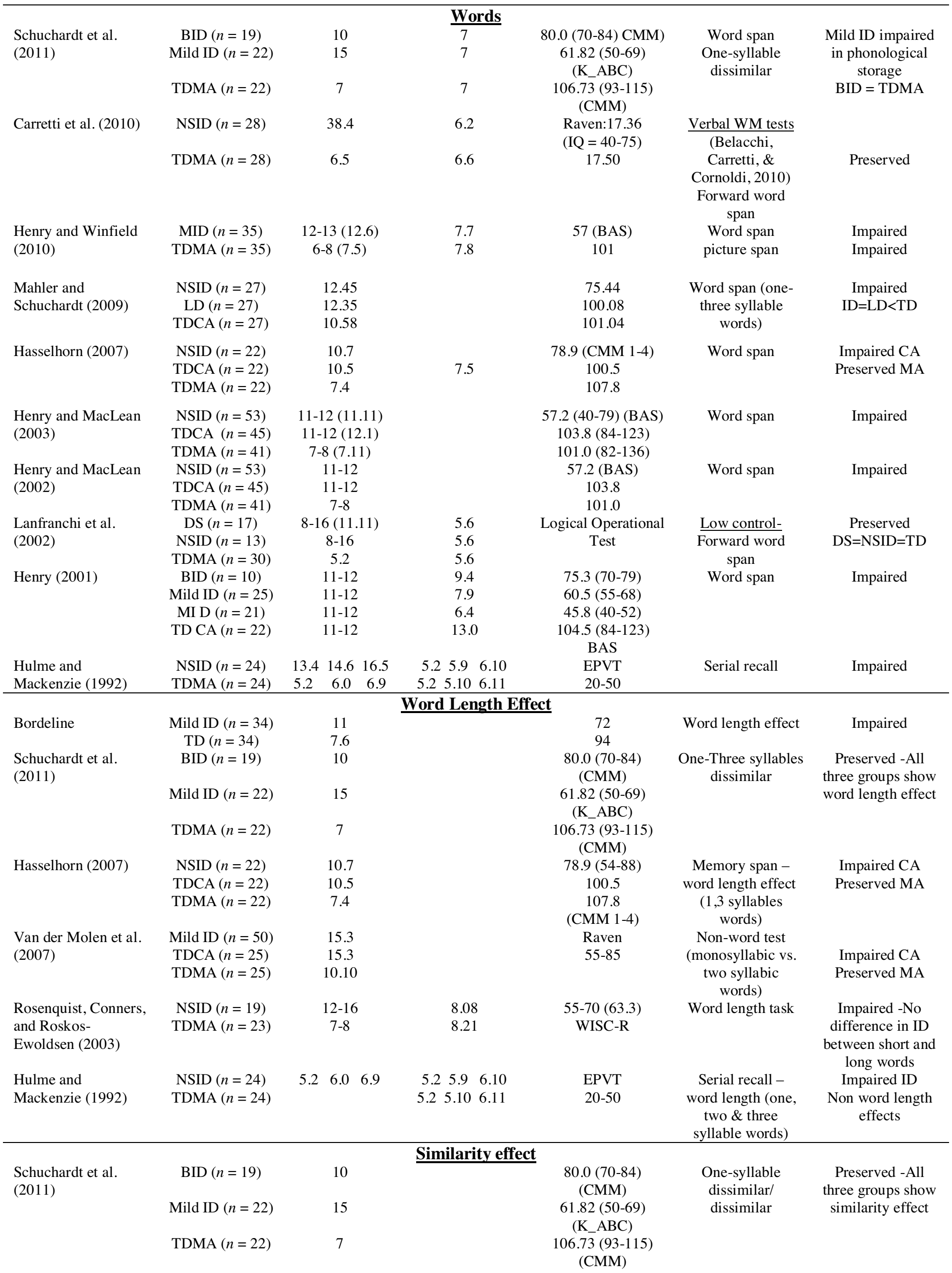
2.2. Findings

Table 1 presents the results of the three components of WM among individuals with NSID. Table 2 relates to the hierarchy of the WM tasks in the three components. The findings will be presented according to the three components, and moderators related to both participants and tasks will be discussed.

Table 1
Phonological loop, visuospatial span and central executive experiments among participants with NSID, compared to participants with TD matched by CA, MA and/or IQ: tests and findings (Alloway, Gathercole, & Pickering, 2007; Baddeley, 1997; Belacchi, Carretti, & Cornoldi, 2010; Bellugi, Lichtenberger, Jones, Lai, & St George, 2000; Danielsson, Henry, Messer, & Rönnberg, 2012; Gathercole, 1999; Gathercole, Adams, & Hitch, 1994; Gathercole & Alloway, 2006; Gunn & Crombie, 1996; Hulme, Maughan, & Brown, 1991; Lanfranchi, Carretti et al., 2009; Lanfranchi, Cornoldi et al., 2009; Laws, 2002; Levén, Lyxell, Andersson, Danielsson, & Rönnberg, 2008; Levén, Lyxell, Andersson, Danielsson, & Rönnberg, 2011; Maehler & Schuchardt, 2009; McCarthy, 1972; Merighi, Edison, & Zigler, 1990; Miller, 1992; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001; Nash & Heath, 2011; Numminen, Service, Ahonen, & Ruoppila, 2001; O'Hearn, Courtney, Street, & Landau, 2009; Pazzaglia & Cornoldi, 1999; Piaget, 1970; Pickering & Gathercole, 2001; Poloczek, Büttner, & Hasselhorn, 2014; Porter, Coltheart, & Langdon, 2007; Rondal, 1996; Schuchardt, Gebhardt, & Mähler, 2010; Vicari, Bellucci, & Carlesimo, 2003; Vicari, Bellucci, & Carlesimo, 2005; Vicari, Carlesimo, & Caltagirone, 1995; Wang & Bellugi, 1994; Wechsler, 1967).

Article name	Group	CA	MA	IQ	Working measures/The test and the modality	Results
			Digit			
Leken et al. (2011)	Mild ID (*n* = 10)	275		85-11	Digit forward	Impaired
	TD (*n* = 5)	27		50-70		
Numminen et al. (2002)	NSID (*n* = 24)	49.88		Raven	Digit Span Forward Task	
	TDMA (*n* = 24)	5.650 (3-6)		Equal fluid intelligence		preserved
Numminen et al. (2001)	NSID (*n* = 24)	38-58 (49.88)	5.63	Raven	Digit span forward	Preserved
	TDMA (*n* = 24)	3-6 (5.50)	5.67			
Conners, Carr, and Willis (1998)	NSID (*n* = 30)	11.72	7.45	66.58 (WISC-R verbal)	Forward digit span	Impaired CA Preserved MA CA>ID=MA
	TDCA (*n* = 30)					
	TDVMA (*n* = 26)	12.36		107.42		
		7.45	7.45	106.77		
Vicari et al. (1995)	DS (*n* = 15)	16.6	5.3	36 Leiter	Forward digit span	Preserved
	NSID (*n* = 14)	16.7	51	39		
	TDMA (*n* = 24)	5.7	5.5	101		
Henry and Winfield (2010)	MID (*n* = 35)	12-13 (12.6)	7.7	57	digit span	Impaired
	TDMA (*n* = 35)	6-8 (7.5)	7.8	101		
Schuchardt, Gebhardt, and Maehler (2010)	BID (*n* = 15)	15		British Ability S. 82.63 (70-84)	Memory span for digit	Impaired
	MID (*n* = 15)	15		61.82 (50-69) (K_ABC)		
	TDCA (*n* = 25)	15		109.80 (90-115)		
	BID (*n* = 19)	10		81.21 (CMMS)		
	TDMA (*n* = 22)	7		104.91		
Van der Molen et al. (2010)	Mild ID (*n* = 39)	13-17	118.1	65 (55-75) (WISC_R)	Digit Recall (Baddeley, 2008)	Preserved MA Impaired Ca
	TDCA (*n* = 39)	13-16	182.6	99.8		
	TDMA (*n* = 26)	9-12	120.7	97.1		
Maehler and Schuchardt (2009)	NSID (*n* = 27)	12.45		75.44	Digit span	Impaired ID=LD<TD
	LD (*n* = 27)	12.35		100.08		
	TDCA (*n* = 27)	10.58		101.04		
Van der Molen et al. (2009)	Mild ID (*n* = 49)	13-17		WISC-III	Digit Recall	Impaired CA Preserved MA
	TDCA (*n* = 39)	13-16		55-85		
	TDMA (*n* = 29)	8-12				
Van der Molen et al. (2007)	Mild ID (*n* = 50)	15.3		Raven	Digit span	Impaired CA and MA
	TDCA (*n* = 25)	15.3		55-85		
	TDMA (*n* = 25)	10.10				
Bayliss et al. (2005)	ID\LD (*n* = 50)	13.6 (10.1-16.3)	7.5	55.32 (27.72-69.89)	Digit span	Impaired
	TDVMA (*n* = 50)	7.3 (5.5-9.1)	7.5	102.36 (80.81-129.17)		
Henry and MacLean (2003)	NSID (*n* = 53)	11-12(11.11)		BPVS-II 57.2 (40-79)	Digit span	Preserved
	TDCA (*n* = 45)	11-12 (12.1)		103.8 (84-123)		
	TDMA (*n* = 41)	7-8 (7.11)		101.0 (82-136)		
Henry and MacLean (2002)	NSID (*n* = 53)	11-12		57.2 (BAS)	Digit span	Preserved MA Impaired CA
	TDCA (*n* = 45)	11-12		103.8		
	TDMA (*n* = 41)	7-8		101.0		
Henry (2001)	BID (*n* = 10)	11-12	9.4	75.3 (70-79)	Digit span	Impaired
	Mild ID (*n* = 25)	11-12	7.9	60.5 (55-68)		
	MI D (*n* = 21)	11-12	6.4	45.8 (40-52)		
	TD CA (*n* = 22)	11-12	13.0	104.5 (84-123)		
Hulme et al. (1991)	NSID (*n* = 55)	19.1 (9.9-38.2)	6.3	20-50	ITPA auditory sequential memory test – digit span Longitudinal study after 2 and 5 years	Impaired
	TDMA (*n* = 55)	6.0 (4.2-8.4)	6.0			

Table 1 (*Continued*)



Words						
Schuchardt et al. (2011)	BID (*n* = 19)	10	7	80.0 (70-84) CMM)	Word span	Mild ID impaired in phonological storage
	Mild ID (*n* = 22)	15	7	61.82 (50-69) (K_ABC)	One-syllable dissimilar	
	TDMA (*n* = 22)	7	7	106.73 (93-115) (CMM)		BID = TDMA
Carretti et al. (2010)	NSID (*n* = 28)	38.4	6.2	Raven:17.36 (IQ = 40-75)	Verbal WM tests (Belacchi, Carretti, & Cornoldi, 2010) Forward word span	
	TDMA (*n* = 28)	6.5	6.6	17.50		Preserved
Henry and Winfield (2010)	MID (*n* = 35)	12-13 (12.6)	7.7	57 (BAS)	Word span	Impaired
	TDMA (*n* = 35)	6-8 (7.5)	7.8	101	picture span	Impaired
Mahler and Schuchardt (2009)	NSID (*n* = 27)	12.45		75.44	Word span (one-three syllable words)	Impaired ID=LD<TD
	LD (*n* = 27)	12.35		100.08		
	TDCA (*n* = 27)	10.58		101.04		
Hasselhorn (2007)	NSID (*n* = 22)	10.7		78.9 (CMM 1-4)	Word span	Impaired CA
	TDCA (*n* = 22)	10.5	7.5	100.5		Preserved MA
	TDMA (*n* = 22)	7.4		107.8		
Henry and MacLean (2003)	NSID (*n* = 53)	11-12 (11.11)		57.2 (40-79) (BAS)	Word span	Impaired
	TDCA (*n* = 45)	11-12 (12.1)		103.8 (84-123)		
	TDMA (*n* = 41)	7-8 (7.11)		101.0 (82-136)		
Henry and MacLean (2002)	NSID (*n* = 53)	11-12		57.2 (BAS)	Word span	Impaired
	TDCA (*n* = 45)	11-12		103.8		
	TDMA (*n* = 41)	7-8		101.0		
Lanfranchi et al. (2002)	DS (*n* = 17)	8-16 (11.11)	5.6	Logical Operational Test	Low control- Forward word span	Preserved DS=NSID=TD
	NSID (*n* = 13)	8-16	5.6			
	TDMA (*n* = 30)	5.2	5.6			
Henry (2001)	BID (*n* = 10)	11-12	9.4	75.3 (70-79)	Word span	Impaired
	Mild ID (*n* = 25)	11-12	7.9	60.5 (55-68)		
	MI D (*n* = 21)	11-12	6.4	45.8 (40-52)		
	TD CA (*n* = 22)	11-12	13.0	104.5 (84-123) BAS		
Hulme and Mackenzie (1992)	NSID (*n* = 24)	13.4 14.6 16.5	5.2 5.9 6.10	EPVT	Serial recall	Impaired
	TDMA (*n* = 24)	5.2 6.0 6.9	5.2 5.10 6.11	20-50		
Word Length Effect						
Bordeline	Mild ID (*n* = 34)	11		72	Word length effect	Impaired
	TD (*n* = 34)	7.6		94		
Schuchardt et al. (2011)	BID (*n* = 19)	10		80.0 (70-84) (CMM)	One-Three syllables dissimilar	Preserved -All three groups show word length effect
	Mild ID (*n* = 22)	15		61.82 (50-69) (K_ABC)		
	TDMA (*n* = 22)	7		106.73 (93-115) (CMM)		
Hasselhorn (2007)	NSID (*n* = 22)	10.7		78.9 (54-88)	Memory span – word length effect (1,3 syllables words)	Impaired CA
	TDCA (*n* = 22)	10.5		100.5		Preserved MA
	TDMA (*n* = 22)	7.4		107.8 (CMM 1-4)		
Van der Molen et al. (2007)	Mild ID (*n* = 50)	15.3		Raven	Non-word test (monosyllabic vs. two syllabic words)	
	TDCA (*n* = 25)	15.3		55-85		Impaired CA
	TDMA (*n* = 25)	10.10				Preserved MA
Rosenquist, Conners, and Roskos-Ewoldsen (2003)	NSID (*n* = 19)	12-16	8.08	55-70 (63.3)	Word length task	Impaired -No difference in ID between short and long words
	TDMA (*n* = 23)	7-8	8.21	WISC-R		
Hulme and Mackenzie (1992)	NSID (*n* = 24)	5.2 6.0 6.9	5.2 5.9 6.10	EPVT	Serial recall – word length (one, two & three syllable words)	Impaired ID
	TDMA (*n* = 24)		5.2 5.10 6.11	20-50		Non word length effects
Similarity effect						
Schuchardt et al. (2011)	BID (*n* = 19)	10		80.0 (70-84) (CMM)	One-syllable dissimilar/ dissimilar	Preserved -All three groups show similarity effect
	Mild ID (*n* = 22)	15		61.82 (50-69) (K_ABC)		
	TDMA (*n* = 22)	7		106.73 (93-115) (CMM)		

Table 1 (*Continued*)

Hasselhorn (2007)	NSID (*n* = 22)	10.7		78.9 (54-88)	Memory span – phonological similarity effect (one syllables similar/dissimilar)	Preserved – similarity in the phonological similarity effect
	TDCA (*n* = 22)	10.5		100.5		
	TDMA (*n* = 22)	7.4		107.8 (CMM 1-4		
Rosenquist et al. (2003)	NSID (*n* = 19)	12-16	8.08	55-70 (63.3)	Phonological similarity test (Hulme et al., 1991)	Preserved
	TDMA (*n* = 23)	7-8	8.21			
Hulme and Mackenzie (1992)	NSID (*n* = 24)	13.4 14.6 16.5	5.2 5.9 6.10	EPVT	Memory span test for acoustically similar and dissimilar words	Impaired
	TDMA (*n* = 24)	5.2 6.0 6.9	5.2 5.10 6.11			
			Non-Words			
Schuchardt et al. (2011)	BID (*n* = 19)	10	7	80.0 (70-84) (CMM)		Mild ID impaired in phonological storage BID = TDMA
	Mild ID (*n* = 22)	15	7	61.82 (50-69) (K_ABC)	Nonword repetion (2,3,4 syllabes)	
	TDMA (*n* = 22)	7	7	106.73 (93-115) (CMM)		
Schuchardt et al. (2010)	BID (*n* = 15)	15		82.63 (70-84)	One-syllable non-words	Impaired
	MID (*n* = 15)	15	7.1	61.82 (50-69)		
	TDCA (*n* = 25)	15		109.80 (90-115)	Non-word repetition	Impaired
	BID (*n* = 19)	10	7.1	81.21		
	TDMA (*n* = 22)	7	7.1	104.91		
Van der Molen et al. (2010)	Mild ID (*n* = 39)	13-17	118.1	65 (55-75) (WISC-III)	Non word recall	Impaired
	TDCA (*n* = 39)	13-16	182.6	99.8		
	TDMA (*n* = 26)	9-12	120.7	97.1		
Maehler and Schuchardt (2009)	NSID (*n* = 27)	12.45		75.44	Non-word repetition	Impaired ID=LD<TD
	LD (*n* = 27)	12.35		100.08		
	TDCA (*n* = 27)	10.58		101.04		
Van der Molen et al. (2009)	Mild ID (*n* = 49)	13-17		55-85 (WISC-III)	Non Word Recall	Impaired MA and CA
	TDCA (*n* = 39)	13-16				
	TDMA (*n* = 29)	8-12				
Hasselhorn (2007)	NSID (*n* = 22)	10.7		78.9 (CMM 1-4)	Non word repetition (2-4 syllables)	Impaired CA
	TDCA (*n* = 22)	10.5	7.5	100.5		Preserved MA
	TDMA (*n* = 22)	7.4		107.8		
Van der Molen et al. (2007)	Mild ID (*n* = 50)	15.3		Raven	Non word test	Impaired CA
	TDCA (*n* = 25)	15.3		55-85		Impaired MA
	TDMA (*n* = 25)	10.10				
Numminen et al. (2002)	NSID (*n* = 24)	49.88		Raven	Non Word Repetition task	Impaired
	TDMA (*n* = 24)	5.650 (3-6)		Equal fluid intelligence	Non Word Span Task	Impaired
Numminen et al. (2001)	NSID (*n* = 24)	38-58 (49.88)	5.63	Raven	Finish non word task	Impaired
	TDMA (*n* = 24)	3-6 (5.50)	5.67			
			Visual-Object			
Henry and Winfield (2010)	MID (*n* = 35)	12-13 (12.6)	7.7	57	Pattern span	Preserved in same mental age
	TDMA (*n* = 35)	6-8 (7.5)	7.8	101		
Van der Molen et al. (2010)	Mild ID (*n* = 39)	13-17	118.1	65 (55-75)	Visual pattern tests (Della Sala,1997)	Preserved MA
	TDCA (*n* = 39)	13-16	182.6	99.8		Impaired CA
	TDMA (*n* = 26)	9-12	120.7	97.1		
Maehler and Schuchardt (2009)	NSID (*n* = 27)	12.45		75.44	matrix span simple	Impaired
	LD (*n* = 27)	12.35		100.08		
	TD (*n* = 27)	10.58		101.04	matrix span complex	Impaired
Van der Molen et al. (2009)	Mild ID (*n* = 49)	13-17			Visual patterns test	Impaired CA
	TDCA (*n* = 39)	13-16				preserved MA
	TDMA (*n* = 29)	8-12				
Henry and MacLean (2003)	NSID (*n* = 53)	11-12 (11.11)		57.2 (40-79)	Pattern span	Impaired CA
	TDCA (*n* = 45)	11-12 (12.1)		103.8 (84-123)		Preserved MA
	TDMA (*n* = 41)	7-8 (7.11)		101.0 (82-136)		
Rosenquist et al. (2003)	NSID (*n* = 19)	12-16	8.08	55-70 (63.3)	Visual complexity task	Preserved
	TDMA (*n* = 23)	7-8	8.21		Visual similarity task	Preserved
Henry and MacLean (2002)	NSID (*n* = 53)	11-12		57.2 BAS	Pattern span	Preserved MA
	TDCA (*n* = 45)	11-12		103.8		ID>MA
	TDMA (*n* = 41)	7-8		101.0		Impaired CA
Henry (2001)	BID (*n* = 10)	11-12	9.4	75.3 (70-79)	Pattern span	Impaired MIQ & mild ID
	Mild ID (*n* = 25)	11-12	7.9	60.5 (55-68)		

Table 1 (*Continued*)

	MI D ($n = 21$)	11-12	6.4	45.8 (40-52)		Preserved BIQ
	TD CA ($n = 22$)	11-12	13.0	104.5 (84-123)		
Visual-Spatial						
Henry and Winfield (2010)	MID ($n = 35$)	12-13 (12.6)	7.7	57	Spatial span	Preserved in same mental age
	TDMA ($n = 35$)	6-8 (7.5)	7.8	101		
Schuchardt et al. (2010)	BID ($n = 15$)	15		82.63 (70-84)	Memory span for locations	preserved
	MID ($n = 15$)	15		61.82 (50-69)		
	TDCA ($n = 25$)	15		109.80 (90-115)	Corsi block simple	Preserved in the same mental age
	BID ($n = 19$)	10		81.21		
	TDMA ($n = 22$)	7		104.91	Corsi block complex	Preserved in the same mental age
Van der Molen et al. (2010)	Mild ID ($n = 39$)	13-17	118.1	65 (55-75)	Block recall=Corsi	
	TDCA ($n = 39$)	13-16	182.6	99.8		Impaired
	TDMA (n = 26	9-12	120.7	97.1		
Maehler and Schuchardt (2009)	NSID ($n = 27$)	12.45		75.44	Memory span for locations	Impaired
	LD ($n = 27$)	12.35		100.08		
	TD ($n = 27$)	10.58		101.04	Corsi-block simple Corsi block complex	Preserved Impaired ID=LD<TD
Van der Molen et al. (2009)	Mild ID ($n = 49$)	13-17			Corsi blocks task	Impaired MA & CA
	TDCA ($n = 39$)	13-16				
	TDMA ($n = 29$)	8-12				
Bayliss et al. (2005)	ID\LD ($n = 50$)	13.6 (9.10-16.3)	7.5	55.32 (27.72-69.89) BPVS-II	Corsi span	Impaired
	TDVMA ($n = 50$)	7.3 (5.5-9.1)	7.5	102.36 (80.81-129.17)		
Henry and MacLean (2003)	NSID ($n = 53$)	11-12 (11.11)		57.2 (40-79)	Visuo-spatial span	preserved
	TDCA ($n = 45$)	11-12 (12.1)		103.8 (84-123)		
	TDMA ($n = 41$)	7-8 (7.11)		101.0 (82-136)		
Henry and MacLean (2002)	NSID ($n = 53$)	11-12		57.2 BAS	Spatial span (Corsi)	Preserved MA
	TDCA ($n = 45$)	11-12		103.8		ID>MA
	TDMA ($n = 41$)	7-8		101.0		Impaired CA
Numminen et al. (2002)	NSID ($n = 24$)	49.88		Raven	Corsi Blocks Task	Impaired
	TDMA ($n = 24$)	5.650 (3-6)				
Henry (2001)	BID ($n = 10$)	11-12	9.4	75.3 (70-79)	Spatial span	Impaired MIQ & mild ID
	Mild ID ($n = 25$)	11-12	7.9	60.5 (55-68)		
	MI D ($n = 21$)	11-12	6.4	45.8 (40-52)		Preserved BIQ
	TD CA ($n = 22$)	11-12	13.0	104.5 (84-123)		
Numminen et al. (2001)	NSID ($n = 24$)	38-58 (49.88)	5.63	Raven	Corsi block	Impaired
	TDMA ($n = 24$)	3-6 (5.50)	5.67			
Vicari et al. (1995)	NSID ($n = 14$)	16.7	51	39	Forward visuo-spatial task – Corsi blocks	Preserved DS & ID
	TDMA ($n = 24$)	5.7	5.5	101		
Central Executive Visuospatial						
Alloway (2010)	BID ($n = 39$)	7.11-11.7 $M = 9.8$		70-85 $M = 77$	WM (AWMA Alloway, et al, 2007)	
	TDCA ($n = 39$)	8.1-11.11		99-133 $M = 118$ WASI	Spatial span Odd-one-out	Impaired Impaired Impaired
Henry and Winfield (2010)	MID ($n = 35$)	12-13 (12.6)	7.7	57	Odd one out span	Preserved in same mental age
	TDMA ($n = 35$)	6-8 (7.5)	7.8	101		Associated with number skills
Leken et al. (2011)	Mild ID ($n = 10$)	275		85-11	Picture spam	Impaired
	TD ($n = 5$)	27		50-70	More complex	Impaired
					Photos	Impaired
					Drawing	Impaired
					Objects	Impaired
					Faces	Impaired
Van der Molen et al. (2010)	Mild ID ($n = 39$)	13-17	118.1	65 (55-75) (FIQ)	Odd-One-Out (Henry 2001)	Preserved MA
	TDCA ($n = 39$)	13-16	182.6	99.8		Impaired CA #
	TDMA ($n = 26$)	9-12	120.7	97.1		
Van der Molen et al. (2009)				VIQ PIQ	Out-One-Out	Impaired CA
	Mild ID ($n = 49$)	13-17		68.6 71.9		Preserved MA
	TDCA ($n = 39$)	13-16		98.6 98.5		
	TDMA ($n = 29$)	8-12		100.5 97.7		
Henry and MacLean (2003)	NSID ($n = 53$)	11-12 (11.11)		57.2 (40-79)	0dd-one-out-span	Preserved MA
	TDCA ($n = 45$)	11-12 (12.1)		103.8 (84-123)		
	TDMA ($n = 41$)	7-8 (7.11)		101.0 (82-136)		
Henry and MacLean (2002)	NSID ($n = 53$)	11-12		57.2	Odd one out	Preserved MA
	TDCA ($n = 45$)	11-12		103.8		impaired CA
	TDMA ($n = 41$)	7-8		101.0		

Table 1 (*Continued*)

Henry (2001)	BID (*n* = 10)	11-12	9.4	75.3 (70-79)	Odd one out	Impaired
	Mild ID (*n* = 25)	11-12	7.9	60.5 (55-68)		
	MI D (*n* = 21)	11-12	6.4	45.8 (40-52)		
	TD CA (*n* = 22)	11-12	13.0	104.5 (84-123)		
Vicari et al. (1995)	NSID (*n* = 14)	16.7	51	39	Backward visuo-spatial task	Preserved ID=TD
	TDMA (*n* = 24)	5.7	5.5	101		
			Phonological Executive			
Alloway (2010)	BID (*n* = 39)	7.11-11.7 (9.8)		70-85 *M* = 77	Backwards digit recall	Impaired
	TDCA (*n* = 39)	8.1-11.11		99-133 *M* = 118	Listening recall	Impaired
				WASI	Counting recall	Impaired
Schuchardt et al. (2010)	BID (*n* = 15)	15		82.63 (70-84)	Backward digit span	Impaired CA-preserved MA
	MID (*n* = 15)	15		61.82 (50-69)		
	NSTD (*n* = 25)	15		109.80 (90-115)	Counting span task	Impaired CA
	BID (*n* = 19)	10		81.21		Preserved MA
	TDMA (*n* = 22)	7		104.91		deficits increased with the degree of ID
Van der Molen et al. (2010)	Mild ID (*n* = 39)	13-17	118.1	65 (55-75) (FIQ)	Backward digit recall	Preserved MA
	TDCA (*n* = 39)	13-16	182.6	99.8		Impaired CA
	TDMA (*n* = 26)	9-12	120.7	97.1	Listening recall	Impaired
Maehler & Schuchardt (2009)	NSID (n = 27)	12.45		75.44	Backward digit spans	impaired ID=LD<TD
	LD (n = 27)	12.35		100.08		
	TD (n = 27)	10.58		101.04	Backwards word span	impaired ID=LD<TD
					Counting span	impaired ID=LD<TD
Van der Molen et al. (2009)				VIQ PIQ	Backward digit span	Impaired CA & MA
	Mild ID (n = 49)	13-17		68.6 71.9		
	TDCA (n = 39)	13-16		98.6 98.5	Listening recall	Impaired Ca & MA
	TDMA (n = 29)	8-12		100.5 97.7		
Numminen et al. (2001)	NSID (*n* = 24)	38-58 (49.88)	5.63	Raven	Digit span backwards	preserved
	TDMA (*n* = 24)	3-6 (5.50)	5.67			
Conners et al. (1998)	NSID (*n* = 30)	11.72	7.45	66.58 WISC-R verbal	Backward digit span	Impaired CA Preserved MA
	TDCA (*n* = 30)	12.36	7.45	107.42		CA>ID=MA
	TDVMA (*n* = 26)	7.45		106.77		
Vicari et al. (1995)	DS (n = 15)	16.6	5.3	36	Backward digit span	Preserved ID=TD
	NSID (n = 14)	16.7	51	39		
	TDMA (n = 24)	5.7	5.5	101		
Numminen et al. (2002)	NSID (*n* = 24)	49.88		Raven	Digit Span Backward Task	Preserved
	TDMA (*n* = 24)	5.650 (3-6)				
Carreti et al. (2010)	NSID (*n* = 28)	38.4	6.2	Raven: 17.36 (IQ = 40-75)	Verbal WM tests (Belacchi et al., 2010)	
	TDMA (*n* = 28)	6.5	6.6	17.50	Backward word span	Impaired
					Selective word span	Impaired
Henry and Winfield (2010)	MID (*n* = 35)	12-13 (12.6)	7.7	57	Listening span	Preserved in same mental age
	TDMA (*n* = 35)	6-8 (7.5)	7.8	101		Associated with number skills
Henry and MacLean (2003)	NSID (*n* = 53)	11-12 (11.11)		57.2 (40-79)	Listening span	Preserved MA
	TDCA (*n* = 45)	11-12 (12.1)		103.8 (84-123)	Reverse digit span	Preserved MA
	TDMA (*n* = 41)	7-8 (7.11)		101.0 (82-136)		
Henry and MacLean (2002)	NSID (*n* = 53)	11-12		57.2	Listening span	Preserved MA impaired CA
	TDCA (*n* = 45)	11-12		103.8		
	TDMA (*n* = 41)	7-8		101.0	Reverse digit	Preserved MA impaired CA
Henry (2001)	BID (*n* = 10)	11-12	9.4	75.3 (70-79) BAS 60.5 (55-68)	Listening span	Impaired
	Mild ID (*n* = 25)	11-12	7.9	45.8 (40-52)		
	MI D (*n* = 21)	11-12	6.4	104.5 (84-123)	Reverse digit span	Impaired
	TD CA (*n* = 22)	11-12	13.0			
Lanfranchi et al. (2002)	NSID (*n* = 13)	8-16	5.6	LO	Backward word span	Impaired
	TDMA (*n* = 30)	5.2	5.6			NSID<TD
					Selective word recall	Impaired
Danielson et al. (2013)	NSID (*n* = 22)	7.3	8			**EX. Verbal preserved**
	TDMA (*n* = 22)	**12**				
	TDCA (*n* = 22)	**14**				
			Dual Task			

Table 1 (*Continued*)

Carreti et al. (2010)	NSID (*n* = 28)	38.4	6.2	Raven: 17.36 (IQ = 40-75)	Dual span task	Impaired
	TDMA (*n* = 28)	6.5	6.6	17.50		
Danielson et al. (2010)	NSID (*n* = 46)	63.2		62.8 Wechsler	Dual task word recall:	Impaired
	TDCA (*n* = 92)	63.2		100		
Maehler and Schuchardt (2009)	NSID (*n* = 27)	12.45		75.44	double span	All impaired ID=LD<TD
	LD (*n* = 27)	12.35		100.08		
	TD (*n* = 27)	10.58		101.04		
Van der Molen et al. (2007)				Raven	Dual-task management,	
	NSID (*n* = 50)	15.3		55-85	Dual task (Baddeley, 1997, verbal/visuospatial)	preserved CA and MA
	TDCA (*n* = 25)	15.3				
	TDMA (*n* = 25)	10.10				
Bayliss et al. (2005)	ID\LD (*n* = 50)	13.6 (10.1-16.3)	7.5	55.32 (27.72-69.89) BPVS-II	Complex span tasks Bayliss et al. (2005)	Preserved
	TDVMA (*n* = 50)	7.3 (5.5-9.1)	7.5	102.36 (80.81-129.17)	Verbal-verbal Verbal-visuo spatial	Preserved
Lanfranchi et al. (2002)				LO	Dual selective word recall	Impaired
	NSID (*n* = 13)	8-16	5.6			
	TDMA (*n* = 30)	5.2	5.6		Dual visuospatial task	Impaired DS=NSID <TDMA
Executive functions						
Danielson et al. (2010)	NSID (*n* = 46)	63.2		62.8 Wechsler	Tower of Hanoi	Preserved
	TDCA (*n* = 92)	63.2		100	Verbal fluency	Impaired
Van der Molen et al. (2007)				Raven		
	NSID (*n* = 50)	15.3		55-85	Information retrieval and manipulation	impaired CA
	TDCA (*n* = 25)	15.3				
	TDMA (*n* = 25)	10.10			Word fluency test	Preserved MA
					Planning	Impaired CA
					WISC-R subtest mazes	Preserved MA
					Inhibition	Impaired CA
					digit generation (DG)	Preserved MA
Conners et al. (1998)	NSID (*n* = 30)	11.72	7.45	66.58 WISC-R verbal	Fluency	Impaired CA Preserved MA
	TDCA (*n* = 30)	12.36	7.45	107.42		CA>ID=MA
	TDVMA (*n* = 26)	7.45		106.77		
Alloway (2010)	BID (*n* = 39)	7.11-11.7 *M* = 9.8		70-85 *M* = 77	D-KEFS (Delly, 2001)	
					Shift attention	Impaired
					Cognitive inhibition	Impaired
	TDCA (*n* = 39)	8.1-11.11		99-133 *M* = 118 WASI	Problem solving behavior	Impaired
					Response inhibition	Impaired
Carreti et al. (2010)	NSID (*n* = 28)	38.4	6.2	Raven: 17.36 (IQ = 40-75)	WM updating word span (Palladino et al., 2001)	Impaired
	TDMA (*n* = 28)	6.5	6.6	17.50		
Hartman at al. (2010)	B ID (n = 61)	7-12		71-79	EF:	
	M ID (n = 36)	7-12		54-70	Tower of London-TOL	Impaired BID=MID<TDCA
	TDCA (n = 97)	7-12		WISC-III		
Willner et al. (2010)	NSID (n = 20)	39.9		58.8 (50-67) BPVS: 81.6	BADS-C Emslie 2003	Weighing up impaired
	TD (n = 10)	38.6		152.3	CEFA-ID Ball 2008	Decision making related more to EF than IQ
Bayliss et al. (2005)	ID\LD (*n* = 50)	13.6 (10.1-16.3) 7.3 (5.5-9.1)	7.5	55.32 (27.72-69.89) BPVS-II	Processing efficiency tasks (processing speed)	
	TDVMA (*n* = 50)		7.5	102.36 (80.81-29.17)	Color association Object association	ID/LD faster than TD
Numminen et al. (2001)	NSID (*n* = 24)	38-58 (49.88)	5.63	Raven	TOH	Preserved ID more trials & violated more rules
	TDMA (*n* = 24)	3-6 (5.50)	5.67			

NSID = ID with non-specific etiology, BID = borderline ID, Mild ID = mild ID with IQ 55-85, MID = moderate ID, TD = with typical development, CA = chronological age, MA = mental age TDMA = with typical development control matched by MA; TDCA = with typical development control matched by CA, VIQ = verbal IQ, PIQ = perceptual IQ , BAS = British Ability Scale, AWMA = Automated Working Memory assessment, D-KEFS = Delis-Kaplan Executive Function System, BADS-C = Children's version of the Behavioural Assessment of the Dysexecutive Syndrome, which includes six tests of EF, CEFA-ID = the Cambridge Executive Functioning Assessment for people with Intellectual Disability, WASI = Wechsler Abbreviated Scale of Intelligence

2.3. *WM in individuals with NSID*

2.3.1. *Moderators related to background characteristics*

2.3.1.1. CA versus MA as criteria for matching the ID and TD groups. The discrepancy between studies may originate in the criteria used for matching the groups. When matching between participants with ID and TD was by CA ($n = 21$), WM was impaired in all studies beyond modality and the component. Participants with TD exhibit a higher MA or IQ than their peers with ID, and it is not surprising that they outperform them on memory tasks. However, when matching between groups was based on MA ($n = 41$), 34% of the experiments yielded equal performance. To find what might explain the inferior

Table 2
The hierarchy of WM tasks among participants with NSID.

Process type	Preserved	Task	N	N Preserved
Phonological loop ($n = 68$)	40%	Digit	22	9
	20%			
	71%			
	77%	Words	15	3
	13%	Similarity effect	7	5
		Word length effect	9	7
		Non-words	15	2
visuo-spatial sketch pad (32)	46%	Visual	15	7
	35%	Spatial	17	6
Central executive ($n = 57$)	35%	Visuospatial tasks	17	6
	37%	Exec. Phonological Digit backward	24	9
	22%	Words backward	9	2
	50%	Word Fluency	4	2
	60%	Planning	5	3
	0	Inhibition	3	0
	0	Switching verbal	2	4
	40%	WM dual task	10	3

performance in the remaining experiments, we triangulated between the studies and found other moderators that influence memory performance of individuals with ID, even when the groups are matched by MA.

Furthermore, memory was preserved in accordance to the intelligence tests used for matching between the groups across all modalities and components of Baddeley's model (phonological loop, visuospatial and executive function tasks). When the criteria for matching groups was passive vocabulary (Peabody Picture Vocabulary- PPVT; Dunn & Dunn, 1981; Dunn, Dunn, Whetton, & Burley, 1997; Wechsler Intelligence Scale for Children, WISC-R-III; Wechsler, 1991; British Ability Scale; Elliott, Smith, & McCulloch, 1996), the performance of participants with ID was inferior to that of participants with TD. However, when matching was based on fluid intelligence tests (Standard progressive matrices, Raven, Court, & Raven, 1992), logical thinking (Columbia Mental Maturity Scale; Burgemeister, Hollander, & Lorge, 1972), the Logical Operation Test (Vianello & Marin, 1997) or Leiter Performance Intelligence (Roid & Miller, 1997), performance was preserved (see Bayliss et al., 2005; Van der Molen et al., 2010).

2.3.1.2. Task-related moderators – phonological loop. Of 68 phonological experiment tasks, 27% were preserved (including digit, words and non-words tasks). We found the following hierarchy in the phonological loop from) more to less preserved): Digit span, memory of words and memory of non-words.

2.3.1.3. Digit span. In 40% of 22 experiments, the performance of participants with NSID was preserved only when compared to individuals with TD with the same MA. Furthermore, the discrepancy between the preserved and impaired experiments stems, among others, from the intelligence tests used for matching between the groups, the level of ID and the scoring methods. When the criteria for matching groups was passive vocabulary (i.e., Peabody Picture Vocabulary-PPVT; Dunn & Dunn, 1981), the performance of participants with ID was inferior to that of participants with TD. However, when matching was based on fluid intelligence tests (Standard progressive matrices test; Raven et al., 1992) or logical thinking (Columbia Mental Maturity Scale; Burgemeister et al., 1972), memory was preserved. Furthermore, in Bayliss et al. (2005), for example, digit span scores of participants with ID was lower than among participants with TD. This study included participants with both mild and moderate ID. In Henry and Winfield (2010), who found that participants' performance for digit memory was impaired, scoring was based on the number of successful attempts needed to complete the task, which Ferguson, Bowey, and Tilley (2002) consider more reliable. When scoring was based on the longest list participants were able to recall (Henry & MacLean, 2003), performance was preserved.

2.3.1.4. Words. Phonological memory measured by word span was preserved in 20% of 15 experiments when matching between the groups was based on fluid intelligence (Carretti, Belacchi, & Cornoldi, 2010; Hasselhorn & Mähler, 2007; Lanfranchi, Cornoldi, & Vianello, 2002), and impaired when matching was based on verbal tests. These criteria were true also in word length and similarities effects. Word length tests examine the effects of word length (Service, 1998) on phonological memory span and spontaneous sub-vocal rehearsal ability. In 77% ($n = 9$) of the experiments, participants with ID were able to recall words with 1 or 2 syllables, but performance for longer words was not preserved. The *similar/dissimilar words effect* was preserved in 71% of 7 experiments. This finding indicates a severe deficit in the phonological store that is solely attributable to storage capacity rather than processing accuracy, which Schuchardt et al. (2011) consider as a core deficit in the population with ID (see Discussion Section).

2.3.1.5. Non-words. *Non-words* (repetition) was preserved in only 13% of 15 experiments, in two studies in which matching between the groups was according to MA and when a fluid intelligence test (Standard progressive matrices, Raven et al., 1992) was used for matching between the groups.

2.4. Visuospatial sketchpad

2.4.1. Moderators related to background characteristics

2.4.1.1. CA versus MA as criteria for matching the ID and TD groups. When matching was according to MA, the performance of participants with ID was equal to the controls with TD in 40% of 32 experiments. In the preserved experiments, fluid intelligence tests (i.e., Standard progressive matrices) were used for matching between the groups.

2.4.1.2. Task-related moderators. Memory of visual-object was measured (Visu-Petra & Benga, 2007) by visual similarity, visual complexity, and span/visual patterns tests. The findings indicate that visual object was preserved in 43% of 15 experiments (Table 2). Memory was impaired when comparison was based on CA, but was more preserved when comparison was based on MA. Pattern span was preserved. However, matrixes revealed impairment. Spatial performance was measured with the memory span for locations, Corsi block simple and complex tasks (where the distance between blocks is larger than in simple tasks). Spatial memory was preserved in 35% of 17 experiments (Table 2). Most of the experiments used the Corsi block (Millner, 1971). Memory was impaired when comparison was based on CA, but more preserved when comparison was based on MA. Corsi complex was impaired.

2.5. Central executive

2.5.1. Moderators related to background characteristics

2.5.1.1. CA versus MA as criteria for matching the ID and TD groups.. In 2 of the 57 experiments, memory was preserved when matching was according to CA. Van der Molen et al. (2007) examined a visual-verbal dual task among adolescents with mild ID versus participants with TD with the same CA and participants with TD with the same cognitive level based on the Raven's Standard Progressive Matrices Test (Raven et al., 1992). However, this experiment was conducted in two stages: The phonological and visuospatial tasks were administered separately, after which they were administered as a dual task. It is possible that the previous familiarity with the task contributed to the preserved performance of the participants with ID on the dual task. Danielsson et al. (2010) examined central executive performance among adults with NSID versus adults with TD with the same CA. Tower of Hanoi, word fluency, dual task and word recall were administered. Participants with ID exhibited preserved performance only for Tower of Hanoi. According to Miyake et al. (2000), this task requires planning, which is considered to have a lower level of task load than updating or shifting tasks. When matching was according to MA, the executive performance of participants with NSID was preserved in 72% of 35 experiments.

2.5.1.2. Task-related moderators. We counted the number of preserved/impaired experiments in central executive tasks and found the following hierarchy (from more to less preserved): Visuospatial tasks followed by phonological tasks and dual tasks. In 35% of the visuospatial executive tasks the performance of participants with NSID was preserved. In the *phonological executive tasks*: Digit memory was preserved in 37% of 24 experiments, indicating that remembering a digit is easier for the population with ID. Memory of executive words tasks was preserved in 22% of the nine experiments that examined executive phonological tasks. In Henry and MacLean (2002, 2003) and Henry and Winfield (2010), participants were asked to repeat the last word of sentences, without reference to their order. However, in Van der Molen et al. (2009, 2010), they were asked to repeat the last word of each sentence in the order they were presented, which increases the level of task control and therefore memory was impaired. The findings show that participants with ID exhibit greater difficulty with listening span, selective word span and backward word span tests, which require simultaneous storage and processing of phonological information, than participants with TD with the same MA (Carretti et al., 2010; Lanfranchi et al., 2002).

2.5.1.3. Dual task. Dual tasks involve memory performance of two modalities simultaneously (phonological-phonological, spatial–spatial or phonological-spatial), and require a higher level of control (Baddeley, 2007). Performance was preserved in 44% of nine experiments for the verbal–verbal and verbal-visual-spatial dual tasks (Bayliss et al., 2005; Van der Molen et al., 2007). In Carretti et al. (2010) and Lanfranchi et al. (2002), the secondary tasks were performed only in response to a stimulus, requiring the participant to focus attention on two sources simultaneously, and performance was impaired.

2.5.1.4. Other executive functions. Preserved performance was found for planning (Tower of Hanoi, WISC-R subtest mazes), although the number of errors and moves was much higher among participants with NSID than among participants with TD. Performance was also preserved in retrieval, verbal fluency and processing efficiency tasks. Impaired performance was found in updating word span tasks (Carretti et al., 2010) that require focusing attention simultaneously on two actions (Palladino, Cornoldi, De Beni, & Pazzaaglia, 2001), inhibition and switching. None of these tasks were preserved. These tasks demand not only storage, but also a high level of control, constant retrieval of information and other manipulations beyond memory itself.

In conclusion, we found a hierarchy of WM performance in the population with NSID (from more to less preserved): visuospatial sketchpad, phonological loop and some of the central executive functions (planning, fluency and even dual tasks), with phonological loop tasks found at the bottom of the hierarchy.

3. Discussion

The intriguing message to emerge from this integrative review is that WM performance of individuals with ID is context-sensitive (Roediger, 2008). That is, there are some conditions in which WM is relatively more preserved and some conditions in which it is impaired. Different abilities are preserved to various degrees. This is the first message of this review.

Two fundamental questions will be at the core of the discussion: (a) What are the moderators that govern the preservation or impairment of WM performance among participants with NSID? (b) Whether and what are the common denominators between the processes of long-term memory (LTM) and WM in the population with NSID?

Our review of WM studies in the population with NSID revealed similarities and differences to the findings that emerged from our long-term explicit memory studies review (Lifshitz-Vahav & Vakil, 2014). Our review suggests a taxonomy of two clusters of moderators that influence WM performance in the population with NSID: (a) Participant-related moderators (CA, intelligence level and etiology), and (b) Task-related moderators.

The participants cluster includes the same moderators or clusters that govern long-term explicit memory in the population with ID: CA and MA (or intelligence). However, the participant-related moderators are quite different due to the specific construct of the WM. Our findings support the horizontal and vertical model of WM (Cornoldi & Vecchi, 2003) in the population with NSID. That is, WM performance in this population is influenced by the modality according to the components model (phonological loop, the visuospatial sketchpad and the central executive which is involved in conditions of high level processing of the two other slave systems) of Baddeley et al. (2011), but is also influenced by the cognitive load of the tasks in each component. Our claim is that only the interrelation between the two moderators provides an adequate profile of WM in individuals with ID. This is the second message of our research review. We will now relate to the two clusters of moderators.

3.1. Cluster 1: participant-related moderators

3.1.1. The influence of CA on WM in the population with ID

Similarly to the moderator that governs explicit memory in the population with ID, this review of WM studies indicates that CA plays an important role in determining WM performance of individuals with NSID. Although the influence of CA on WM in the population with ID was not examined directly in the WM studies (most of the experiments focus on adolescents with NSID), its role emerges from the difference in performance when selection of the control group was based on MA rather than on CA. In most of the WM studies that matched individuals with ID and controls by CA, individuals with TD outperformed their peers with ID. This is self-evident. Thus, the different gap pattern between the two groups when selection of the latter was based on CA implies the effect of age on WM.

However, in some of the studies that matched participants with ID and controls with TD based on MA, the performance of participants in the three etiologies was equal to their controls. When matching is based on MA, the participants with ID are older than their peers with TD, which gives them an advantage (Van der Molen et al., 2010). This finding raises the question of a developmental-difference controversy (Zigler & Balla, 1982) in the population with ID. The question is whether the deficit in WM can be interpreted as reflecting a developmental lag or a qualitative deviation (structural difference) from typical development (Zigler & Balla, 1982). The fact that the performance of individuals with NSID is equal to that of their controls with TD when the former are older supports the developmental approach. Carlesimo, Marotta and Vicari (1997) and Facon and Facon-Bollengier, (1999) found that adolescents with ID outperformed children with ID with the same MA in crystallized tests. Lifshitz and Katz (2009) and Lifshitz, Tzuriel, Weiss, and Tzemach (2010) found a similar trend among adults and adolescents with ID with the same cognitive level. The Compensation Age Theory (Lifshitz-Vahav, 2015) postulates that CA determines the cognitive ability of individuals with ID beyond their MA. Their maturity and cumulative life experience may explain their more efficient coping with cognitive skills in adulthood (Numminen, Lehto, & Ruoppila, 2001).

3.1.2. The influence of MA or intelligence on WM in the population with ID

Jarrold, Baddeley and Phillips (2007) stated that IQ may be more important in predicting performance on LTM tasks, which are considered a fluid ability and are more related to general intelligence *g* than to verbal MA. Our review of WM studies in the population with ID supports this claim: In all experiments, when memory performance was inferior to that of participants with TD, matching was based on verbal ability or the MA (examined by the PPVT, Dunn & Dunn, 1981, 1997). In all experiments that indicate equal performance between participants with NSID and TD, matching was based on fluid intelligence tests (examined by the Standard progressive matrices, Raven et al., 1992; or the Logical Operations, Vianello & Marin, 1997). This discrepancy in WM performance as a consequence of the different tests used for matching between participants with ID and TD was also supported in our previous explicit memory studies review (Lifshitz-Vahav & Vakil, 2014). Baddeley et al. (2011) claim that the three components of WM are associated with fluid intelligence. Thus, it is not surprising that fluid intelligence tests are more accurate and reliable measures of the basic cognitive intelligence of individuals with ID, and that they predict both their WM and LTM performance better than their MA.

Our findings support the vertical model suggested by Cornoldi and Vecchi (2003). This model reflects the degree of required control, which is defined by the amount of active processing required to manipulate the information maintained in a temporary memory system. The vertical model of cognitive load raised by Cornoldi and Vecchi (2003) is parallel to the concept of attention level in the time-based resources-sharing model suggested by Camos and Barrouillett (2014, see p. 4). This WM integrative review indicates that individuals with ID can manage with WM tasks demanding a lower level of attention in the process and storage stages. However, they exhibit difficulties in highly attention-demanding executive tasks involving other manipulations besides the recall itself, such as selection, retrieval, updating, or inhibition. Our findings indicate a taxonomy of task performance in each component in the model by Baddeley et al. (2011). We identified three levels of cognitive load or task control in the phonological loop, the visuospatial sketchpad and the executive function. Consistent with our hypothesis, memory performance was equal to the performance of participants with TD at a lower cognitive load or lower attention-demanding tasks, but was inferior to participants with TD in higher cognitive load tasks which require a higher level of attention.

The fact that the performance of individuals with NSID depends on the task load indicates that WM performance does not depend solely on the modality, but rather on the participants' basic cognitive level, that is – on their mental age, but more correctly on their intelligence (considering their chronological age). This is the third message of our study. This claim is in accordance with that of Levy (2011) and Levy and Antebi (2004) who found that IQ was the best predictor of word reading skills among participants with NSID, Down syndrome and Williams syndrome, beyond the unique phenotype of each etiology. We shall now present the hierarchy of the three components in the population with ID.

3.2. Cluster 2 – task-related moderators

The findings indicate a hierarchy (from more to less preserved) in performance of individuals with ID of three components: The visuospatial tasks, some of the executive functions tasks (it should be noted that as in qualitative studies, this hierarchy is based on percent and not on sample and effect size as used in meta-analyses, see Procedure Section), and the phonological loop tasks at the bottom of the hierarchy (least preserved).

3.2.1. The visual component

The findings of the more preserved WM visual tasks were also supported in our integrative research review of explicit LTM studies in the population with ID (Lifshitz-Vahav & Vakil, 2014). In the LTM studies, none of the verbal tasks yielded equal performance between individuals with ID and their TD controls. Equal performance on verbal tasks was achieved when the word-list was accompanied by visual scaffolding. The gap between memory of visual and verbal memory in WM as well as in LTM supports the 'picture superiority' hypothesis (Dulaney & Ellis, 1991; Paivio, 1971) claiming that processing visual information enables individuals with ID to develop the meaning behind the visual stimuli more than words alone. Visual pattern span was more preserved than both simple and complex matrixes, that were impaired.

3.2.2. Spatial memory

Visual spatial WM memory was less preserved compared to visual object tasks even when ID and TD groups were matched by MA. The essence of spatial memory has occupied scientific literature since the 1970s. Hasher and Zacks (1979) claimed that spatial memory is an automatic process. They presented six criteria for automatic processing and claimed that spatial memory is not influenced by different moderators related to the task or to the subjects (task demands, practice, feedback, awareness of intent, CA and intelligence level). In contradistinction, Nave-Benjamin's (1987, 1988) findings indicate that encoding of spatial location information is influenced by these moderators, and this memory therefore involves effort.

Based on our long-term explicit memory review (Lifshitz-Vahav & Vakil, 2014) and the present WM review, our argument is that encoding of location memory in individuals with NSID is mediated by non-automatic processes (Naveh-Benjamin, 1988) and is influenced by task load (Vinter & Detable, 2003), strategy use and intentional learning (Alevriadou, 2010; Dulaney & Ellis, 1991). According to Dulaney, Raz and Devine (1996) and Alevriadou (2010), encoding of spatial information is mediated by effort processes, and spatial memory is processed differently among people with ID than among those with TD. The population with ID relies on minimal cognitive resources, and what seems to be an automatic process for those with TD who have sufficient cognitive resources necessitates an effort among those with ID. This conclusion should be regarded with caution, due to the small number of studies on this issue.

3.2.3. Phonological loop

Similarly to our integrative research review of long-term memory studies in the population with ID (Lifshitz-Vahav & Vakil, 2014), this integrative research review of WM studies in the population with ID indicates that the phonological verbal tasks are at the bottom of the performance hierarchy compared to the visuospatial sketchpad and some of the executive function tasks. It should be noted that in our long-term explicit memory integrative research review (Lifshitz-Vahav & Vakil. 2014), verbal tasks yielded equal performance of individuals with ID and TD only with visual scaffolding. The findings of this WM review support our previous claim about visual images superiority in the population with NSID. Unlike our integrative research review of explicit LTM, the current integrative WM review indicated that of 68 phonological experiment tasks, 27% were preserved (including digit, words and non-words tasks). That is, in the short term, individuals with NSID could hold verbal material without visual scaffolding.

Task hierarchy in the phonological loop was as follows (from more to less preserved): Digit span forward, followed by words and then non-words. The relatively preserved memory for a digit can be explained by Piaget's (1970) cognitive development stages. Memory for numbers is acquired at the relatively young age of three, prior to memory for words. The first ten single-digit numbers are preserved. Recalling numbers is accompanied by rhythmic movement, which facilitates the remembering of numbers, also for individuals with ID (Vygotsky, 1986). Another explanation could be the feature of the phonological loop which is the capacity for vocal rehearsal. In this system, sequences of well-learned items such as a digit are readily retrievable from the LTM and may be maintained before their constituent features are disrupted by decay or interference. Thus, as stated, contrary to the findings of the long-term memory review (Lifshitz & Vakil, 2014), individuals with NSID could relatively hold verbal material in the STM without visual scaffolding (Schuchardt et al., 2011).

Our study revealed the word length effect, i.e. short words take a shorter time to articulate and benefit from more rehearsals, which increases the probability that they will be recalled (Jarrold & Hall, 2013; Service, 1998). Our findings indicate that individuals with ID are capable of recalling two-syllable words, and in some cases three syllables, when other moderators are employed. Words with four syllables place more constraints on memory storage, and decrease the performance, even of participants with TD (Schuchardt et al., 2011).

According to Hasselhorn and Mähler (2007) and Schuchardt et al. (2011), this finding supports the claim of automatic activation of the sub-vocal rehearsal. That is, individuals with ID show no specific deficits in the rehearsal process. However, our findings reveal a deficit in repetition of non-words (familiarity or meaningfulness effect) of different syllable lengths. Lack of familiarity or meaning causes a barrier on the storage mechanism compared to the population with TD (Schuchardt et al., 2011). This finding indicates a severe deficit of individuals with ID in the phonological store which can be attributed to storage capacity and not to the accuracy of processing (Schuchardt et al., 2011). It is documented that storage plays a key role in early language development, in the acquisition of active vocabulary, and in the use of grammatical forms and syntactic structures (Adams, 1996; Baddeley, Gathercole, & Papagno, 1998). Limited storage capacity encumbers vocabulary and grammatical structures, which are the core constraint in the cognitive development of individuals with ID. When the expansion rate of the knowledge base is slow, less content is entered, processed, and subsequently stored in long-term and working memory. According to Schuchardt et al. (2011), this indicates a qualitative difference between individuals with ID compared to those with TD. On the other hand, knowledge of the lexicon and of grammatical structures can compensate for incomplete word representations in the phonological store (Brown, Preece, & Hulme, 2000).

Individuals with NSID exhibit the phonological similarity effect, i.e. storage of similar words to more confusion than dissimilar words (Camos & Barrouillet, 2014). Concurrent articulation using similar language processes could block or at least impede the sub-vocal rehearsal of memory items and impair WM recall (Camos & Barrouillet, 2014).

This finding indicates accuracy of processing in the population with ID (Hasselhorn & Mähler, 2007; Jarrold, Baddeley, & Hewes, 2000; Rosenquist, Conners, & Roskos-Ewoldsen, 2003).

In conclusion, our review revealed that the deficit of individuals with NSID does not lie in rehearsal or accuracy of processing of verbal material but in the phonological store, which can be attributed to storage capacity. In this respect, the deficit in the phonological loop of individuals with NSID is structural (Schuchardt et al., 2011). Deficits in storage capacity can therefore be seen as a causal factor in intellectual disabilities (Schuchardt et al., 2011). Limited storage capacity causes difficulty in the acquisition of vocabulary and grammatical structures. The language problems that people with ID typically experience, which seem to have a negative impact on general cognitive development, can be seen in this context. Consequently, the expansion rate of the knowledge base is slow – less content is entered, processed, and subsequently stored in LTM. t thus seems likely that both a lack of phonological storage capacity and the associated linguistic deficits contribute to the cognitive deficits observed in individuals with mild NSID. More studies are needed in order to support this claim.

3.2.4. Executive function

The same explanations that we proposed earlier for the more preserved digit span forward and words can serve as an explanation for their relatively more preserved digit backward, letter and word fluency. These abilities are readily retrievable from LTM and are less vulnerable to decay. Participants with NSID also exhibit more preserved performance in planning tasks (verbal or visuospatial), which are considered low-demand tasks, even though they are classified as executive function tasks.

Thus, participants with ID are capable of coping with executive function tasks, albeit at a lower control level beyond the modality. However, they exhibit lower performance compared to participants with TD in higher control/attention tasks. For example: Selecting requires making a semantic judgment and remembering (Van der Molen et al., 2009, 2010) or selecting an item according to a specified criterion and remembering (Palladino, 2001). Updating requires removing some or all of the items stored in WM and replacing them with new items. Shifting requires refreshing tasks in which a cue directs the subject to foreground a recently presented item. Inhibition is the ability to ignore irrelevant stimuli while performing an additional task. It includes the ability to change and/or stop an action, behavior or response when this is not desirable. Dual tasks require relating to two modalities simultaneously. Although these tasks differ in their nature, they are well-known for capturing a higher attention level because they require cognitive manipulation beyond the memory itself (Camos & Barrouillett, 2014).

The role of rehearsal in WM is controversial. Earlier we presented the approach that associated sub-vocal rehearsal with WM. However, Jarrold and Hall (2013) state that rehearsal plays a role in LTM. That is, it is needed for assisting people to recall after a delay. As stated by Jarrold and Hall (2013): "Rehearsal is not required when one recalls a list of just-presented items immediately. . . However, in situations in which individuals have to maintain the information during an interval, rehearsal could be employed. . . An individual's rehearsal capacity is constrained by, and may in fact be secondary to, his or her recall capacity" (p. 184). In our opinion, a meta-analysis that will compare between WM studies in the population with NSID and LTM in this population should be conducted in order to shed light and give a more precise answer to this issue.

4. Conclusions, limitations, and future research

Our review indicates similarities and differences between WM and LTM (Lifshitz-Vahav & Vakil, 2014) performance mechanisms in the population with ID. Two clusters of moderators influence the performance of the two types of memory: The participants cluster includes CA and intelligence. However, the participant-related moderators are quite different due to the specific construct of the WM. WM performance in the population with NSID is dictated by the component (Baddeley & Hitch, 1974; Baddeley et al., 2011) or modality. The visuospatial sketchpad was more preserved, followed by several executive tasks. The phonological loop was at the bottom of the hierarchy. However, WM performance is governed not only by modality, but also by the cognitive load of the task (Lanfranchi, Carretti, Spanò, & Cornoldi, 2009; Lanfranchi, Cornoldi, Drigo, & Vianello, 2009; Vertical-Horizontal Model, Cornoldi & Vecchi, 2003). This finding indicates that intelligence plays an important role in determining WM performance of individuals with ID beyond modality. We found a hierarchy in task performance in each component (from more to less preserved): In the phonological loop: digit span, followed by memory of words and memory of non-words. In the visuospatial sketchpad: memory of visual tasks and then memory of spatial tasks. In the central executive: Perceptual planning and retrieval (fluency) and some of the dual tasks were more preserved than shifting, inhibition and selection. The executive phonological tasks were at the bottom of the performance hierarchy.

One factor possibly limiting the current analysis is that we relied on journal articles. Additional non-significant results were perhaps not included in published articles or dissertations due to the 'file drawer problem' which is problematic in all research, and in reviews in particular. The effect of CA on WM was examined with reference to the control group. However, differences in WM of participants with ID and controls with TD of various ages could not be examined due to insufficient memory studies among adults (and children) with NSID. Using different types of intelligence tests for matching (visual/verbal) between ID and TD groups may yield different findings. We recommend that future researchers use more than one intelligence test for matching between the groups. Conducting integrated research that will examine WM and long-term memory will help solve the source of deficit in verbal tasks in the population with NSID. This integrative review focused on individuals with NSID. There is a need for more research on Williams syndrome, Down syndrome and other etiologies. Research examining the effect of gender on memory is recommended (Perez, Peynircioğlu, & Blaxton, 1998). The hierarchy in WM performance in the three components was based on counting the number of preserved/impaired experiments in each buffer. It is recommended to conduct a meta-analysis of LTM and WM which will take the sample and effect size of the studies in both types of memory into account. A mathematical-analytical method that will define the cognitive load of the various tasks in a more systematic way is needed.

4.1. Educational implications

Educators should be aware of the notion that CA affects memory and strategy use. They should keep in mind that the memory of participants with ID could improve with age. Therefore, in instances when students with NSID do not successfully learn material when it is first presented, it is possible that they will be able to master it at a later age. Such awareness should encourage teachers to continue training and practicing strategies with students despite the lack of immediate effects. Visual material is encoded more deeply and creates a visual image in addition to the symbolic meaning of the word (Paivio, 1971). Visual scaffolding is recommended when teaching individuals with ID. Rehearsal leads to better recall and deep processing (Atkinson & Shifrin, 1968) and was found to be an efficient manipulation in the population with ID (Brock, Brown, & Boucher 2006). This leads to the following practical recommendations: When teaching prose, narratives, or current events, use Luftig's (1987) task analysis method: divide the narrative into small units or paragraphs. Repeat each unit several times. Encourage participants to rehearse the words or story they heard verbally. Employ repetitions. When teaching social problem solving, repeat the problem and the solution several times. When giving mathematical exercises, repeat each exercise several times (Luftig, 1987). The required task control should be taken into account when preparing intervention programs for these etiologies.

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