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This meta-analysis combines the effect size (ES) of 40 explicit memory experiments in populations with intellectual disability (ID). Eight meta-analyses were performed, as well as contrast tests between ES. The explicit memory of participants with ID was inferior to that of participants with typical development (TD). Relatively preserved explicit memory performance was found among participants with Williams syndrome compared with participants with TD and with Down syndrome. The mean ES between the groups with ID vs. TD, when control group selection was based on chronological age, was greater than when comparison was based on mental age. There was no difference in the ES between recall and recognition tests. Verbal memory was more impaired than visual memory.

Keywords: explicit memory; meta-analysis; effect size; intellectual disability; typical development

Introduction

Memory, which is defined as the capacity to acquire, retain and retrieve experiences and/or information, is no longer considered a unitary function. Functional dissociation in participants without brain damage and neuropsychological dissociation in brain-damaged patients suggest that memory is composed of a series of functionally independent, but interacting, systems. Memory is not a unitary system. The short-term memory (STM), or working memory, is the system in which essential temporary information is stored for a short period of time. Some researchers claim that STM and long-term memory (LTM) represent the same system, but that the information found in the STM can be used under very special conditions, and it can almost never be stored for a long time (Craik and Lockhart 1972; Ranganath and Blumenfeld 2005). Others claim that these are two separate systems that act together in an integrative manner (Atkinson and Shiffrin 1971). Nonetheless, there is agreement that STM enables us to maintain or perform manipulations on a limited amount of information (see review in Baddeley [2000]). LTM is the system in which information which we receive from the environment is stored for long periods of time. Information transferred to the LTM can also be forgotten, but at a much slower rate than the information in the STM. One of the fundamental dissociations in LTM is between explicit and implicit memory. Schacter and Buckner's (1998, 284–285) definition of these two components of LTM is:

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> Explicit memory refers to conscious recollection of previous experiences, as revealed by standard tests of recall and recognition that require intentional retrieval of previously acquired information. Implicit memory refers to non-conscious effects of past experiences on subsequent behaviour and performance, such as priming or skill learning, that are revealed by tests that do not require conscious recollection of previous experiences.

The present meta-analysis focuses on explicit memory.

Forness and Kavale (1993) carried out a meta-analysis of 268 memory studies among populations with mild to moderate intellectual disability (ID) that were performed between 1960 and the mid-1980s. Of those studies, 172 focused on memory performance and 96 on learning strategies for improving memory. Approximately 45% of the studies were carried out between 1961 and 1970, 50% between 1971 and 1980 and only 5% after 1980, indicating that interest in memory studies decreased. The findings indicated that 'primary memory' (STM) in populations with ID does not differ from that of their peers with typical development (TD). However, differences in secondary memory (LTM) were obvious. Forness and Kavale (1968) postulated that secondary memory has a more limited capacity among people with ID. Another possibility is that the mechanism which transfers items from the primary to the secondary memory is impaired. The aforementioned meta-analysis contributed to understanding memory processes in populations with ID. However, it only covered memory studies until the mid-1980s.

The current meta-analysis focuses on memory studies performed since 1990, when the new concepts of explicit and implicit memory (Graf and Schacter 1987) were introduced into research of memory in populations with ID. Until 1990, most cognitive and neuropsychological studies focused on individuals with Down syndrome (DS). The neuropsychological profiles of other aetiologies, such as Williams syndrome (WS), and the localisation of their deficit in the brain comprised the basis for memory studies since 1990. A search of studies published between 1990 and 2007 yielded 35 studies dealing in LTM among populations with ID. Thus, research on LTM among populations with ID is still in its infancy. However, it is difficult to draw conclusions based on these studies. Some studies compared participants with WS and TD, others focused on participants with DS and TD. The criteria for selection of the control group are varied, where some used mental age (MA) and others used chronological age (CA). Some studies used recall, others used recognition tests. Some used a visual modality, others used a verbal modality. Statistical analysis was also varied.

Cohen (1992) estimated that samples of 393 per group are needed to achieve a 0.80 level of power for detecting small (0.20) effect sizes when comparing differences between the means of two groups at a 0.05 significance level. No study of explicit memory had such large samples.

This article presents a meta-analysis of experiments that compared the explicit memory of participants with ID with various aetiologies with peers with TD. The effect of several moderators, such as the age of the control group, type of memory test and modality of the tasks, was examined as well. We will now discuss each moderator.

Selection of control group

One of our goals was to examine whether differences in explicit memory would be found between participants with ID and with TD with the same MA and the same CA.

Our hypothesis was anchored in the nature of explicit memory, which is influenced by intelligence and CA. It appears in early childhood, but continues to develop during the preschool and school periods (Graf 1990; Reber, Waikenfeld, and Hernstadt 1991). Paris (1978, 153) claimed that:

> 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.

Memory processes such as encoding and retrieval have been shown to increase with age (Bjorklund and Douglas 1997; Kail 1990). Thus, the ability to remember information increases with age and is influenced by the general level of the individual's knowledge, conceptual development, and vocabulary expansion. This is apparently also true for populations with ID. Carlesimo, Marotta, and Vicari (1997) indicated that when selection of the control group is based on CA, individuals with TD are older cognitively than those with ID. It is, therefore, not surprising that the former received higher scores than the latter. However, when controls are matched by MA, children with ID are older than those with TD and the equal performance between them and their controls is understandable. Carlesimo, Marotta, and Vicari (1997) claimed that older participants with ID have the advantage of greater maturity, additional life experience and academic years than their MA-matched peers. We hypothesised that greater deficits in explicit memory would be found among participants with ID when the control group (TD) is matched by CA than by MA.

Type of test: recall vs. recognition

One of the intriguing questions in memory literature is whether recall and recognition represent the same process and what the underlying processes are behind these tests (Tulving and Schacter 1990). A recall task is a form of active remembering, i.e. the stimuli are not presented to the participants and they should retrieve them from memory. In free recall they are instructed to recall items in any order. Recognition is a form of passive retrieval, where participants are exposed to stimuli and need to recognise them from among other stimuli. Baddeley (2000) claimed that recall requires more explicit and episodic encoding than recognition. Recognition tests create less motivation and make fewer demands than recall tests (Jarrold, Baddeley, and Phillips 2007). Participants with prefrontal damage exhibit difficulties in free recall, but relatively preserved recognition abilities (Wheeler, Stuss, and Tulving 1997). Difficulties in free recall were found in populations with neurological and psychiatric pathologies, including depression, Huntington (Zakzanis 1998) and Parkinson disease (Appollonio et al. 1994). Such cases with impaired recall but preserved recognition indicate that the presented material was properly encoded in memory and was stored, at least to some extent, thus indicating a specific deficit in retrieval (Lezak 1995). The concept of a lower level of processing required in recognition than in recall is also expressed in memory studies among populations with ID. Jarrold, Baddeley, and Phillips (2007) found inferiority among participants with WS and DS in free recall, with no differences in recognition between both groups and those with TD. We, therefore, hypothesised that greater deficits would be found in free recall than in recognition between participants with ID and with TD.

Modality: visual vs. verbal

The modality of the task is also at the focus of memory studies. Paivio (1971) proposed the dual-code hypothesis according to which many events are represented in two different ways. The 'picture superiority effect' states that pictures are recalled better because they are encoded and stored in verbal and imaginable codes. Paivio argued that verbal and non-verbal codes provide inputs to two separate memory stores. Imagery provides a coding system: items coded in this manner are stored in an imagery memory that is more durable than the verbal memory store. A picture of a common object is remembered better than its name because pictures typically have more distinctive codes that suffer less interference. Craik and Lockhart (1972) claimed that during the processing of visual information, participants develop the meaning behind the picture stimuli more than with words, and their processing improves. Part of the visual modality is the spatial memory. The mental space is comprised of mental constructions of elements and the spatial relations between them. The spatial relations between them range from the more typical schematic or categorical to the metric. According to Hasher and Zacks (1979), spatial location memory is based on automatic processing. Studies demonstrated relative preservation of spatial information in populations with ID (Dulaney and Ellis 1991; Katz and Ellis 1991). We hypothesised that greater deficits would be found in the verbal than in the visual modality among participants with ID compared with participants with TD.

Cognitive profile of DS and WS

DS is the most common genetic cause of ID (Rodger 1987). Varying degrees of ID are the most consistent feature of DS (Vicari, Bellucci, and Giovanni 2006). WS is a rare genetic disorder associated with a behavioural profile that typically includes mild–moderate ID.

DS and WS differ in their psychological profiles. The most marked psychological feature of WS is dissociation between relatively strong language skills and poorer visuo-spatial abilities (Bellugi and Wang 1998; Jarrold et al. 2007), leading to a clear verbal advantage in this population. The visuo-spatial problems associated with WS are evidenced by poor performance in drawing and copying tests, and in the performance subtests of the Wechsler scales (Bellugi et al. 2000). Differences between verbal and non-verbal abilities are less marked in DS, but their cognitive profile is also uneven. Language acquisition tends to be delayed relative to non-linguistic cognitive abilities (Gunn and Crombie 1996). However, they may exhibit remarkably strong language skills (Rondal 1995). WS and DS are associated with contrasting STM deficits. Wang and Bellugi (1994) examined digit and Corsi span and found that participants with WS performed better in the verbal STM task but had lower scores in the visuo-spatial STM task. Individuals with DS exhibit deficiency in explicit memory (LTM) compared with individuals with WS and TD (Vicari, Carlesimo, and Caltagirone 1996), whereas their implicit memory is preserved. However, there are contradicting results. Vicari, Brizzolara et al. (1996) found that performance of individuals with WS was similar to that of individuals with TD in the digit span test, but was impaired on a test of LTM for visual information.

People with WS and their peers with TD have a similar neurocerebellar volume (volume of the frontal cortex in relation to the posterior cortex and limbic structures

[Bellugi, Wang, and Jernigan 1994]). The limbic system and amygdala, which are implicated in facial processing and affect recognition tasks, are spared in WS (Bellugi and Wang 1998). Individuals with WS have the same absolute volume of Heschel's gyrus as TD individuals, an area of the primary auditory cortex (Hickok et al. 1995) associated with language and auditory STM and LTM.

Pennington et al. (2003) demonstrated a general decrease in brain volume of individuals with DS and limited development of the frontal lobes, limbic areas and the cerebellum as well as damage to the hippocampus and thalamus (Pennington et al. 2003). These regions are known to be important for explicit memory. We hypothesised that participants with WS would exhibit relatively preserved explicit memory compared with participants with TD and better explicit memory performance than participants with DS.

Goals and hypotheses

The goals of this meta-analysis were:

(1) To examine whether differences would be found in explicit memory between participants with ID and matched peers with TD. We hypothesised that participants with TD would exhibit higher performance than those with ID.

(2) To determine whether the differences in explicit memory are the same when selection of participants with TD is based on MA and CA. We hypothesised that greater deficits would be found among participants with ID when the group with TD is matched by CA than by MA.

(3) To examine whether the type of memory test and the modality affect the differences between participants with ID and TD. We hypothesised that greater deficits would be found in free recall than in recognition and in the verbal than in the visual modality among participants with ID compared with participants with TD.

(4) To determine whether differences in explicit memory exist between participants with various aetiologies and participants with TD. We hypothesised that participants with WS would exhibit relatively preserved explicit memory compared with participants with TD and better performance than participants with DS. The latter would exhibit deficits compared with participants with TD.

Method

A computerised search of publications on ID published from 1990 to 2008 was performed in journals that focus on memory and cognition; PsycLIT database; Dissertation Abstracts International; the Social Science Citation Index; ERIC; Webspires; Proquest; Ebsco; and Google Scholar. Letters were sent to libraries in Europe requesting articles that were not found in Israel. The key words were explicit or declarative memory and mental retardation or intellectual disability as well as LTM, semantic and episodic memory, recall and recognition. Inclusion criteria were: studies of populations with ID without other disabilities such as autism or mental illness; IQ range mild to moderate ID; samples larger than a case study; comparison between populations with ID and TD; studies that included statistical analyses or presented means and standard deviations (SDs).

The studies

Out of 35 LTM studies in populations with ID, approximately 83% were carried out since 1995. Of these, 69% were carried out since 2000. Thirteen studies focused on implicit and explicit memory, 20 focused only on explicit memory. Of the 35 studies, 23% focused on WS, 26% on DS, and 71% on populations with non-specific ID (NSID); 80% focused on youths and adolescents under 21 and 20% on participants older than 21.

Several of the 35 explicit memory studies were excluded. Three did not contain statistical measures or means and SDs of each group separately. In two, the mean IQ was above 70. Some articles could not be found in Israel or abroad. Four focused on aetiologies without comparing with a TD population. Twenty-six studies comprised the database for this meta-analysis.

In 10 of the 26 articles, more than one experiment was performed with different participants. Thus, this meta-analysis contains 40 experiments with a total of 2071 participants: 852 with ID and 1219 with TD. Of those with ID, 69 have WS, 99 have DS, and 684 are with NSID. We performed eight meta-analyses according to aetiology, selection of control group, type of task and modality.

The small sample of each aetiology forced us to compare the effect size (ES) of each aetiology versus TD. The following comparisons between the ES of the various aetiologies and TD were performed: WS vs. TD compared with DS vs. TD; WS vs. TD compared with NSID vs. TD; and DS vs. TD compared with NSID vs. TD. We produced 40 ES from 26 studies.

As noted by Rosenthal (1991), inclusion of multiple ES from the same experiment treats non-independent results as independent, in effect weighting each study according to the number of ES it produces. This can bias the outcome of the meta-analysis. Rosenthal (1991) recommended having each study contribute a single ES in order to avoid this problem. In the current meta-analysis, the studies that provided more than one ES included different participants in each experiment: In the study of Vicari, Bellucci, and Carlesimo (2005) there was a group with DS, a group with WS, and two control groups. Dulaney and Ellis (1991) used different participants for examining the memory of objects and of location. These studies, therefore, contributed more than one ES. We provided only one ES for the studies that examined the same participants in several experiments.

Phases of meta-analysis

The meta-analysis contained the following phases:

(1) Calculation of ES for each study. In some cases these could be computed directly from the reported means and SD. This measure does not require mean and SD data, but rather data of *t*- or *F*-tests and the sample size. The standardised ES *g*, as reported in Hedges and Olkin (1985), was used (see Equation 1).

$$g = \frac{2t}{\sqrt{(N_1 + N_2) - 2}} \tag{1}$$

When *F* data were presented, Equation 2 was used.

$$g = \frac{2\sqrt{F}}{\sqrt{(N_1 + N_2) - 2}} \qquad (2)$$

(2) Calculation of the *d* for each study. The ES calculated according to the afore-mentioned procedures (*g*) provided biased estimates of the true ES, since not all researches reported a SD. A correction factor (Hedges 1984) was thus applied in order to convert the *g* score to a *d* score (see Equation 3).

$$d = (1 - \frac{3}{4n^E + 4n^C - 9})g \qquad (3)$$

In Equation 3 n^E = number of participants in the experimental group, n^C = number of participants in the control group (Hedges 1984). The ES obtained from this computation was needed to compute an ES variance and SD for each study.

(3) Calculation of confidence intervals. 95% confidence intervals (CIs) were obtained for each of the calculated ES, using Equation 4.

$$95\%\text{CI} = d \pm (C_{\alpha/2})(S_d) \qquad (4)$$

In Equation 4, $C_{\alpha/2}$ is the two-tailed critical value of the standard normal distribution (here 1.96) and s_d is the estimated SD for the study ES (see Table 1). When the CI includes 0, *d* is not significant at the 0.05 level and when the CI does not include 0, *d* is significant, indicating differences in explicit memory between the groups. We were interested in determining whether a significant ES exists for the entire collection of studies included in the meta-analysis and, therefore, computed a CI for the weighted mean ES.

(4) Calculation of homogeneity. This homogeneity statistic indicates whether the composite mean weighted ES found in the first step is consistent across the studies included in the meta-analysis. If so, it can be considered as representative of the population from which it was drawn and free from the effect of moderator variables. The meta-analysis is considered complete when homogeneity is achieved. However, because of the effects of moderator variables, the composite mean weighted ES calculated from a large number of independent studies is usually not homogeneous. In this case, categorical model testing is used to identify moderator variables that explain the inconsistency. We divided the studies into groups according to certain potential moderators. Categorical model testing is analogous to analysis of variance and yields two relevant statistics: a within-class effect indicating whether the ES within each moderator are homogeneous (*Qwi*) and a between-classes effect, analogous to a main effect in analysis of variance, indicating whether significant differences exist between the categories of the potential moderators (*Qb*). This model-fitting procedure is repeated for as many moderator variables as the experimenter chooses to examine, until homogeneity is achieved.

(5) Division into groups according to moderators. The 40 experiments were divided into sub-groups according to aetiology, control group, type of task and

modality. The homogeneity of each group, a weighted mean *d* and total CI were calculated.

(6) Contrast analysis. Computation of contrasts between two homogeneous groups of studies within the same moderator variable was conducted. Differences in mean weighted ES from two homogeneous categories imply the existence of a moderator variable (Hedges and Olkin 1985). This statistical procedure was enabled by contrast analysis between the mean ES obtained for each sub-group (*d*) according to Equation 5 (Hedges and Olkin 1985).

$$Z = \frac{-1(d_1) + 1(d_2)}{\sqrt{(-1)^2 (1/_{TW}) + (1)^2 (1/_{TW})}} \tag{5}$$

The obtained value is squared and its significance is calculated according to the chi-square table. When this value is higher than the critical value, there is a significant difference between the mean ES.

Results

Explicit memory

Our first goal was to examine whether the ES of explicit memory studies in populations with ID indicates different patterns of performance between participants with ID and those with TD. We calculated the ES for each study, and examined the homogeneity of the studies. The chi-square of 40 ES was not significant: $\chi^2_{39} = 19.67$, $p > 0.05$, i.e., the studies share homogeneous ES and can be included together. The mean weighted ES (*d*) for all 40 studies was 1.04, with a 95% CI that ranged from 0.81 to 1.27, which is a large ES (Cohen 1988). Our hypothesis was supported: significant differences in explicit memory exist between participants with ID and those with TD, i.e. participants with TD exhibited higher performance than those with ID. Table 1 presents the ES (*d*) and CIs of the 40 experiments included in this meta-analysis.

Table 1 demonstrates that the *d* score was positive in 36 studies (90%); i.e., explicit memory among participants with TD was higher than among participants with ID. In four studies (10%) the *d* score was negative, i.e., the explicit memory of participants with ID was higher than among participants with TD. In 25 studies (62.5%), the ES was greater than 0.8; i.e., large differences existed between the groups. Twelve studies (30%) indicated moderate differences between the groups (0.5), whereas a low *d* score (0.2) was obtained in three studies (7.5%), indicating small differences between the groups.

Explicit memory according to control group

The second goal was to examine whether the ES of explicit memory studies indicate a different pattern between participants with ID and those with TD when comparison is based on MA (35% of the studies) vs. CA (65% of the studies). The chi-square of each group was not significant ($\chi^2_{15} = 3.99$, $p > 0.05$; $\chi^2_{23} = 11.42$, $p > 0.05$ for MA and CA, respectively). The studies in each group could, therefore, be included together.

Table 1.   Effect sizes and 95% confidence intervals (CIs) of the explicit memory studies.

Study	n ID	n TD	Effect size (d)	95% CI Lower	95% CI Upper
Jarrold, Baddeley, and Phillips (2007)	15	110	0.42	−1.54	2.38
	20	110	1.25	−0.71	3.21
Brock, Brown, and Boucher (2006)	11	11	0.25	−1.71	2.21
Vicari, Bellucci, and Carlesimo (2005)	15	15	0.59	−1.37	2.55
	15	15	0.99	−0.97	2.95
Henry and Gudjonsson (2004)	11	37	1.85	−0.11	3.81
	11	37	1.38	−0.58	3.34
	13	37	0.87	−1.09	2.83
	13	37	0.85	−1.11	2.81
Gudjonsson and Henry (2003)	101	93	1.17	−0.79	3.13
	27	93	2.79	0.83	4.47
	17	14	−0.21	−2.17	1.75
	30	14	−0.42	−2.38	1.54
Atwell, Conners, and Merrill (2003)	34	41	0.79	−1.17	2.75
Robert, Vaughan, and Roberts (2002)	30	30	1.09	−0.87	3.05
Vicari, Bellucci, and Carlesimo (2001)	12	12	0.05	−1.91	2.01
Carlin et al. (2001)	16	16	0.75	−1.21	2.71
Fletcher, Maybery, and Bennett (2000)	20	20	2.24	0.28	4.20
Vicari, Bellucci, and Carlesimo (2000)	14	20	0.99	−0.97	2.95
Mattson and Riley (1999)	11	21	2.05	0.90	4.01
Wyatt and Conners (1998)	20	20	0.69	−1.27	2.65
	20	20	0.50	−1.46	2.46
	20	20	0.50	−1.46	2.46
	15	20	0.44	−1.52	2.40
Vakil, Shelef-Reshef, and Levy-Shiff (1997)	26	27	0.82	−1.14	2.78
Carlesimo, Marotta, and Vicari (1997)	15	30	0.81	−1.15	2.77
	15	30	0.86	−1.10	2.82
Turner, Hale, and Borkowski (1996)	54	46	1.64	−0.32	3.60
Dulaney, Raz, and Devine (1996)	22	20	1.36	−0.60	3.32
	24	20	1.59	−0.37	3.55
Komatsu, Naito, and Fuke (1996)	21	27	0.89	−1.07	2.85
Vicari et al. (1996)	16	16	0.96	−1.00	2.92
Perrig and Perrig (1995)	19	11	−0.48	−2.44	1.48
Dobson and Rust (1994)	26	26	0.83	−1.13	2.79
Gordon et al. (1994)	23	23	0.73	−1.23	2.69
Takegata and Furutuka (1993)	10	10	1.05	−0.91	3.01
Dulaney and Ellis (1991)	15	15	0.65	−1.31	2.61
	15	15	−0.49	−2.45	1.47
Katz and Ellis (1991)	20	20	1.46	−0.50	3.42
	20	20	1.56	−0.40	3.52

Notes: ID, intellectual disability; TD, typical development.

The mean weighted ES indicates significant differences between participants with ID vs. TD when comparison was based on MA ($d = 0.63$) and on CA ($d = 1.15$). The CIs did not include zero (0.86–1.44 and 0.59–0.66 for MA and CA, respectively). Table 2 indicates moderate or smaller ES in three studies (18.75%) that compared participants with ID and TD based on MA, indicating better performance of participants with ID than with TD. However, the ES (above 0.8) in 75% of the studies that compared participants with ID and TD based on CA indicated large differences between the groups.

The Z-value of the contrast between the ES of participants with ID and TD when comparison was based on MA and CA ($Z^2(1) = 25.40$, $p < 0.02$) indicated significant differences between the two. Our hypothesis was supported: the gap in the explicit memory between participants with ID and with TD was significantly smaller when comparison was based on MA than when it was based on CA.

Explicit memory according to type of task and modality

Type of test

Twenty-nine of the studies used recall tests and 11 used recognition tests. The chi-square of each group was not significant ($\chi^2_{28} = 15.91$, $p > 0.05$ and $\chi^2_{10} = 2.47$, $p > 0.05$ for recognition and recall, respectively). Therefore, the studies in each group can be included together. The weighted ES of the recognition task experiments ($d = 0.82$; CI 0.47–1.18) and recall tasks ($d = 0.93$; CI 0.64–1.22) were significant, indicating large differences between the experimental and the control group in both types of tasks (Table 2).

The Z-value obtained in the contrast between the mean ES in the studies of participants with ID and with TD when using a recall task vs. a recognition task was $Z^2(1) = 0.93$, $p < 0.02$. The Z-value is lower than the critical chi-square value, indicating no significant differences in the mean ES between the two types of tasks. Our hypothesis was not supported: explicit memory among participants with ID was significantly impaired in both recall and recognition tasks compared with participants with TD.

Table 2.   Effect size and 95% confidence intervals (CIs) of the moderators.

Moderator	Articles (*n*)	Effect size (*d*)	95% CI	
			Lower	Upper
WS	5	0.45	0.02	0.8
DS	6	1.28	0.79	1.76
NSID	29	0.90	0.61	1.18
MA	16	0.63	0.59	0.66
CA	24	1.15	0.86	1.44
Recognition	11	0.82	0.47	1.18
Recall	29	0.93	0.64	1.22
Verbal	13	1.05	0.62	1.47
Visual	27	0.83	0.55	1.10

Notes: WS, Williams syndrome; DS, Down syndrome; NSID, non-specific intellectual disability; MA, mental age; CA, chronological age.

Modality

The chi-square of studies that used verbal tasks (χ^2_{26} = 11.76, p > 0.05) and those that used visual tasks (χ^2_{13}= 6.32, p > 0.05) indicated homogeneity of the ES; thus they could be included together. The weighted ES of the verbal task experiments (d = 1.05; CI 0.55–1.10) and the visual tasks (d = 0.83; CI 0.62–1.47) were significant, indicating large differences between the experimental and the control group in both types of tasks.

The *Z*-value obtained in the contrast between the mean ES of participants with ID versus those with TD when using recall or recognition tasks was $Z^2(1)$ = 4.84, p < 0.05, indicating significant differences between the mean ES of the two types of tasks. Our hypothesis was supported: In spite of the large ES of both tasks, the gaps between participants with ID and with TD were smaller in experiments that used visual tasks than in experiments that used verbal tasks.

Explicit memory according to aetiology

WS compared with TD

Chi-square analysis indicated that the five WS articles included in this meta-analysis (12% of the studies) shared a common ES (χ^2_4 = 0.29, p > 0.05). The weighted ES (0.45) indicates small differences in explicit memory between participants with WS and with TD. These differences were not significant, since the CI (0.02–0.8) included zero (Cohen 1992). Table 2 indicates small differences between participants with WS and with TD in three of the five studies, i.e., our hypothesis was supported: the explicit memory of participants with WS is close to that of participants with TD.

DS compared with TD

Chi-square analysis indicated that the six DS articles (15% of the studies) shared a common ES (χ^2_5 = 0.72, p > 0.05) and can be included together. The weighted ES (d = 1.28) was significant, since its CI did not include zero (0.79–1.76). Our hypothesis was supported: the findings indicate large and significant differences in explicit memory between participants with DS and with TD; i.e., participants with DS exhibit a deficit in explicit memory compared with those with TD.

NSID compared with TD

Chi-square analysis indicated that the 29 NSID articles (72% of the studies) share a common ES and can be included together (χ^2_{28} = 16.55, p > 0.05). The weighted ES (d = 0.9) was significant, since the CI does not include the zero (0.6–1.18). This finding indicates large and significant differences in explicit memory between participants with NSID and with TD. In 62% of these studies, the *d* was greater than 0.8, indicating large differences between the groups, whereas a negative ES was obtained in 13.7%, indicating better performance of the participants with ID than those with TD.

Contrasts

WS and DS. Contrasts of the mean ES in the study groups with WS compared with TD vs. the study groups with DS compared with TD were performed to determine whether

differences would be found in the mean ES between the two aetiologies compared with TD (Hedges and Olkin 1985). The *Z*-value ($Z^2(1) = 13.22$, $p < 0.001$) indicated significant differences between the ES. The mean ES of the explicit memory of participants with WS compared with those with TD was significantly lower than that of participants with DS compared with those with TD. Our hypothesis was supported: participants with WS exhibited preserved explicit memory performance relative to participants with DS.

WS and NSID. The *Z*-value of the contrast between the ES of the explicit memory of participants with WS compared with those with TD and the ES of participants with NSID compared with those with TD was $Z^2(1) = 7.26$, $p < 0.01$; i.e., significant differences were found between the ES. The mean ES of the explicit memory of participants with WS compared with TD was significantly lower than that of participants with NSID compared with TD. Participants with WS exhibit more preserved explicit memory than participants with NSID.

DS and NSID. The *Z*-value of the contrast between the ES of the explicit memory of participants with DS compared with those with TD and the ES of participants with NSID compared with those with TD was $Z^2(1) = 6.59$, $p < 0.02$; i.e., significant differences were found between the ES. The mean ES of the explicit memory of participants with DS compared with TD was significantly higher than that of participants with NSID compared with TD. Participants with DS exhibited greater deficit in explicit memory than participants with NSID.

Our hypotheses regarding aetiologies were supported. The contrast tests show that the ES of participants with WS compared with participants with TD was much smaller than the ES of participants with DS and with NSID compared with participants with TD. Thus, the explicit memory of participants with WS is similar to that of populations with TD, whereas participants with DS exhibit the greatest gap compared with participants with TD.

Discussion

Results of explicit memory studies in populations with ID since 1990 are inconsistent. Therefore, a meta-analysis that included 1219 participants with TD and 852 with ID was carried out.

Our first hypothesis of a higher performance of participants with TD than those with ID was supported. The weighted mean ES of the 40 experiments in this meta-analysis was 1.04, which is considered a large ES, indicating significant differences in explicit memory between participants with ID and those with TD. This difference can be attributed to the nature of explicit memory and the cognitive impairments of populations with ID. Explicit memory is characterised by conscious use of encoded information, storage of the information and retrieval (Kail 1990), and places heavy demands on attention resources (Vicari, Bellucci, and Carlesimo 2000). It is comprised of semantic encoding of the verbal material (Carlin et al. 2001) and is influenced by the general knowledge of the individual (Carlesimo, Marotta, and Vicari 1997). Explicit memory is influenced by chronological age, intelligence, psychiatric disorders and neurological impairments (Reber, Waikenfeld, and Hernstadt 1991; Schacter, Chin, and Ochsner 1993). Participants with ID exhibit difficulties in verbal rehearsal (Borkowski, Carr, and Pressley 1987), reduced ability in retrieval (Winters

and Semehuk 1986), strategy use (Paour 1992), and attention deficits (Reed 1996). However, in 17.5% of the studies there was no difference between participants with ID and TD (Carlesimo, Marotta, and Vicari 1997; Dulaney and Ellis 1991; Henry and Gudjonsson 2003; Perrig and Perrig 1995; Vicari, Bellucci, and Carlesimo 2001). The absence of a difference between participants with ID and TD could be attributed to several reasons.

In most of the studies, the match between the groups was based on MA, that is, participants with ID were older than participants with TD. As stated, this type of comparison advantages participants with ID. In some of the studies depth of processing influenced the performance of participants with ID. For example, Carlin et al. (2001) exposed participants with ID and participants with TD with the same MA and CA to two ways of encoding and found that free recall was greater for participants with ID and their CA-matched controls than for the MA-matched controls in the fade-in procedure. Dulaney and Ellis (1991) exposed participants to semantic and non-semantic instructions. In the semantic instruction group, participants had to name each picture and identify the pictured item they used every day. In the non-semantic instruction group, participants were asked only to name each pictured item aloud. Dulaney and Ellis (1991) found that the deeper (semantic) encoding of items led to better recognition than did shallower encoding. No differences emerged between participants with and without ID in the semantic encoding group, whereas participants with ID exhibited greater memory loss in the non-semantic procedure than those with TD. Dulaney and Ellis (1991) concluded that when participants with ID are led to encode information in a deeper fashion, their recognition memory is equivalent to that of participants with TD. Three of the five experiments that focused on WS aetiology yielded no differences in free recall between participants with WS and those with TD (Brock, Brown, and Boucher 2006; Jarrold, Baddeley, and Phillips 2007; Vicari, Bellucci, and Carlesimo 2001). In these studies comparison between participants with ID and the control group was based on MA. Recognition was preserved in two studies (Vicari, Bellucci, and Carlesimo 2001; Jarrold, Baddeley, and Phillips 2007). Thus, age, aetiology and level of processing influence the performance of explicit memory in populations with ID.

Age of control group

Our findings indicate that the age of the control group plays an important role in determining the difference in explicit memory between participants with ID and with TD. Twenty-four studies compared participants with ID and with TD with the same CA, whereas 16 compared participants with ID and with TD with the same MA. When comparison was based on CA, larger differences were found between the group with ID and the group with TD than when it was based on MA. The smaller gap in explicit memory between participants with ID and their MA-matched controls versus CA-matched controls may be attributed to the effect of age and the contribution of CA to cognitive ability.

Explicit memory is influenced by intelligence as well as by CA. Carlesimo, Marotta, and Vicari (1997) stated that the longer exposure to linguistic and academic experiences of adolescents with ID than younger participants with TD may explain the more efficient use of semantic strategies in word learning tasks compared with MA-matched younger children with TD. Memory processes such as encoding and retrieval also increase with age (Bjorklund and Douglas 1997). The ability to remember

information increases with age and is influenced by the general level of the individual's knowledge and conceptual development.

The influence of CA on the cognitive ability of individuals with ID was examined in a series of studies. Facon and Facon-Bollengier (1999) claimed that life experience may aid participants with ID to succeed in some cognitive tasks and partly determines their MA. Thus, comparison of MA between adolescents with ID and children with TD reduces the gap between the two groups. Facon and Facon-Bollengier's study was conducted on younger age groups. Lifshitz, Tzuriel and Weiss (2005) found that adults with ID gained more from a dynamic assessment procedure in teaching analogical reasoning than adolescents with ID. The contribution of CA to the cognitive ability of participants with ID can serve as an explanation for the larger differences in explicit memory between the group with ID and the group with TD when comparison was based on CA than when it was based on MA.

Type of test

One of the intriguing findings of the current meta-analysis relates to the effect of the type of test on the differences between participants with ID and TD. The findings indicate that the mean ES in both cases (recall and recognition) was over 0.8, which is a large ES. Therefore, the contrast between the means of the ES of the two types of tasks was not significant. Our hypothesis, of differences between the recognition and the recall task of participants with ID compared with participants with TD, was not supported. This finding contributes to our understanding of the source of memory barriers in populations with ID. Numerous studies relate to this question. Katz and Ellis (1991) report a lack of consolidation of a mnestic trace, while Wyatt and Conners (1998) report reduced ability for active retrieval. This meta-analysis indicates that participants with ID exhibit difficulties in recall as well as in recognition. It is possible that the deficit among participants with ID focuses not only on the anterior parts of the brain, which are known to be responsible for processes of retrieval of episodic information. Computerised imaging studies among young persons with TD indicated that the medial temporal lobes and the frontal lobes are used for episodic encoding and retrieval. It is not clear whether individuals with NSID exhibit deficit only in the prefrontal cortex or also in hippocampal areas. In this analysis, those with ID exhibited impaired memory in recall as well as in recognition, suggesting that both their encoding and retrieval processes are impaired.

Modality

The effect of the modality of the task on explicit memory was also examined. Large differences in explicit memory were found between participants with ID and TD in both visual and verbal tasks. However, the contrast between their mean ES was significant. Our hypothesis was supported: the gap in the performance of visual tasks of participants with ID vs. participants with TD was lower than in the verbal tasks. The results are consistent with the dual-code theory (Paivio 1971); i.e., a picture of a common object is remembered better than its name. Our findings are also consistent with the theory of depth processing (Craik and Lockhart 1972), which claims that the deeper the processing the better the memory. During the processing of visual information, participants develop the meanings behind the picture stimuli more than with words, and their processing improves. Furthermore, 13% of the studies we reviewed

used spatial location tasks, which are assumed by Hasher and Zacks (1979) to be encoded automatically. These reasons may serve as explanations for our findings of relatively higher performance in visual tasks compared with verbal tasks.

In conclusion, the mean ES in this meta-analysis demonstrate inferiority in explicit memory of participants with ID to those with TD, and a deficit in recall and recognition tests, indicating a deficit in both encoding and retrieval. The inferiority is reduced when comparison is based on MA and when the task is tested in the visual modality.

Explicit memory and aetiology

Few studies compared different aetiologies of ID in the same research. Owing to the small number of studies that focused on each aetiology, we could not compare the ES between experiments that included the aetiologies themselves, but had to compare the ES of experiments that included the aetiologies vs. ES in experiments of participants with TD. Furthermore, we could not examine the effect of other moderators, such as the control group, type of task or modality of task, on the various aetiologies. All hypotheses regarding the aetiologies were supported. The results of the meta-analysis and the contrast tests between the ES of the experiments of each aetiology vs. those with TD indicate relatively preserved explicit memory among participants with WS compared with participants with TD, and better explicit memory than participants with NSID and DS. Participants with DS were found to have a greater deficit than those with NSID. The findings support the hypothesis that deficits in explicit memory cannot be explained solely by a low general intelligence, but are associated with the different cognitive profiles of the various aetiologies (Reber, Waikenfeld, and Hernstadt 1991; Schacter, Chin, and Ochsner 1993).

Language skills among participants with WS are relatively preserved, compared with significant deficits in visuo-motor integration and spatial perception (Bellugi et al. 2000). Participants with DS exhibit an opposite profile, expressed by impaired linguistic development (Byrne et al. 1995), with relative preservation of visuo-spatial skills (Vicary et al. 1999). However, there are contradictory findings (Wang et al. 1995).

The neuroanatomical profile of participants with WS can explain their preserved explicit memory. A functional magnetic resonance imaging (fMRI) study among individuals with WS indicated normal function of the frontal areas, which are involved in episodic encoding and retrieval (Reiss et al. 2000). This may explain why explicit memory is preserved in this aetiology. fMRI examinations among participants with DS (Jernigan et al. 1993) documented a general deficit in the frontal lobes, limbic regions (Pennington et al. 2003), diencephalic nuclei and cerebellum, which are critical for explicit memory performance.

Limitations, implications and future research

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 owing to the 'file drawer problem', which is problematic in all research and in meta-analyses in particular.

Owing to the small samples of each aetiology, we could not perform separate meta-analyses for each aetiology. A larger number of studies on this population will

shed light on the effect of different moderators such as age of control group, type of tests and modality of tasks on their explicit memory.

Gender is a potential moderator that could not be examined in the current meta-analysis because data for males and females were not provided.

In our meta-analysis, the effect of CA on explicit memory was examined with reference to the control group. However, differences in explicit memory of participants with ID and those with TD of various ages could not be examined owing to insufficient memory studies among adults with ID. Other moderators that could not be examined in the current meta-analysis are depth of processing, learning rate and the effect of the serial position curve. It is recommended to increase the number of studies that will relate to the effect of those moderators on long-term explicit memory in populations with ID.

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