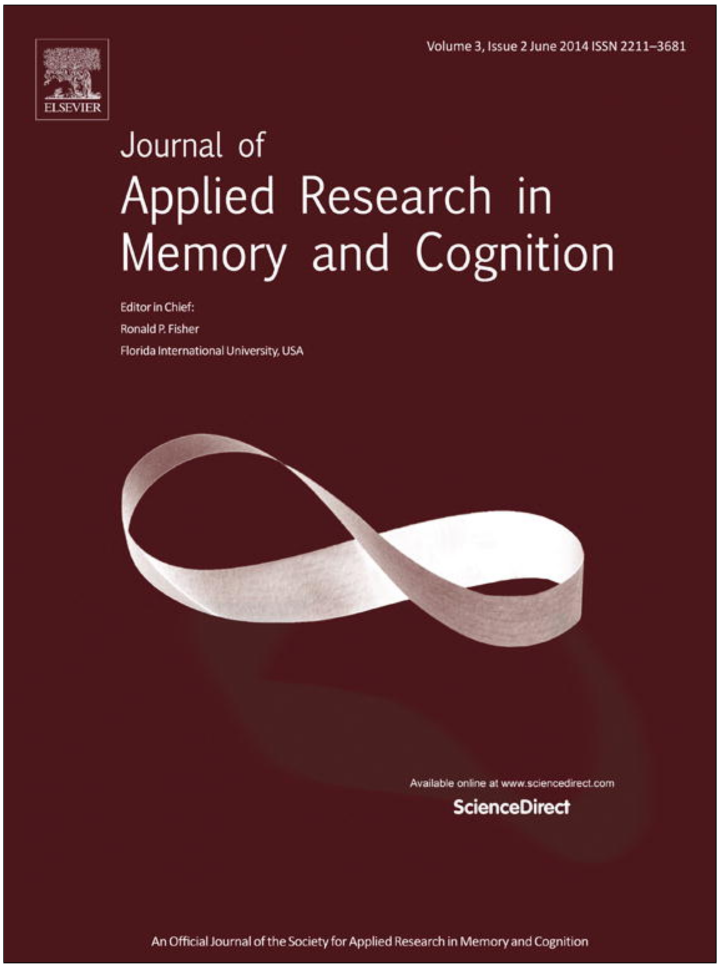

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Literature Review

Taxonomy of moderators that govern explicit memory in individuals with intellectual disability: Integrative research review

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ABSTRACT

This integrative research review aims to discover moderators that influence explicit memory performance of individuals with intellectual disability (ID). We reviewed 47 explicit memory studies (since 1990) that were conducted in populations with ID. We suggest a taxonomy of moderators related to the participants, encoding and retrieval stages, where only an interrelation between the three dictates memory performance. We found that individuals with nonspecific ID can achieve the same level of recognition as individuals with typical development (TD) with the same chronological age when all encoding moderators are favorable. Recognition tests facilitate recollection more than free recall in all etiologies. The performance of individuals with ID was poorer than that of individuals with TD in all auditory memory tasks. Spatial location memory varied with task demands, practice, intention, age and intelligence. We conclude with suggestions for further research and educational implications.

Contents

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Explicit memory refers to the conscious recollection of previous experiences, as revealed by standard tests, and includes recall and recognition, which require intentional retrieval of previously acquired information (Schacter & Buckner, 1998). It is characterized by conscious and deliberate learning, and requires use of encoded information and retrieval strategies (Schneider & Pressley, 1989; Squire, 1994), is influenced by the individual's general knowledge (Kail, 1990) and places heavy demands on attention resources (Craik & Lockhart, 1972; for reviews on the underlying brain substrates of the various memory processes see Baddeley, 2003; Roediger, 2008; Schacter & Buckner, 1998; Squire, 1994). The present review focuses on explicit memory, due to its importance in the education and learning of individuals with intellectual disability (ID). Understanding the moderators that influence explicit memory in individuals with ID might help educators design intervention programs that aim to improve their memory performance.

This paper reviews memory studies among individuals with ID from 1990, when a change began in memory studies of populations with ID. Since 1990, the new terminology and concept of explicit and implicit memory (Graf & Schacter, 1987) were introduced into memory studies of this population. Furthermore, until then, most cognitive and neuropsychological studies focused on individuals with Down syndrome. The neuropsychological profiles of other etiologies, such as Williams syndrome, and the association between their cognitive profile and the localization of their deficit in the brain has comprised the basis for memory studies since 1990. Roediger (2008) presents some of the questions that are at the core of memory research in the general population, such as: Does repetition improve memory? Are spaced presentations better than massed presentations? Does deeper encoding enhance retention relative to less meaningful, superficial analyses? The same questions were introduced into memory research of populations with ID, since 1990, but to a lesser extent.

We have recently published a meta-analysis of 40 explicit memory studies in populations with ID and suggested that the explicit memory of individuals with ID is impaired (Lifshitz, Stein, Weiss, & Vakil, 2011). However, the meta-analysis summarizes the effect size of all the studies in which people's memory was preserved and those in which it was impaired. Cohen (1988, 1992) argued that a 'summary effect' may ignore findings that are insufficient to alter the generalizations, but might hold important qualitative data that are potentially significant for rehabilitation and educational purposes.

In order to apply our research to rehabilitation and education purposes, we decided to re-examine the explicit memory studies using a different methodology, *integrative research review*, to elucidate the underlying mechanism of preserved/impaired explicit memory. Integrative research review infers generalizations about a substantive subject from a set of studies directly bearing on the same issues in an integrated manner, such that new frameworks and perspectives on the topic are generated (Cooper, 1982; Randolph, 2009; Torraco, 2005). "Its goal is to summarize the accumulated knowledge regarding the relationship(s) of interest, highlight important issues, critiques, and synthesize representative literature that research has left unresolved (Torraco, 2005, p. 3)". The goal of the current review was to resolve literature conflicts on explicit memory among individuals with ID and identify the conditions/moderators that influence their memory performance compared to controls with typical development (TD).

In 1979, Jenkins proposed a tetrahedral model of moderators that influence memory performance in the general population. The model was revised by Roediger (2008) and reveals four main factors: *participants* (age, abilities, knowledge, disability); *encoding* (events manipulated during encoding); *events* (type of memory task); and *retrieval* (type of test). Jenkins (1979) and Roediger (2008) concluded that memory performance is *context sensitive* and depends on the level of the other variables that were manipulated or were not manipulated in the experiments and the interrelations between them (Roediger, 2008). However, both Jenkins and Roediger state that there is no specific principle that determines the interrelations or the weight of each of these variables in memory experiments.

We will examine the effect of the moderators suggested by the tetrahedral model among three ID etiologies: nonspecific etiology (nonspecific ID), Down syndrome and Williams syndrome.

1. Cognitive profile of individuals with nonspecific etiology

Individuals with ID constitute a heterogeneous group with reference to 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 spontaneous strategy use (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 (Das, 1985). They also exhibit inefficient short-term memory (STM) (Ellis, 1978) as well as working memory deficit (Hulme & Mackenzie, 1992). However, other studies found preserved STM and WM in this population (Carretti, Belacchi, & Cornoldi, 2010).

2. Cognitive profile of individuals with Down syndrome and Williams syndrome

Down syndrome is the most common genetic cause of ID (Rodger, 1987). Varying degrees of ID are the most consistent feature of individuals with Down syndrome (Vicari, Bellucci, & Giovanni, 2006). Williams syndrome is a rare genetic disorder associated with a behavioral profile that typically includes mild-moderate ID. The most marked psychological feature of Williams syndrome is dissociation between more preserved language skills and poor visual-spatial abilities (Bellugi & Wang, 1998), leading to a clear verbal advantage in this population. Differences between verbal and nonverbal abilities are less marked in Down syndrome, but their cognitive profile is also uneven. Language acquisition tends to be delayed relative to non-linguistic cognitive abilities (Gunn & Crombie, 1996). Williams syndrome and Down syndrome etiologies are associated with contrasting STM deficits. Wang and Bellugi (1994) found that individuals with Williams syndrome exhibit strength in verbal STM tasks but deficit in visual-spatial STM tasks. Individuals with Down syndrome exhibit deficit in verbal tasks, but preserved visual-spatial tasks (Vicari, Bellucci, & Carlesimo, 2005). Individuals with Williams syndrome exhibit preserved explicit and impaired implicit memory. The opposite was found for individuals with Down syndrome (Vicari, Carlesimo, Brizzolara, & Pezzini, 1996b).

This integrative research review focuses on memory studies among individuals with nonspecific ID, Down syndrome and Williams syndrome. We use the moderators suggested by Jenkins (1979) and Roediger (2008) as determining memory performance in the general population, and examine their interrelations on explicit long-term memory (LTM) in the three ID etiologies. Our aim is to point to moderators that govern memory performance beyond the cognitive pattern of each etiology. Our operative goals were to examine the influence of possible moderators on explicit memory performance of individuals with ID: type of test (free recall and recognition), strategy use and level of processing, modality (auditory/visual and spatial memory tasks), intentional (where participants receive explanations on the goals of the task and the test) versus incidental learning (where participants receive explanations only on the task), and prompting (encouraging participants to keep remembering as much as they can after stopping to produce responses) (Carlin, Soraci, Dennis, Chechile, & Loiselle, 2001). We also examine the effect of several conditions/moderators that are related to the test: Differences in performance between the encoding into LTM or retrieval from LTM as well as the influence of repeated trials on the retention of individuals with ID.

3. Method

We conducted a computerized search of articles on ID published between 1990 and 2012 in journals that focus on memory and cognition and in journals that focus on ID, using the PsycLIT database, Dissertation Abstracts International, the Social Science Citation Index, ERIC, Webspires, Proquest, Ebsco, and Google Scholar. Key words were 'explicit memory', 'declarative memory' and 'mental retardation' or 'intellectual disability', as well as 'long-term memory', and other expressions such as 'semantic or episodic memory', 'recall or recognition'. 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 47 studies. Of these, 60% focused on individuals with nonspecific ID ($n = 28$), 25% focused on individuals with Down syndrome ($n = 12$), and 15% on individuals with Williams syndrome ($n = 7$). In 82% of the studies, the focus was on youths and adolescents under the age of 21, and only 10% ($n = 5$) focused on participants older than 21. The mental age (MA) of participants in the studies of nonspecific ID ranged from 6 to 13. Most of the nonspecific ID studies focused on mild ID (IQ = 49–75), but 10 (21%) also included participants with moderate ID (IQ = 30–55). The MA of the participants with Williams syndrome was 5–9.3 and their IQ ranged from 53 to 64. For those with Down syndrome, the MA was 4.5–7.8 and the IQ ranged from 35 to 50. Gender differences were not examined.

4. Procedure

An integrative research review includes six stages (Cooper, 1982; Randolph, 2009; Torraco, 2005): (1) problem formulation; (2) data collection; (3) evaluation of data; (4) data analysis; (5) presentation of results; and (6) interpretation and discussion. The need and the rationale for conducting this research review on explicit memory among individuals with ID are explained in the theoretical background. Roediger's (2008) model was used for evaluation and analysis of memory experiments (some of the studies reported several experiments; these are referred to as 'experiments', not 'studies'). The model was shortened to three groups of moderators (triadic model) that are relevant to individuals with ID (Fig. 1): Moderators related to background characteristics (etiology, criteria for matching the ID and TD groups, chronological age (CA) and level of intelligence), moderators related to the *encoding stage* (modality, strategy use, practice, intention and prompting) and moderators related to the *retrieval stage* (type of test, acquisition versus delay stages and learning trials).

According to the integrative research review methodology, we triangulated (Randolph, 2009) between the moderators in order to find their involvement when memory was preserved or impaired. We follow the text with examples when needed. In cases of contradicting results with the same moderators, we re-read the articles to find other moderators that might influence performance. We performed an integration of the results, and in the discussion we interpreted the results and place them in a theoretical framework.

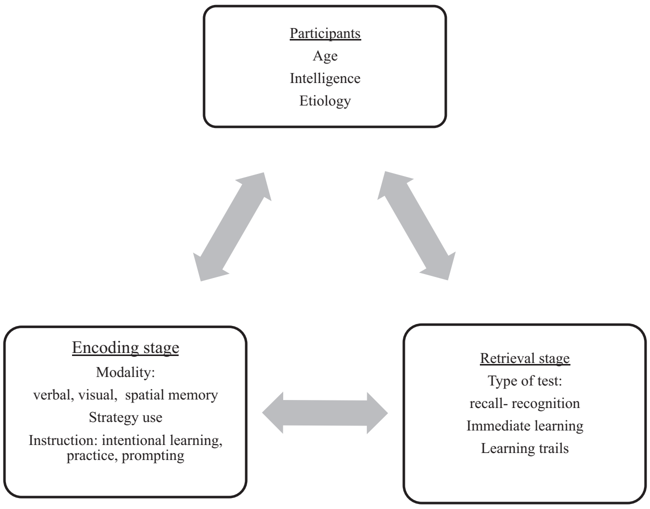

Fig. 1.

5. Results

In the results section, we will describe the memory experiments according to the moderators presented above for each etiology: nonspecific ID, Down syndrome and Williams syndrome. Tables 1–3 present the findings according to these moderators and Table 4 summarizes the impact of the three groups of moderators (Roediger, 2008) on memory performance among individuals with the three etiologies. The experiments in which individuals with ID performed lower than their TD controls are referred to as 'impaired experiments', and those in which both groups performed equally are referred to as 'preserved experiments'.

5.1. Individuals with nonspecific ID

5.1.1. Moderators related to participants

Chronological versus *mental age as criteria for matching ID and TD groups*. The discrepancy between studies may originate in the criteria used for matching the groups. When matching between individuals with ID and TD was by CA, free recall was impaired. Recognition was impaired except for two experiments (Carlin et al., 2001; Dulaney & Ellis, 1991). However, when matching between groups was by MA, memory was preserved in 100% of the recognition experiments and in 27% of the free recall experiments (Table 4).

Chronological age: Only four studies tapped the influence of CA on explicit memory. Turner, Hale, and Borkowski (1996) found an increase in performance of picture-recall at ages 10, 11 and 12. Henry and Gudjonsson (2004) found an increase in free recall of visual events between the ages 8 and 9 and 11 and 12. Wyatt and Conners (1998) found an increase in performance between 6 and 8 and 10 and 12 years, and stability between 10 and 12 and 15 and 17 years. Perrig and Perrig (1995) found correlations between CA and free recall. Only five studies focused on adults with ID (Table 1), and none of these compared the performance of younger and older ages.

Level of intelligence: In 21% (of 47) of the experiments, the participants with nonspecific ID included participants with moderate ID in addition to those with mild ID. Three of the studies performed correlations between explicit memory and intelligence. Perrig and Perrig (1995) reported weak correlations between IQ (WISC) and free recall but strong correlations between IQ and false alarm in the recognition tests. No correlations were found between IQ (WISC), the Rey Auditory Verbal Learning Test (AVLT, Rey, 1968; Hebrew version, Vakil & Blanchstein, 1991) and the Rey Complex Figure

Table 1

Explicit memory studies in individuals with NSID and TD controls according CA, MA, type of test, modality and findings.

Article name	Group	CA (mean or range)	MA (mean or range)	IQ (mean or range)	Explicit measures The tests and the modalities	Results		
						Time 1	Delay 1	Delay 2
Thomas (1990)	Mild ID (N = 60)	10–15		59–73	*Visual modality*	*Acquisition*	*1 day*	*2 days*
	Moderate ID (N = 60)	10–15		30–55	Free recall	Impaired	Impaired	Impaired
	TD (N = 60)	10–15		120	Elaboration: Non semantic (recall names)-semantic (name and the use)-cluster (name and category)			
					Relocation			
					Non semantic	Impaired	Impaired	Impaired
					Semantic cluster			
Dulaney and Ellis (1991)	ID	17.9		65	Visual modality	Acquisition	1 day	1 week
	TD	19		100	Recognition of pictures			
					Non semantic	Preserved	Impaired	Impaired
					Semantic	Preserved	Preserved	Preserved
					Location			
					Recognition of Non semantic	Preserved	Preserved	Preserved Preserved
					Recognition of Semantic	Preserved	Preserved	
Katz and Ellis (1991)	Moderate ID	12–19		48.1	Visual modality	Acquisition	1 day	
	TD	16–50		100	Free recall of pictures			
	Mild TD	14–20		67.3	Semantic/non semantic	Impaired	Impaired	
	TD	14–20		100	*Relocation of pictures*			
					Semantic/non semantic	Preserved	Impaired	
Takegata and Furutuka (1993)	ID	Adults			Visual modality		5 min	1 week
	TD	Adults			Recognition test		Impaired	Impaired
Dobson and Rust (1994)	Mild ID	15	9.88	64.8		1 week	1 month	2 months
	TDMA	9.61	9.88		Face recognition	Preserved	Preserved	Preserved
	TDCA	15.80	15.80*		Picture recognition	Preserved-TDMA	Preserved-TDMA	Impaired-TDMA
						Impaired-TDCA	Impaired-TDCA	Impaired-TDCA
Gordon, Jens, Hollings, and Watson (1994)	ID (N = 23)	8–13	6	57	Performed/imagined activities	Acquisition	6 weeks	
	TD (N = 23)	6–7	6.2	96	Free recall of performed/imagined activities	Impaired	Impaired	
					Open- End que	Preserved	Preserved	
					Specific ques	Impaired	Impaired	
					Misleading		Impaired	
Dulaney et al. (1996)	ID(22)	35		49	Visual	Acquisition	1 day	
	TD(20)	35		100	Recognition	Impaired	Impaired	
					Location memory			
					Visual recognition	Impaired	Impaired	

Table 1 (*Continued*)

Article name	Group	CA (mean or range)	MA (mean or range)	IQ (mean or range)	Explicit measures The tests and the modalities	Results		
						Time 1	Delay 1	Delay 2
Perrig and Perrig (1995)	ID (N = 19)	12.6	6.9		Visual modality			
	TD (N = 14)	6.2	6.2		Free recall		Preserved	
					Recognition		Preserved	
Komatsu et al. (1996)	ID (N = 21)	14–20	6–13		Verbal modality		Immediately	
		18–30			Free recall of:			
	TD younger (N = 27)				Reading word (visual)		Preserved	
	TD older (N = 21)	6–8			Generated word		Impaired	
		18–23						
Turner et al. (1996)	ID (N = 31)	10.2		65	Visual modality	1 year	2 years	3 years
	TD (N = 33)	9.9		109	Free recall of:	Impaired	Impaired	Impaired
					readiness repetition (num of items)			
					Circular recall (change in item order)			
					Categorization recall			
Carlesimo et al. (1997)	ID (N = 15)	16	9.1		Verbal modality	Acquisition	15 min	
	TD (N = 30)	9.1	9		Free recall	Impaired	Impaired	
					Recognition		Impaired	
					Prose recall		Impaired	
					Spatial memory			
					Rey figures		Impaired	
Vakil et al. (1997)	ID (N = 26)	18.58	9.6	60.23	Visual modality	Acquisition	Immediately	
	TD (N = 27)	10.70	11.2		Visual paired assessment	Impaired	Impaired	
					Rey AVLET-free recall	Impaired	Impaired	
					Recognition	Impaired	Impaired	
Wyatt and Conners (1998)	ID (N = 20)	6–8		45.8	Visual modality	Training	5 min	
		10–12		57.3	Free Recall of Fragment pictures	Preserved	Impaired	
		15–17		55.3				
	TD (N = 20)	6–8		86.8				
		10–12		87.6				
		15–17		84.5				
Michel, Gordon, Ornstein, and Simpson (2000)	ID (N = 20)	11.7	6.3		Situation of health check - vis	Acquisition	6 weeks	
	TDMA (N = 20)	6.3	6.7		Free Recall of personally experince event of			
	TDCA (N = 20)	11.7	13.5		health check	Preserved- TDMA	Preserved- TDMA	
						Impaired-	Impaired-	
					Open Ended ques	TDCA	TDCA	
						Preserved- TDMA	Preserved- TDMA	
					Elaborated ques.	Impaired-	Impaired-	
					Intusions	TDCA	TDCA	
					Suggestability	Impaired-		
						TDMA, TDCA		
Cherry et al. (2000)	Mild ID (N = 6)	40.7		40.7	Recognition of sentences with three types of		Immediately	
	Moderate ID (N = 16)				elaboration (base, arbitrary, explanatory) with		Impaired	
	Sever (N = 2)	34.4		100	Retrieval support Low/High			
	TD (N = 24)						Impaired	
Fletcher et al. (2000)	ID	9	6	60	Visual modality		Immediately	
	Gifted	9	12	120	Discover the rule under pictures' allocation			
	TD	6	11	100			Impaired	
	TD	12	14	100				

Table 1 (*Continued*)

Article name	Group	CA (mean or range)	MA (mean or range)	IQ (mean or range)	Explicit measures The tests and the modalities	Results		
						Time 1	Delay 1	Delay 2
Carlin et al. (2001)	ID (N = 16)	16	8.03		Visual modality	Acquisition	Immediately	
	TDMA (N = 16)	7.1	8.03		Free recall	Preserved- TDMA,	Preserved-TDMA	
	TDCA (N = 16)	17.10	17.10			TDCA	Impaired	
					Recognition		TDCA	
						Preserved- TDMA,		
						TDCA	Preserved	
							TDMA	
							TDCA	
Jones et al. (2002)	ID (N = 30)	18+		50–70	Vis modality		Immediately	
	TD (N = 30)	18+		100–120	Free recall of pictures		Impaired	
					Incidental/intentional			
					Relocation of pictures		Preserved	
					Incidental			
					Intentional		Impaired	
Atwell et al. (2003)	ID (N = 42)	17	9	60	Visual modality	Acquisition	Immediately	
	TD (N = 43)	19	19	104	Recognition of random sequence	Impaired	Impaired	
					in Artificial grammar paradigm task			
Gudjonsson and Henry (2003)					*Verbal modality*	*Acquisition*	*2 weeks*	
	Mild ID (child)	7.9		63.3	suggestibility	Impaired	Impaired	
	Moderate ID (chi)	6.4		46.8				
	TD	12.9		<75				
	Mild Adults	30		67.4		Impaired	Impaired	
	Moderate Adults	30.6		49.6				
	TD	30.6		94.4				
Henry and Gudjonsson (2003)	Mild ID (N = 30)	11.11	8.3	65.57	Visual-live scene	Acquisition	2 weeks	
	TDMA (N = 14)	7.11	8.6	106.64	Free recall + General quest.	Preserved- TDMA	Preserved-TDMA	
	Moderate. ID (N = 17)	11.10	6.3	45.47		Impaired-	Impaired-	
	TDMA (N = 14)	6.6	6.8	100.64		TDCA	TDCA	
	TDCA (N = 25)	11.11	13	104.52				
					Open ended miss leading	Preserved- TDMA,		
						TDCA		
					Gudjonson suggestibility scal		Preserved- TDMA	
					Free recall			
					Interrogative sugges shiftt		Impaired-	
							TDCA	
Vinter and Detable (2003)	Mild ID (N = 11)	7.67	4.58	50–69	Motor modality	Acquisition	3 min	
	TD (N = 12)	4.83	4.75	100	Discover the rule that governed	Impaired	Impaired	
	Mild ID (N = 19)	13.25	7.42	50–69	The Trace task (Start Rotation	for MA and	for MA and CA matched	
	TD	7.42	7.50	100	Principal) tracing task (Clock	CA matched		
	Moderate ID (n = 10)	8.17	3.67	30–49	wise-counterclockwise) and the			
	TD	4.08	4.08	100	Movement rotation (Top/bottom)			
	Moderate (N = 18)	14.40	5.50	30–49				
	TD (N = 5)	5.50	5.50					
		5.50	5.50	100				
Agnew and Powell (2004)	Mild (N = 20)	11.04	6.8	56–75	Magic show scene -visual	Acquisition	3 days	4 days
	TDMA (N = 53)	6.87	6.8	100	N. of items (3 days after)	–	Preserved	
	TDCA (62)	10.66	10.6	100	Correct items		Impaired	Preserved
	Moderate ID (N = 22)	12.03		>55	Free narative			Impaired
	TDMA (N = 19)	6.08	6.87	100	Specific cued recall (leading)			Impaired
	TDCA (N = 14)	11.58	10.47	100	Forced-choice			

Table 1 (*Continued*)

Article name	Group	CA (mean or range)	MA (mean or range)	IQ (mean or range)	Explicit measures The tests and the modalities	Results		
						Time 1	Delay 1	Delay 2
Henry and Gudjonsson (2004)	Mild ID	12.2	7.11	59.68	Video clip-visual	Acquisition	1 day	
	Moderate ID	12.4	6.6	45.81	Weaker/stronger trace condition	–	Impaired Impaired	
	TD	12.7	13.6	105.11	Free recall			
					General ques.			
					Open ended non leading/miss		Preserved	
					Closed Leading/miss leading		Preserved	
Simon et al. (2005)	ID (N = 13)	28.4	9.3		Location memory	Acquisition	Immediately	
	TD (N = 13)	24	24		Concrete objects	–	Impaired	
Henry and Gudjonsson (2007)	Mild ID (N = 18)	8–9	5.5	69	Video clip of visual scene	Acquisition	*2 weeks*	
	TD (N = 18)	9	9.5	101		–		
	Moderate ID (N = 16)	12	6.7	58	General question		Impaired	
	TD (N = 18)	12	12	98	Non/miss leading questions		Impaired Preserved	
					Correct yes/no questions			
Alevriadou (2010)					Location of physical activities	Acquisition	immediately	
	ID (N = 30)	9.5	7.8		(Free recall) Intent. position + Intent	–		
	TD (N = 30)	7	7.7		exercise Intent. position + Incid. exercise		Impaired	
					Incid. position + Incid. exercise		Impaired	
							Preserved	
Van de Molen, Van Luit, Van de Molen and Jongmans (2010).	ID (N = 39)	15.1	9.8		Every day Verbal modality	Acquisition	20 min	
	TDMA (N = 39)	10.36	10.5		Story recall	–	Impaired TDCA	
	TDCA (N = 39)	15.25	15.2				Impaired TDMA	
					Visual modality			
					Photo recognition		Preserved TDCA	
					Location memory		Preserved TDMA	
					Route recall		Impaired TDCA	
							Preserved TDMA	

ID = Intellectual disability with non specific etiology, TD = Typically developed, CA = Chronological age, MA = Mental age, TDMA = Typically developed matched control based on mental age; TDCA = Typically developed matched control based on CA, Inten = intentional, Incid = incidental.

Table 2
Explicit memory studies among WS etiology and TD controls according to CA, MA, type of test, modality and findings.

Article authors	Group	CA (mean/range)	MA (mean/range)	IQ (mean/range)	Explicit measures The tests and the modalities	Results		
						Time 1	Time 2	Time 3
Vicari et al. (1996a)	WS	10.12	5		Verbal modality	Acquisition	15 min	30 min
	TD	5.38	5		Free recall		Impaired	
					Primacy + Mid list	Impaired		Impaired
					Recency		Impaired	
					Recognition	Preserved		
					Visual modality		10 min	
					Rey test – Copy	Impaired		
					Delay		Impaired	
Vicari et al. (2001)	WS (N = 12)	11–19	6.5			Acquisition	Immediately	10 min
	TD (N = 12)	6	6.7		Free recall;	–	Preserved	
					Pictures recognition			Preserved
					Words recognition			Preserved
Nichols et al. (2004)	WS (N = 23)	15.2	14.74	2.5		Acquisition	Immediately	20 min
	TD (N = 29)	9.5	15.01	11	Free recall of words	Preserved	Impaired	Impaired
				(scales scores of	Cued recall			Impaired
				Block design)	Recognition			Impaired
Vicari (2004)	WS (N = 14)	14.7	6.5		Verbal and Visual modalities	Acquisition	Immediately	
	TD (N = 32)	6.5	6.5		Free recall of words	–	Preserved	
					Words recognition		Preserved	
					Pictures recognition		Preserved	
Vicari et al. (2005)	WS (N = 15)	8.7–30	6.8		Visual modality	Acquisition	Immediately	
	TD (N = 15)	6.7	6.7		Recognition of objects	–	Preserved	
					Recognition of spatial location		Impaired	
Brock et al. (2006)	WS (N = 11)	13.8	9.3		Verbal modality	Acquisition	Immediately	
	TD (N = 24)	6.1	6.1		Experment 1:			
					Free recall in three conditions	Preserved	Preserved	
					New words condition	Preserved	Preserved	
					Repeated word (crder of items	Preserved	Preserved	
					changed), Repeated items (same			
					order in each trial)	Preserved	Preserved	
					Recency > Mid list + primary			
					Experment 2: Overt rehearsal	Preserved	Preserved	
					Free recall of new words	preserved	Preserved	
					Primacy > Recency + mid list			
Jarrold et al. (2007)	WS (N = 15)	17		53	Verbal modality	Acquisition	Immediately	
	TD (N = 110)	7.5		110	Free recall (People test)		Impaired	
					Recognition (Name test)		Impaired	
					Visual modlaity			
					Free recall (The door test)		Impaired	
					Recognition (Shap test)		Impaired	
					Covariation with the PPVT			
					Verbal recall		Impaired	
					Verbal recognition		Preserved	
					Visual recall		Impaired	
					Visual recognition		Preserved	
					Covariation with the Raven test			
					Verbal recall		Preserved	
					Verbal recognition		Preserved	
					Visual recall		Impaired	
					Visual recognition		Preserved	

WS = William Syndrome, TD = Typically developed, CA = Chronological age, MA = Mental age.

Table 3
Explicit memory studies among DS etiology and TD controls according to CA, MA, type of test, modality and findings.

Article name	Etio	CA (mean or range)	MA (mean or range) Verbal IQ	IQ (mean or range) Raven	Explicit measure The tests and the modalities	Results		
						Time 1	Time 2	Time 2
Dulaney et al. (1996)	DS(24)	35		49	Visual	Acquisition	1 day	
	TD(20)	35		100	Recognition	Impaired	Impaired	
					Location memory			
					Visual	Impaired	Impaired	
Zucco et al. (1995)	DS(15)	20.9	11.6	55	Location memory	Acquisition	1 week	
	TD(15)	11	11.6	100	Visual modality			
					Pictures		Impaired	
					Nonsense pictures		Impaired	
					Verbal modality			
					Concrete words		Impaired	
					Abstract words		Impaired	
Carlesimo et al. (1997)	DS (N = 15)	17	9.7		Verbal modality	Acquisition	15 min	
	TD (N = 30)	9	9		Primacy + recency > mid list	Impaired	Impaired	
					Free recall		Impaired	
					Recognition		Impaired	
					Prose recall		Impaired	
					Visou-perceptual modality			
					Rey's figure		Impaired	
Mattson and Riley (1999)	DS (N = 11)	8.5–18		40–50	Verbal modality	Acquisition	Immediately	
	TD (N = 42)	9.3–16		92–141	Free recall test	–	Impaired	
					Recognition		Impaired	
Vicari et al. (2000)	DS (N = 14)	21	6.5		Verbal and visual modality	Acquisition	Immediately	
	TD (N = 20)	5.09	6.3		Free recall (words + photos)	Impaired	Impaired	
					Word recognition		Impaired	
					Picture recognition		Impaired	
Nichols et al. (2004)	DS (N = 14)	15.2	14.74	3		Acquisition	Immediately	20 min
	TD (N = 29)	9.5	15.31	11	Free recall of words	Impaired	Impaired	Impaired
				(scaled scores of Block design)	Cued recall			Impaired
					Recognition			Impaired
Pennington et al. (2003)	DS	14.68	4.5		Verbal modality	Acquisition	(30 min)	
	TD	4.92	4.5		NEPSY List Learning Test			
					(Korkman, et al., 1998)	Impaired	Impaired	
					Free recall			
					Visual modality			
					CANTAB (Fray et al., 1996)	Impaired	Impaired	
					Recognition			
					Pair associates learning	Impaired	Impaired	
					Location memory			
					Water maze	Impaired	Impaired	
Vicari (2004)	DS (N = 14)	21	6.5		Verbal and Visual modalities	Acquisition	Immediately	
	TD (N = 32)	6.5	6.5		Free recall of words	–	Impaired	
					Words recognition		Impaired Impaired	
					Pictures recognition			
Simon et al. (2005)	DS(14)	30.2	7.8		Location memoey		Immediately	
	TD(14)	24	24		Concrete objects		Impaired	

Table 3 (*Continued*)

Article name	Etio	CA (mean or range)	MA (mean or range) Verbal IQ	IQ (mean or range) Raven	Explicit measure The tests and the modalities	Results		
						Time 1	Time 2	Time 2
Vicari et al. (2005)	DS (N = 15)	10.10–29.7	5.4		Visual modality	Acquisition	Immediately	
	TD (N = 15)	5.7	5.7		-Recognition of Visual spatial	–	Preserved	
					-Recognition of Visual object		Impaired	
Jarrold et al. (2007)	DS (N = 20)	13.9		35	Verbal modality	Acquisition	Immediately	
	TD (N = 110)	7.5		110	Free recall (People test)		Impaired	
					Recognition (Name test)	–	Impaired	
					Visual modlaity			
					Free recall (The door test)		Impaired	
					Recognition (Shap test)		Impaired	
					Covariation with the PPVT			
					Verbal recall		Preserved	
					Verbal recognition		Preserved	
					Visual recall		Impaired	
					Visual recognition		Preserved	
					Covariation with the Raven test			
					Verbal recall		Preserved	
					Verbal recognition		Preserved	
					Visual recall		Impaired	
					Visual recognition		Preserved	
Visu-Petra et al. (2007)	DS (N = 25)	14.5	5.9		CANTAB (Fray et al., 1996)	*Acquisition*	30 min	
	TD (N = 25)	5.6	5.6		Verbal modality			
					paired associates learning		Impaired	
					Visual modality			
					Recognition		Impaired	
					Location memory		Impaired	
					Recognition			

DS = Down Syndrome, TD = Typically developed, CA = Chronological age, MA = Mental age.

Table 4
The impact of three groups of moderators on explicit memory performance of participants with NSID, WS and DS.

	Participants' background				Encoding stage										Retrieval stage			
	Matching between ID and TD				Type of task						Instructions							
	CA		*MA*		*Verbal*		*Visual*		*Strategy*		*Intentionally*		*Practice*		*Prompting*		*Trails*	
	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.	No. of exp.	Impact of mod.
NSID																		
Recognition 50%/14	8	(25%)	6	(100%)	7	0	7	100%	4	50%	7	3(42%)	3	100%				
Free recall 27%/22	15	0	7	6(85%)	14	0	8	75%	3	67%	3	2(66%)	1	100%	3	100%	2	50%
Spatial memory 37%/13	9	(3)27%	4	50%	–	–	13	37%			5	3(60%)	2	1(50%)			.	
Questions	3	1	4	3														
William syndrome																		
Recognition 69%/13	–		13	61%	7	0	6	100%	–		–		–					
Free recall 50%/14	–		14	50%	7	0	7	100%	1	100%	1	100%	1	100%			3	66%
Spatial memory 25%/8	–		8	25%	–		8	25%	–		–		2 (copy)					
Down syndrome																		
Recognition 29%/14	1	0	13	15%	6	(16%)	8	(12%)		0							4	0
Recall 10%/10	–		10	10%	11	(9%)	5	0	1	0								
Visual spatial 22%/9	1	0	8	2(25%)	–	–	9	3(33%)	–	–								

Note. No. of exp.—The total number of research articles that examined the potential moderator, b) Impact of mod.—The number of articles that performance was influenced by the specific moderator.Matching acc. To CA– Matching according to Chronological Age, Matching acc. to MA – Matching according to mental age.

(RCF) (Rey, 1968) among individuals with nonspecific ID (Vakil, Shelef-Reshef, & Levy-Shiff, 1997).

5.1.2. Moderators related to the encoding stage

Modality (encoding stage). In all MA-matched studies in which memory performance of individuals with ID was preserved, the task was of the visual type. Memory performance of auditory tasks was preserved only when accompanied by visual scaffolding (the examiner showed pictures while reading the word list). However, visual tasks do not guarantee preservation of memory.

Strategy use in recognition and free recall. Four studies examined strategy use during recognition, but only two (Carlin et al., 2001; Dulaney & Ellis, 1991) yielded equal performance of individuals with ID and TD. In Atwell, Conners, and Merrill (2003) and in Cherry, Njardvik and Dawson (2000), the control group was matched by CA. Dulaney and Ellis (1991) manipulated two procedures of picture recollection: in the first, participants were exposed to pictures that were related semantically to each other, and in the second, the pictures were not related to each other. Equal performance was found among individuals with ID and with TD only when using the semantically related pictures.

Of the three experiments (Atwell et al., 2003; Carlin et al., 2001; Komatsu, Naito, & Fuke, 1996) that manipulated strategies during free recall (MA-matched), the memory of individuals with ID was preserved in only one. Carlin et al. (2001) manipulated fade-in and fade-out procedures. Equal performance was achieved in the fade-in procedure where participants were likely to generate possible solutions prior to identifying the clear pictures. The authors claimed that the enhanced free recall stemmed from the availability of additional retrieval cues generated in the encoding process during fade-in.

Intentional learning. The results are inconsistent. In Dulaney and Ellis (1991), picture recognition was preserved in the intentional condition, whereas Jones, Vaughan, and Roberts (2002) found that memory was preserved in the incidental condition (the groups were CA-matched in both experiments).

Practice: Memory was preserved in all experiments that manipulated the training stage.

Prompting: Memory was preserved in all experiments that manipulated this moderator (encouraging participants to keep remembering after they stop giving answers). In Dobson and Rust (1994), participants were prompted to continue the task until they reached the 100% criterion.

Spatial memory: Spatial memory was preserved in 38% of 13 experiments (Table 4). In all but one study (Dulaney & Ellis, 1991), individuals with ID exhibited poorer performance than CA-matched peers. When matching was based on MA, performance was preserved in 50% of four experiments. Individuals with ID failed to discover the rules that governed the Start Rotation Task (Vinter & Detable, 2003) and picture allocation (Fletcher, Mayberry, & Bennett, 2000). These tasks require a high level of abstract thinking and expressive language, which impose a heavy burden on memory. As for intentional/incidental learning, in Dulaney and Ellis the performance of participants with ID was preserved under the intentional condition where the nature and purpose of the test were explained prior to the practice phase, whereas Jones et al. (2002) found that individuals with ID succeeded more in the incidental task. In the intentional condition the participants were asked to remember the objects' location, whereas in the incidental condition they were asked to determine whether the objects would fit into a small box. Jones et al. (2002) claimed that deciding whether the object would fit into the box provided a strategy that contributed to their success. Practice yielded contradicting results (Dulaney & Ellis, 1991; Vinter & Detable, 2003). As for strategy use, in Dulaney and Ellis one group of participants had to relocate pictures that were related semantically (objects that are used every day), and the other group had to relocate pictures that were not related semantically. The authors concluded that strategy use did not affect location memory, whereas Thomas (1990) found the opposite.

5.1.3. Moderators related to the retrieval stage

Type of test (most explicit memory studies in populations with ID used recall/recognition tests). Recognition was preserved in 50% (14 experiments). In all of the preserved experiments, the number of old items and new distracters in forced-choice testing were equal. In all of the impaired experiments, the number of new items exceeded the number of old items. Individuals with ID exhibit limitation in dealing with several aspects of a cognitive task simultaneously, and difficulty in figure-ground perception (Campione & Brown, 1984; Reed, 1996). Multiple distractions (additional new distractor items) prevent them from selecting the relevant stimulus.

Free recall in individuals with nonspecific ID was preserved in 27% of 22 experiments, but only in visual tasks and in experiments in which matching between the ID and TD groups was based on MA. In all experiments in which memory was impaired, memory was examined by the auditory modality (words, sentences, stories).

The length of the word list or the pictures (15–88), the length of the delay (2 min to one month) and the duration of exposure to the materials did not influence performance in recognition and free recall tests. Four studies employed the same moderators: CA-based match, semantic strategy, practice and prompting. In those studies, the recognition of participants with ID was preserved (Dulaney & Ellis, 1991). This was not the case for free recall (Katz & Ellis, 1991; Thomas, 1990; Turner et al., 1996).

Immediate versus delayed tests. The time of testing varied between immediate recall conducted just after learning (acquisition) and delayed recall. This procedure enabled determining whether differences between participants with ID and their TD controls lie in the acquisition or the retrieval stage. Only 22 of the reviewed experiments examined memory performance at both time points. In 36% of the experiments, the memory of participants with ID was preserved in both stages (for recall, recognition and location memory). In 22%, the memory of participants with ID was preserved only in the immediate test but not in the delayed test. In Carlesimo, Marotta, and Vicari (1997), participants with ID exhibited superiority over their TD peers in recall of semantic words in the acquisition test. The authors attributed the advantage of individuals with ID to their CA (more years of schooling and life experience, see discussion section). However, their advantage in the immediate test disappeared after a delay. In Henry and Gudjonsson (2003), individuals with ID improved their performance when moving from the immediate test to the delayed test. In the remaining studies (40%), the performance of participants with ID was impaired in both time tests.

Short term memory versus *long term memory*. The serial position curve in individuals with nonspecific ID was examined in three experiments. The recency effect in free recall is assumed to reflect the output of the short-term store, because it is removed by the addition of a short delay between presentation and recall (e.g., Glanzer & Cunitz, 1966). In contradistinction, primacy effects are assumed to arise because early presented items are rehearsed more often (Rundus, 1971; Tan & Ward, 2000) and this increases their chances of entering the long-term store. The mid-list items form the asymptotic part of the curve and are generally considered a reliable index of the ability to store new information in the LTM.

Carlesimo et al. (1997) reported that participants with ID scored lower than MA-matched peers on the primacy and mid-list, but performed similarly on the recency part of the list. This suggests that participants with ID exhibit a deficit in LTM, in contrast to STM which was relatively preserved. In Carlin et al. (2001), participants with ID and participants with TD matched by MA and CA exhibited a recency effect but not a primacy effect. Turner et al. (1996) examined the serial position curve in seven learning trials among individuals with ID and TD with the same CA. Seven pictures of common objects were presented in each trial. In both groups, the number of pictures recalled in the seventh trial (which is a recency item) was greater than in trials 1–6, trial 6 was greater than 1–5, trial 5 was greater than trials 1–3, position 4 was greater than 2–3, and position 1 was greater than position 2. This pattern reflects the use of cumulative rehearsal in both groups (Turner et al., 1996).

Learning trials. Only two experiments examined learning rates in individuals with nonspecific ID (matching between ID and TD groups by MA). Vakil et al. (1997) used the Rey AVLT and found superior performance by individuals with TD even in the first trial. However, both groups exhibited a similar learning curve pattern over five trials. Carlesimo et al. (1997) found that participants with ID exceeded their MA-matched peers along five trials. They attributed this superiority to the participants' maturity and life experience.

5.2. *Individuals with Williams syndrome*

Moderators related to the participants. All the experiments used MA-based matching. Individuals with Williams syndrome were in the mild ID range. The effect of CA was not examined.

5.2.1. *Moderators related to the encoding stage*

Modality. Although the Williams syndrome etiology exhibits phonological and verbal strength (Bellugi & Wang, 1998), their performance was impaired in auditory tasks where a word list was only read by the examiner. However, their memory was preserved when the word list was accompanied by pictures or word cards (Vicari, Brizzolara, Carlesimo, Pezzini, & Volterra, 1996a; Vicari, Bellucci, & Carlesimo, 2000; Vicari, Bellucci, & Carlesimo, 2001).

Strategy use/deep processing. One study manipulated strategy during free recall. In Brock, Brown and Boucher (2006), participants with Williams syndrome and TD were taught to use a cumulative rehearsal strategy. Both groups exhibited a primacy effect.

Spatial memory. It is well documented that the Williams syndrome etiology exhibits a global impairment in manipulating visual-spatial information (Jarrold, Baddeley, & Phillips, 2007). In Jarrold et al. (2007), participants with Williams syndrome exhibited poorer performance in recall and recognition of visual-spatial tasks (shape and door tests; Baddeley, Emslie, & Nimmo-Smith, 1994). However, when scores were standardized on the basis of intelligence as determined by performance on the Raven Standard Progressive Matrices (SPM, Raven, 1983), the difference in the spatial recognition test seemed to disappear, whereas the deficit in the shape test remained. According to Jarrold et al. (2007), the deficit of participants with Williams syndrome in the shape test, which is a visual-spatial test, lies in their barriers in copying and drawing.

5.2.2. *Moderators related to the retrieval stage*

Recognition and free recall. Recognition was preserved in 69% (of 13 experiments, Table 4) and free recall in 50% (of 14 experiments). In the preserved recognition experiments, the number of old items and new distracters were equal. In all the impaired experiments, the number of new distracters exceeded the old items. Performance was preserved only in visual tasks or visual scaffolding in auditory tasks in recall and recognition.

Immediate versus *delayed tests*. Nichols et al. (2004) found that recall of a word list in individuals with Williams syndrome was preserved in the immediate test but was poor in the delayed test. Another argument regarding the Williams syndrome etiology is their performance in STM and LTM. Vicari et al. (1996b) and Brock et al. (2006) claimed a dissociation between STM and LTM. When examining the serial position curve, Vicari et al. found that both individuals with Williams syndrome and with TD exhibited a recency effect, but only individuals with TD also exhibited a primacy effect. Brock et al. (2006) found superiority of the recency items over the primacy and mid-list items among participants with Williams syndrome and with TD. However, when both groups engaged a cumulative rehearsal strategy, both exhibited a primacy effect.

Learning rate. Vicari et al. (2005) found that individuals with Williams syndrome exhibited the same learning rate in three trials as their TD peers in the visual-object task, but not in the visual-spatial task. Brock et al. (2006) compared free recall among individuals with Williams syndrome and MA-matched peers under three conditions: new words (different words in each trial), repeated words (same words but different order) and repeated list (the same words/order). Individuals with Williams syndrome demonstrated improvement in the three conditions over five trials. Nichols et al. (2004) found that individuals with Williams syndrome performed poorer in the five trials. However, the differences between the ID and TD groups should be treated with caution, due to differences in the basic intelligence level between the groups, according to the Block design test.

5.3. *Individuals with Down syndrome*

Moderators related to participants. MA-based matching was used in all except one experiment.

5.3.1. *Moderators related to the encoding stage*

Modality. In most of the experiments, participants with Down syndrome exhibited poorer performance in auditory and visual tasks across all test types (recall/recognition) compared to participants with TD. However, Vicari et al. (2005) indicated dissociation between more preserved visual-spatial tasks and greater impairment of visual-object tasks in this etiology. In Jarrold et al. (2007), participants with Down syndrome were found to have impaired recall and recognition in auditory and visual modalities compared to participants with TD with the same CA. Due to differences between participants with Down syndrome and TD controls in verbal MA (according to Peabody Picture Vocabulary Test, PPVT, Dunn & Dunn, 1997) and visual intelligence tests (Colored Progressive Matrices, CPM, Raven, 1983), co-variations were performed for recall and recognition once with PPVT as a covariate and once with the CPM. The findings indicated that the deficit of participants with Down syndrome in the auditory tasks disappeared (recall and recognition). The preserved recall was attributed by Jarrold et al. (2007) to the fact that this task requires recall of relatively familiar names. Furthermore, the participants received visual scaffolding, suggesting that compensatory mechanisms may support long-term verbal learning in this etiology. However, they obtained lower scores in the visual-spatial recall test even after covariation with the PPVT and SPM tests. A possible reason might be the drawing difficulties which are at the origin of this etiology (Jarrold et al., 2007).

Spatial memory. Vicari et al. (2005) indicated more preserved visual-spatial tasks but greater impairment in visual-object tasks in this etiology. Pennington, Moon, Edgin, Stedron, and Nadel (2003) found poorer performance of participants with Down syndrome in the Water Maze test and Visu-Petra, Benga, Tincas and Miclea (2007) indicated lower performance of this etiology in all visual-spatial tasks (CANTAB, Cambridge Neuropsychological Test Automated Battery, Fray, Robbins, & Sahakian, 1996). However, in those tasks the participants had to learn associations between an *abstract* visual pattern and its location. This is a complex task which places a great burden on memory resources. However, three studies (Dulaney, Raz, & Devine, 1996; Simon, Watson, & Elliott, 2005; Zucco, Tessari, & Soresi, 1995) found poorer performance of individuals with Down syndrome compared to their typical development controls even in recalling the location of concrete objects. Note, that matching between the Down syndrome group and their controls was based on CA, which disadvantages the former group.

5.3.2. *Moderators related to the retrieval stage*

Recognition/free recall. Performance under recognition tests was preserved in 30% (of 13 experiments) while performance under free recall tests was preserved only in 20% (of 10 experiments) when matching with the controls was based on MA. That is, the explicit memory of individuals with Down syndrome is not totally impaired, and in some conditions their memory might be preserved (see above, in the modality paragraph).

Strategy use/deep processing. One study employed strategy use among individuals with Down syndrome (Carlesimo et al., 1997): Participants were asked to recall semantic and non-semantic words. The participants with Down syndrome did not gain from the semantic strategy. However, in this study the words were presented orally by the examiner, without visual scaffolding.

Immediate versus *delayed tests*. Participants with Down syndrome exhibit a deficit in explicit memory in the acquisition as well as in the retention stages. As for STM and LTM, Carlesimo et al. (1997) tapped the effect of the serial position curve, where individuals with Down syndrome scored lower than those with TD in the primacy and recency lists.

Learning rate. Individuals with Down syndrome did not gain from learning trials (Table 4). Carlesimo et al. (1997) stated that this phenomenon documents a particular difficulty in the use of semantic strategies and spared semantic elaboration in the Down syndrome etiology. Nichols et al. (2004) claimed that the language deficit exhibited by individuals with Down syndrome in the five trials is more severe than their global delays.

6. Discussion

The explicit memory performance of individuals with ID *is context-sensitive*, similarto that of the general population (Jenkins, 1979; Roediger, 2008), and depends on three kinds of moderators that were/were not employed in the experiments. The three kinds of moderators include sub-moderators: (a) Moderators related to participants (sub-moderators: etiology, criterion for matching ID and TD groups [CA or MA], level of intelligence including type of intelligence test used to compare between ID and TD controls); (b) Moderators related to the encoding stage (sub moderators: task modality [auditory/visual/visual-spatial], strategy use and mode of administration [practice and prompting], learning trials); (c) Moderators related to the retrieval stage (sub-moderators: type of test [recall/recognition], immediate versus delayed tests).

Our claim is that only an interrelation between the three moderators (participants, encoding and retrieval) provides an accurate picture of explicit memory in individuals with ID. As stated, this review was conducted on three etiologies of ID, and each etiology exhibits a different cognitive and neuroanatomical profile. Some of the moderators have the same influence on memory performance beyond etiologies (effect of CA), while others have a different effect. We will relate to moderators related to the participants and then to the effect of other moderators in each etiology.

6.1. *Moderators related to the participants*

The influence of chronological age on explicit memory. The effect of this moderator was drawn from studies that examined the influence of CA and from the matching between individuals with ID and TD controls (CA or MA). The influence of CA on explicit memory was examined in four experiments only in the nonspecific ID etiology. The findings indicate an increase in memory between 6 and 12 years and stability in the ages of 15–17, which correlates with the memory trajectory in the general population. Vakil, Blachstein, and Sheinman (1998) examined the norms for children using the Rey AVLT. Memory changes in 8–10 year-olds were found to be more dynamic than in 11–17 year-olds. Paris (1978) claimed: "Until the age of 7 or 8, children do not ordinarily elaborate and transform stimuli that are to be recalled later. Older children, 11 or 12 years of age, begin to rearrange items and construct additional relationships spontaneously, as adults commonly do" (p. 153). Caution should be exercised, however, because our conclusion is based on very few studies.

Our review indicates that CA plays an important role in determining memory performance. This claim emerges from the difference in performance when selection of the control group was based on MA rather than CA. In most studies that matched individuals with ID and controls by CA, individuals with TD outperformed those with ID. When matching is based on MA, the participants with ID are older than their TD peers. Carlesimo et al. (1997) and Facon and Facon-Bollengier (1999) stated that CA determines the cognitive ability of individuals with ID beyond their MA. The longer exposure to linguistic and academic experiences of adolescents with ID may explain their more efficient use of semantic strategies. This claim was supported by other studies (Lifshitz & Katz, 2009; Lifshitz, Tzuriel, Weiss, & Tzemach, 2010) that found higher performance of adults with ID than adolescents with ID with the same MA. This implies that CA influences cognitive ability beyond MA.

The influence of intelligence on explicit memory. Jarrold et al. (2007) found that despite the strength of the Williams syndrome etiology in linguistic skills, their verbal memory appeared to be below the level predicted by a verbal MA test as drawn from the PPVT (Dunn & Dunn, 1997), but at approximately the same level as predicted by the nonverbal CPM (Raven, 1983) which is considered as a measure of the *g* general intelligence (Spearman, 1927). Jarrold et al. stated that free recall tasks rely on metacognitive strategies and may be linked to general levels of intellectual functioning. The discrepancy between the actual verbal memory score and the expected score according to the verbal MA in Williams syndrome would probably disappear if other measures of verbal MA were employed (Brock et al., 2006).

Conversely, when scores are standardized for MA based on the PPVT rather than on the CPM, individuals with Down syndrome did not show impairment in verbal memory tasks. This finding contrasts with previous evidence of impaired verbal LTM in Down syndrome (Nichols et al., 2004; Pennington et al., 2003). However, in these studies matching between individuals with Down syndrome and TD was based on general intelligence. Given that verbal abilities tend to lag behind nonverbal skills in this etiology, matching for an average of verbal and nonverbal skills disadvantages individuals with Down syndrome on verbal memory tasks (Jarrold et al., 2007). Henry and Gudjonsson (2004) argue that MA is a better predictor of explicit memory performance for eyewitness questions than verbal and nonverbal IQ. However, some scholars claim that MA develops more slowly in individuals with ID (Ellis, 1978). Thus, the same MA in individuals with and without ID may be qualitatively different. Jarrold et al. (2007) stated that MA tends to be a stronger predictor of performance than is IQ, but IQ may be more important in predicting performance of explicit memory tasks. Resolving this conflict is beyond the scope of this review.

6.2. *The influence of etiology on explicit memory*

What is the explicit memory phenotype of individuals with nonspecific ID? Experiments in this etiology are influenced by moderators related to the participants, to the encoding and to the retrieval stage. The big message of the present article is that in recognition, individuals with ID can achieve the same level of explicit memory expected from their CA (Carlin et al., 2001; Dulaney & Ellis, 1991) when all moderators in the encoding and retrieval stages are favorable (visual modality, equality between new/old items, strategy use, training, and prompting). This was not the case for free recall. Using the same moderators did not produce equality in free recall between individuals with ID and their CA-matched controls. 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. This finding supports the 'picture superiority' hypothesis (Dulaney & Ellis, 1991; Paivio, 1971), that processing visual information enables individuals with ID to develop the meaning behind the visual stimuli more than words alone.

Craik and Lockhart (1972) stated that items that are deeply processed have a greater chance of being retained. Dulaney and Ellis (1991) claimed that meaningful tasks facilitate retention even in individuals with ID. Can strategy use constitute a principle that dictates memory performance in individuals with ID? In agreement with Roediger (2008), our review indicates that the effect of strategies also depends on the type of test. Deep processing improves recognition. However, it was effective in only one (Carlin et al., 2001) of three free recall experiments that employed deep processing. Because of the small number of free recall experiments that employed deep processing, it is hard to draw conclusions on the effect of deep processing on free recall among populations with ID. Additional studies are needed in order to clarify this point.

The current review indicates that individuals with nonspecific ID exhibit difficulties in recall but have more preserved recognition. Their deficit lies mainly in the retrieval stage (Lezak, 1995), a characteristic also found in individuals with prefrontal dysfunction, such as depression, Huntington's or Parkinson's diseases (Hodge, Salmon, & Butters, 1992).

Spatial memory: The findings revealed deficits in spatial memory even when ID and TD groups were matched by MA. Contrary to Hasher and Zacks (1979), our argument is that encoding of location memory in individuals with nonspecific ID is mediated by non-automatic processes (Naveh-Benjamin, 1988) and is influenced by task demands (Vinter & Detable, 2003), strategy use and intentional learning (Alevriadou, 2010; Dulaney & Ellis, 1991), practice and prompting (Dulaney & Ellis, 1991). Dulaney et al. (1996) and Alevriadou (2010) argue that individuals with ID process location memory differently from the TD population. Caution should be exercised since this conclusion is based on only a few studies.

Does the deficit of individuals with nonspecific ID lie in the acquisition stage or retrieval in the LTM? In the results section we reported differences in memory performance in the immediate and the delayed tests as reflecting the testing paradigm. However, these two testing times reflect two different memory processes: the acquisition to and retrieval from LTM. Two explanations were suggested over the years for this dilemma: a deficit in acquisition and/or a retrieval deficit in the LTM (Belmont & Butterfield, 1974; Ellis, 1978; Reed, 1996). The common denominator between the two explanations is that individuals with ID exhibit a deficit in the information-processing learning stage. According to the acquisition explanation, their deficit lies only in the acquisition stage but not in the retrieval stage, as stated by Spitz and Borys (1984), "retarded and non-retarded groups usually differ in acquisition level – as measures by immediate recall – but not in the slope of retention over short intervals" (p. 333). The LTM explanation claims a deficit in both the acquisition and the retrieval stage. It is difficult to draw conclusions regarding the source of the deficit of individuals with ID from our study, since only 22 of the studies we reviewed related to both stages. Of them, 22% of the experiments support the "acquisition explanation" according to which performance of participants with ID was impaired only in the acquisition stage but not in the retrieval stage. 40% of the experiments support the LTM explanation, since the performance of participants with ID was impaired in both stages. In 36% of the experiments, performance of participants with nonspecific ID was preserved in the acquisition as well as in the retrieval stages, and this is the second message of this review. That is, when the above moderators were favorable, the performance of participants with ID was preserved in both the acquisition and the retrieval stage.

As for the gap between STM versus LTM: In studies that examined the serial position curve, individuals with nonspecific ID exhibited a recency effect but not a primacy effect, suggesting a deficit in the LTM.

What is the explicit memory phenotype of individuals with Williams syndrome? The encoding and retrieval moderators that governed explicit memory in the nonspecific ID etiology also influence the performance of the Williams syndrome etiology. Despite their relatively strong language skills (Jarrold, Baddeley, Hewes, & Phillips, 2001), memory was preserved only when receiving visual scaffolding along with hearing the verbal list (Brock et al., 2006; Vicari et al., 2001), suggesting that their verbal strength is limited. Similarly to participants with nonspecific ID, recognition was preserved only when the number of old and new items was equal. Recognition was more preserved than free recall, suggesting that their deficit lies mainly in the retrieval stage (Lezak, 1995). Other moderators, such as practice, intentional learning and prompting, were not employed in the memory experiments in this etiology. Our review supports other findings (Bellugi & Wang, 1998) according to which participants with Williams syndrome exhibit a deficit in spatial tasks in the encoding and the retrieval stages.

Does the deficit of individuals with Williams syndrome lie in the STM or LTM? Only one study examined performance immediately and after a delay. In this etiology, the argument is about their performance in STM versus LTM. The answer to this question depends on the task modality. Based on a deficit in the primacy effect, Vicari et al. (1996a) claimed "a dissociation between normal short-term memory and deficient long-term verbal memory in this etiology" (p. 510). Brock et al. (2006) attributed their poorer primacy effect to the 'rehearsal strategy', since when taught to use an accumulative rehearsal, they also exhibited a primacy effect. Regarding the visual-spatial modality, Vicari et al. (2005) suggested the 'reductionist hypothesis,' which postulates impaired perceptual processing or working memory maintenance of visual-spatial adaptation as well as a deficit in drawing and copying abilities (Bellugi, Lichtenderger, Jones, Lai, & George, 2000). Our claim is that the deficit of the Williams syndrome etiology in spatial tasks lies also in the encoding stage.

The neurocognitive profile of individuals with Williams syndrome can explain their relatively preserved recall and recognition. Their neuro-cerebellar volumes, volumes of the frontal cortex in relation to the posterior cortex, and limbic structures such as the amygdala and hippocampus are similar to those of people with TD (Bellugi & Wang, 1998). They have the same absolute volume of Heschel's gyrus, an area of the primary auditory cortex (Hickok et al., 1995) associated with the syndrome's characteristic strengths in language, auditory short and LTM. They have a marked reduction in posterior areas (Reiss, Eliez, Schmitt, & Straus, 2000). More pronounced difficulties in managing visual-spatial material could be related to particularly delayed maturation of the dorsal visual system compared to a relatively more preserved ventral component (Braddick, Atkinson, & Wattam-Bell, 2003).

What is the explicit memory phenotype of individuals with Down syndrome? Similarly to participants with nonspecific ID and participants with Williams Syndrome, the explicit memory of participants with Down syndrome was influenced by moderators related to participants, encoding and retrieval, but in other directions.

When matching between participants with William syndrome and their with TD controls was based on CA, the performance of participants with Down syndrome was impaired across task modality and test types. According to Pennington et al. (2003), the poor performance of the Down syndrome group in explicit memory domains supports the thesis of hippocampal dysfunction in this etiology.

Vicari et al. (2005) indicated dissociation between more preserved visual-spatial tasks and greater impairment of visual-object tasks in this etiology, which is also related to the brain phenotype. Individuals with Down syndrome present a relatively preserved maturation of the dorsal compared to the ventral component of the visual system, resulting in more preserved performance on visual-spatial tasks than on visual-object memory tests. The finding of particularly impaired visual-object learning in this etiology is inconsistent with the hypothesis that the dorsal tract is more vulnerable to brain damage during development than the ventral tract, irrespective of the etiology of the cerebral insult (Vicari et al., 2005).

When matching between participants with Down syndrome and their TD controls was based on MA, the results were inconsistent. It is documented that individuals with Down syndrome exhibit impaired linguistic skills (Byrne, Buckley, MacDonald, & Bird, 1995). Due to differences between participants with Down syndrome and TD controls in PPVT verbal MA (Dunn & Dunn, 1997) and SPM visual intelligence tests (Raven, 1983), covariations were performed for recall and recognition once with PPVT as a covariate and once with the SPM. The findings indicated that the deficit of participants with Down syndrome in the auditory tasks disappeared for recall and recognition. This is the third message of this review, which indicates that the performance of auditory LTM of participants with Down syndrome is not totally impaired.

Our review indicated inconsistent findings regarding the visual-spatial memory of participants with Down syndrome. Dulaney et al. (1996) suggested that spatial memory is more automatic than memory for visual or verbal content, and is therefore less impaired in persons with Down syndrome. However, our review is in agreement with the claim that spatial memory is mediated by non-automatic processes and varies with task demands (Naveh-Benjamin, 1988). In our opinion, the inconsistent performance of individuals with Down syndrome in visual-spatial tasks is associated with the complexity of the task. We suggest that the working memory vertical/horizontal model (Cornoldi & Vecchi, 2003) could be applied to explain the inconsistent findings of participants with Down syndrome in visual-spatial LTM. The *horizontal continuum* refers to modality, whereas the *vertical continuum* refers to the degree of control (task load) required in the task. Control may range from a simple rehearsal activity to complex demands: changing order, selection, inhibition, and transformation. The Water Maze test (Pennington et al., 2003) and the spatial task in Visu-Petra et al. (2007) which were impaired, were more complex and abstract than the task of only relocating objects, which was preserved (Vicari et al., 2005). Thus, the claim that individuals with TD perform better on visual-spatial tasks is not comprehensive, and depends on the task load.

7. Conclusions, limitations, and future research

This integrative research review aimed to find moderators that govern explicit memory performance of individuals with ID. This review suggests a triadic model of moderators related to the participants, to the encoding and to the retrieval stages. The interrelation between the moderators influences memory performance in the three etiologies. The findings led to three new insights. First, individuals with nonspecific ID can achieve the same level of recognition performance as individuals with TD with the same CA when the above-mentioned moderators are set to favorable values in the experiments. Second, when all of the above-mentioned moderators are set to favorable values in the experiments, the performance of participants with ID is preserved in the acquisition and retrieval stages. Third, our review indicates that the verbal LTM of participants with Down syndrome is not totally impaired.

Generally, only one or two moderators that were mentioned above were used as independent variables in the experiments that served as a basis for this review (the dependent variables were recall and recognition tests). It was therefore difficult to examine the weight of each moderator's contribution to recall and recognition performance of participants with ID. In future research we recommend setting all the above-mentioned independent variables together in order to empirically examine their contribution to the explained variance of explicit memory performance in the three etiologies.

Further studies of explicit memory among individuals with moderate ID will help educators refine their expectations and requirements from this group. We recommend that future researchers use more than one intelligence test for matching ID and TD groups. The reviewed studies focused mainly on younger ages. Examining the explicit memory trajectory throughout the lifespan could shed light on the effect of CA on memory performance. There is a need for more research on explicit memory in Williams syndrome, Down syndrome and other etiologies. We suggest that the horizontal/vertical model of Cornoldi and Vecchi (2003) is also relevant for understanding explicit memory of the Down syndrome etiology, i.e. modality and task load influence their performance. More research is needed to support this claim. The effect of gender should also be examined (Perez, Peynircioğlu, & Blaxton, 1998). Examining the STM and LTM in the same experiments is needed in order to find the source of the memory deficit, as well as studies on the contribution made by learning trials.

7.1. Educational implications

Our fourth message is directed to clinicians, rehabilitation workers and educational staff. Contrary to the assumption that individuals with ID should be exposed to concrete information and sensory-based experiences (Bray, 1976), our review indicates that individuals with ID can benefit from the same strategies, procedures and technique used in the population with TD for ameliorating their explicit memory. Our findings focus on explicit memory in three etiologies, where each presents a unique cognitive and neurological profile (Vicari et al., 2001). Therefore, some of our educational implications are related to all etiologies, while others are related specifically to the Williams syndrome the and Down syndrome etiologies.

Effect of chronological age. Our review indicates that CA plays an important role in determining the memory performance of individuals with ID beyond their mental age. This claim emerges from the difference in performance when matching with the control group is based on CA or MA. When matching is based on MA, the participants with ID are older than their TD peers. Carlesimo et al. (1997) and Facon and Facon-Bollengier (1999) stated that the longer exposure to linguistic and academic experiences of adolescents with ID may explain their more efficient use of semantic strategies. Maturity and life experience will help them to acquire the same material with increasing age. Teachers, clinicians, rehabilitation workers should be aware of the effect of CA on the explicit memory of individuals with ID. These conclusions give a more colorful cast to what is often difficult and tedious labor and offer a ray of hope to those engaged in this work. Such awareness should encourage the above workers to continue training and practicing with students despite lack of immediate effects.

Task modality. Despite the strength of participants with Williams syndrome in linguistics skills and the relative strength of participants with nonspecific ID and Down syndrome in visual tasks, our review indicates that memory performance of the three etiologies was preserved only when auditory and visual tasks were combined. Our study supports the notion that visual material is encoded more deeply and creates a visual image in addition to the symbolic meaning of the word (Paivio, 1971). It is recommended to combine the auditory and visual modalities when teaching words, prose or narratives. When teaching subjects such as history, civics and even mathematics, it is recommended to accompany the material with pictures, photos and word labels.

Depth of processing. One might argue that individuals with ID encode information at shallower level (Dulaney & Ellis, 1991), and therefore deep processing is beyond their capability. Our review indicated that deep encoding improved the explicit memory of individuals with nonspecific ID and with Williams syndrome. Only one study tapped the deep encoding strategy in participants with Down syndrome using the auditory modality without visual scaffolding. It is therefore not surprising that they failed. Nevertheless, enabling them to encode information at a deeper level might ameliorate their memory. It is recommended to expose participants in the three etiologies to deep encoding which involves use of semantic words, generative strategies, etc. Basic memory strategies are recommended when teaching verbal material: rehearsal, organization, elaboration, and meta-memory.

Prompting facilitates the memory performance of individuals with ID (Carlin et al., 2001; Dulaney & Ellis, 1991). For assessment purposes, we recommend encouraging participants to keep remembering (prompting) as much as they can when they stop producing a response. It is also recommended to expose participants to intentional tests and to explain the purpose of the task.

Type of test. Recall is a form of active remembering in which participants are expected to retrieve stimuli from memory. Recognition is a form of passive retrieval, in which participants are exposed to stimuli and select them from among other stimuli (Baddeley, 2000; Tulving & Schacter, 1990). Recognition facilitates retrieval (Lezak, 1995). We therefore recommend designing memory tests based mainly on recognition. It is also recommended to employ the same number of old and new distracter items.

Participants with Williams syndrome. Due to the strength of participants with Williams syndrome in linguistic skills and their deficit in visual-spatial tasks, it is assumed that learning in this etiology should be based only on the verbal modality (Vicari et al., 2001). Nonetheless, we recommend also including visual-spatial tasks.

It is recommended to employ linguistic strategies during encoding to improve these individuals' spatial orientation tasks. For example, insert word labels on maps and hang word signs to label rooms such as classrooms or the cafeteria. When teaching drawing or copying skills, the process should be accompanied with verbal explanations (Vicari et al., 2005).

Participants with Down syndrome. Other scholars claim that due to impaired linguistic skills in this etiology (Vicari et al., 2001; Wang & Bellugi, 1994), teaching should be based on the visual modality as an alternative to verbal presentation. Our review indicates that when visual scaffolding was provided, their verbal memory was preserved (Jarrold et al., 2007). As mentioned above regarding participants with nonspecific ID and William syndrome, we recommend basing teaching and intervention programs on auditory and visual modalities even in the Down syndrome etiology. Our study indicates a deficit of individuals with Down syndrome even in visual-spatial tasks. However, task load was not taken into account. It is therefore suggested to take the task load into account when constructing intervention programs.

Conflict of interest

The authors declare that they have no conflict of interest.

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