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Acquisition of Reading and Intellectual Development Disorder

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Abstract
We propose a review of the literature of the studies investigating reading acquisition in intellectual deficiency (ID), with particular focus on the explanatory factors for reading difficulties. Indeed, we explore the role of intellectual efficiency, perceptual abilities, oral language development, phonological processing and memory. The study of reading acquisition in ID is a challenge because of a high degree of heterogeneity in the results which, together with other variables influencing learning and development. This review has allowed us to understand that there are multiple reasons why individuals with ID have difficulty learning to read. More specifically, there is a link between reading skills and certain cognitive skills, such as perception, oral language, phonological processing and working memory.

Keywords Intellectual deficiency · Reading · Explanation factors

Schooling (cf. Fig. 1 and Table 1)

Intellectual development disorder, better known as *intellectual disability* (ID), is a neurodevelopmental disorder, according to the *Diagnostic and Statistical Manual of Mental Disorders-V* (DSM-5, 2013). Its diagnosis is based on three criteria: general intellectual functioning significantly below the mean (IQ < 70–75), major deficits in adaptive behavior, and onset during the developmental period (before 18 years). Although 1–2% of the population has ID (Maulik et al. 2011), there have been very few studies of how children with ID learn to read at school. And yet today's societies regard reading as a fundamental skill. Reading involves a set of linguistic processes that extract semantic, orthographic and phonological representations of speech. Good identification of written words relies on good phonological decoding abilities (Parrila et al. 2004) and orthographic processing (Cunningham et al. 2001). Therefore, reading is a skill that requires its cognitive subcomponents to be automated. However, we must not reduce the mastery of reading to written word recognition abilities. Learning to read begins well before the beginning of formal

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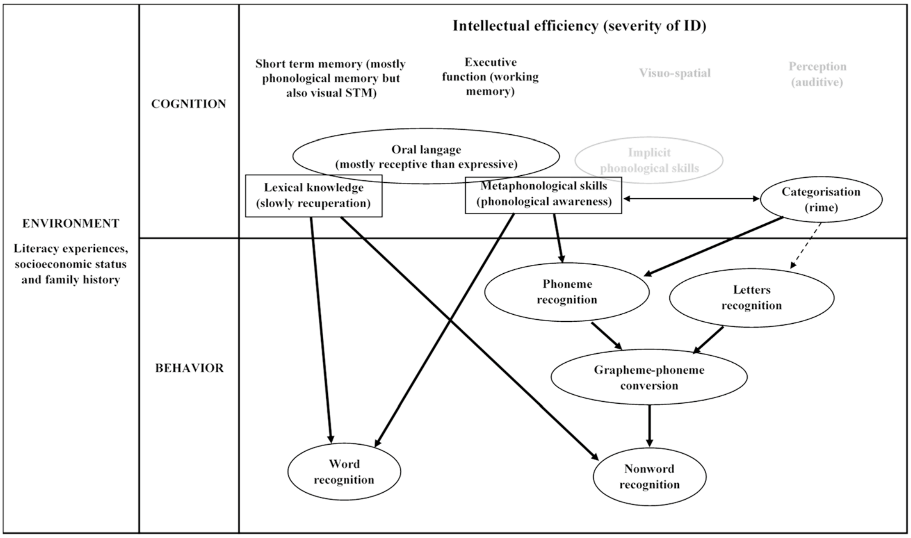

Fig. 1 Proposition of hierarchical model representation, inspired by Morton and Frith model (1995), about factors were recognized in the ID literature for strong predictor (solid arrow) or possible predictor (arrow in dotted lines) of reading abilities (word and nonword recognition). We incorporated some other factors recognized as predictors depending on the ID aetiology and severity (light grey). All these factors are altered and can therefore explain the reading difficulties in individuals with ID

instruction. Emergent literacy (Katims 2000), that is, basic reading skills and knowledge, is enhanced during childhood through the practice of oral language and exposure to written words (Hindman et al. 2008; Levy et al. 2006; Sénéchal and LeFevre 2002). Literacy experiences (shared reading, writing activities) in typical development influence the acquisition of reading and associated skills (letter knowledge, phonological skills, oral language) (Burgess et al. 2002; Phillips and Lonigan 2009). However, these experiences are compromised, and sometimes even inaccessible, for children with ID (Martini–Willemin 2013). Katims (2001) found that only one in five children with mild or moderate ID had literacy skills. Buckhalt et al. (1978) showed that the mothers of children with Down syndrome (DS) may behave and interact differently, relative to the use of oral language. Nevertheless, Ratz and Lenhard (2013), who studied 1612 young individuals aged 6–21 years with severe to profound ID, demonstrated that socioeconomic status and family history have no impact on reading performance in ID. These results highlight the limitations of adopting a cross-sectional approach, insofar as it does not allow the acquisition of reading to be observed in sufficient detail.

Based on these findings, we reviewed the sparse studies of reading acquisition in ID, with particular focus on the explanatory factors for reading difficulties.

At present, not all children with ID become expert readers, owing to unknown etiological factors. For example, the mean reading level of individuals with ID aged 16–22 years is equivalent to that of typically developing children aged 6–10 years (Fajardo et al. 2013; Morgan and Moni 2008). Recent studies have reported that individuals with ID aged 13–34 years are able to learn to read to some extent (Loveall and Conners 2013). Those aged 10–20 years, for instance, exhibit a delay in letter discrimination, but some relative reading skills (Martini–Willemin 2013). These works nevertheless need to be viewed with some caution, given the extreme variability of the results

Table 1 Main results about reading abilities (word recognition and comprehension) and possible predictors found in the studies included in this article

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
Barker et al. (2013)	294 children (106 girls and 188 boys)	7–10 years (9.2 years)	Mild ID (mean IQ = 63.11)	English		Reading difficulties
						Possible predictors: deficit of phonological awareness
Bayliss et al. (2005)	50 children and adolescents	10.1–16.3 years (mean = 13.6 years)	Mild to severe ID (mean verbal IQ = 55.32)	English	Reading level	Reading difficulties
						Possible predictors: deficit in working memory
Berger (2002)	192 adolescents	11–15 years	Mild ID (IQ 63 to 80)	French		Relatively good reading skills
Dessalegn et al. (2013)	2 cases	16 years	Williams syndrome	English		Reading and spelling abilities differed by more than 5 grade levels, despite the strong similarity in terms of their cognitive abilities and phonological abilities
	1: BMP (boy)					*Possible predictors:* visual-spatial impairment and a threshold level of phonological skills
	2: HFK (girl)					
Fajardo et al. (2013)	2 experiments	1: mean 19 years	Borderline to mild ID	Spanish	Experiment 2	Reading difficulties (level of 8–9 year) and deficit of inferential comprehension

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
	1: 19 students (10 girls and 9 boys)	2: mean 20 years	1: mean IQ = 71		Chronological age	
	2: 16 students (10 girls and 6 boys)		2: mean IQ = 67.5		Reading level	
Henry and Winfield (2010)	35 children and adolescents	11–13 years (mean = 12.6 years)	Mild to moderate ID (mean mental age = 7.7 years; mean IQ = 56.6)	English	Mental age	Reading difficulties
						Possible predictors: impairment in phonological short-term memory, deficit in working memory
Gombert (2002)	Adolescents	Mean 13.9 year	Down syndrome	French	Reading level	Reading difficulties
						Possible predictors: deficit in phonological awareness but not on implicit phonological
Katims (2001)	Total of 132 students	9.1–19.6 years (mean = 14 years)	Mild to moderate ID (mean IQ = 54.69; mean mental age = 7.6 years)	English		Reading difficulties: 22% achieved the full criteria of "minimum literacy"
	47 in elementary					
	39 in middle school					
	46 in high school					
Laws and Bishop (2003)	2 groups	2 groups	2 groups	English	Mental age	More deficits in reading comprehension rather than reading accuracy

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
	1: 19 participants (12 girls and 7 boys)	1: 10 to 19 years (mean = 15.9 years)	1: Down syndrome (mean raven score = 15.7)			*Possible predictors to reading comprehension:* expressive language, difficulty in phonological memory (storing and updating), impairment on grammar (morphology) and syntax
	2: 17 participants (5 girls and 12 boys)	2: 4 to 7 years (mean = 5.8 years)	2: Specific language impairment (mean raven score = 16.4)			
Lemon and Fuchs (2010)	Meta-analysis of 20 studies	Children and adult	Down syndrome	English	Chronological age	Reading and comprehension difficulties
					Mental age	*Possible predictors:* poor phonological awareness (syllable and phoneme)
					Reading level	
Levy (2011)	2 groups	2 groups	Mild ID	Hebrew		Reading acquisition is possible
	1: 19 young people (11 girls and 8 boys)	1: 13 to 20.5 years (mean = 17.5 years)	1: Down syndrome (mean IQ = 60.8)			
	2: 19 young people (11 girls and 8 boys)	2: 13.3 to 21.8 years (mean = 16.6 years)	2: unknown aetiology (mean IQ = 59.1)			*Possible predictors:* ID severity, vocabulary, phonological awareness (phoneme) and short-term memory
Maehler and Schuchardt (2009)	54 children	2 groups	1: Learning disabilities	German	Chronological age	Reading difficulties

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
	1: 27 children (14 girls and 13 boys)	1: Mean = 12.35	2: Mild ID with learning disabilities (IQ = 55–85)			*Possible predictors:* deficit in working memory
	2: 27 children (16 girls and 11 boys)	2: Mean = 12.45				
Majerus et al. (2011)	6 participants (4 girls and 2 boys)	6.6–7.11 years	Williams syndrome	French	Chronological age	Reading deficits
					Reading level	*Possible predictors:* allophonic speech perception and increased atypical categorical speech perception
Martini–Willemin (2013)	Meta-analysis of 52 studies	10–20 years	Down syndrome	English		Multifactorial explanation of the reading difficulties
Morgan and Moni (2008)	Meta-analysis of 45 studies	Adolescents and adults	Mild to moderate ID	English		Reading and comprehension difficulties
Ratz and Lenhard (2013)	3 groups 1612 participants (608 girls and 1004 boys)	6–21 years	Mild to profound ID	German		Reading is possible (31.9% at an alphabetical level and 32% at an orthographic level of Frith model)
						Possible predictors: ID severity, cognitive skills underlying the reading, socioeconomic status and family history
Saunders and DeFulio (2007)	30 adults (6 girls and 24 boys)	21–58 years (mean = 35 years)	Mild ID of unknown etiology (mean IQ = 65 to 70)	English		Variability in reading ability-

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
						Possible predictors: phonological processing skill (phonological awareness: rime categorization) (strong predictor) and ID severity
Steele et al. (2013)	52 children	2 groups	2 groups (means mental age = 3.2 years)	English	Nonverbal mental age	To children with DS
	1: 26 children	1: 5.1 to 8.1 years (mean = 6.6 years)	1: Williams syndrome		Reading level	*Possible predictors*: poor phonological awareness, vocabulary, and good letter knowledge
	2: 26 children	2: 5.11 to 8.11 years (mean = 6.11 years)	2: Down syndrome			Relative reading ability
						To children with WS
						Good reading skills
						Possible predictors: good early literacy, letter knowledge, phonological awareness, and vocabulary
Wise et al. (2010)	80 children (24 girls and 56 boys)	6.8–12 years (mean = 9.4 years)	Mild ID of mixed etiology (fragile X syndrome, DS, or unspecified) (mean IQ = 61.39)	English		Variability in reading ability

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
						Possible predictors: phonological skills (strong predictor), receptive and expressive vocabulary (partially correlated) and ID severity
Deficit in sublexical procedure						
Bird et al. (2000)	12 children (8 girls and 4 boys)	Longitudinal study	Down syndrome	English		Reading difficulties: used more lexical rather than sublexical route (decoding deficit) but learning to read is possible
		T1: 6.2 to 11.6 years (mean = 9.7 years)				*Possible predictors:* deficit of phonological awareness (phoneme)
		T2: 9.25 to 14.8 years (mean = 12.9 years)				
		T3: 10.7 to 16.1 years (mean = 14.3 years)				
Boudreau (2002)	20 children and adolescents (9 girls and 11 boys)	5.6–17.3 years (mean = 11.3 years)	Down syndrome (mean mental age = 4.13 years)	English	Mental age	Variable reading ability: good word identification (used the lexical route rather than sublexical route) unlike decoding and reading comprehension

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
						Possible predictors: ID severity, receptive vocabulary (stronger predictor), working memory (stronger predictor), phonological awareness (rime and phoneme) and good print knowledge
Cupples and Iacono (2002)	*Longitudinal study*	6.7–10.3 years (mean = 8.5 years)	Down syndrome	English		Reading difficulties: learning to read is possible and used preferentially lexical route rather than sublexical route
	22 children (14 girls and 8 boys)					
						Possible predictors: phonological awareness (phoneme)
Levy et al. (2003)	20 young people (8 girls and 12 boys)	12.8–20.4 years (mean = 16.5 years)	Williams syndrome (IQ = 40–84)	English		Reading acquisition is possible: used lexical route but partially sublexical procedure (difficulty to decoding)
			IQ < 50: 8 participants			

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
			$50 < IQ < 70$: 9 participants			*Possible predictors:* level decoding, letter knowledge, verbal and nonverbal IQ, poor phonological awareness (rime), and vocabulary
			$IQ > 70$: 3 participants			
Loveall and Conners (2013)	18 young and adults	13.17–33.83 years (mean = 19.97 years)	Mild to moderate ID (mean IQ = 60.44; mean mental age = 8.87 years)	English	Verbal mental age	Use the lexical route (self-teaching processes establishment) rather than sublexical route (decoding difficulty)
Roch and Jarrold (2008)	12 participants	10.5–26.7 years (mean = 18.11 years)	Down syndrome (mean mental age = 8.9 years)	English	Reading level	Reading is possible but atypical: used preferentially lexical procedure rather than sublexical route *Possible predictors:* deficit phonological awareness (rime)
Verucci et al. (2006)	17 children	7.7–28.5 years (mean = 16.5 years)	Down syndrome (mean mental age = 6.2 years)	Italian	Reading level	Reading difficulties: partially used lexical route rather than sublexical (impairment in grapheme–phoneme conversion and decoding) and reading comprehension deficit

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
						Possible predictors: deficit in phonological awareness (syllable and phoneme)
Deficit in lexical procedure						
Barca et al. (2010)	Elisa's case (girl)	13.8 years	Williams syndrome (IQ = 56, mental age = 7.2 years)	Italian	Reading level	Use the sublexical procedure (despite slow decoding) rather than the lexical path (no automatization, partially established)
Cohen et al. (2001)	61 adults (30 girls and 31 boys)	18–56 years (mean = 32 years)	Mild ID (mean IQ = 64)	French		Use the sublexical procedure (despite slow decoding) rather than the lexical route (no automatization)
						Predictors to read: verbal IQ but not with performance IQ
Conners et al. (2001)	65 children (21 stronger decoders and 44 weaker decoders)	8–12 years:	*Light to profound ID*	English	Stronger and weaker decoders	*Good decoders* have better word reading performances (sublexical route) than *poor decoders*, but both have poor comprehension
		21 stronger decoders (mean = 10.8 years)	21 stronger decoders, IQ = 56.7			

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
		44 weaker decoders (mean = 9.6 years)	44 weaker decoders, IQ = 53			*Possible predictors:* deficit in phonemic awareness and rehearse or refresh phonological codes in working memory
Laing et al. (2001)	2 studies	2 studies	Williams syndrome	English	*Study 1 and 2:*	Reading difficulties but learning to read is possible: used more sublexical route rather than lexical route
	1: 15 participants	1: 9 to 27.7 years (mean = 15.1 years)			Reading level	*Possible predictors:* poor phonological awareness (phoneme) and ID severity
	2: 15 participants	2: 10.9 to 27.7 years (mean = 15.6 years)			Receptive vocabulary	
Laws and Gunn (2002)	*Longitudinal study* 30 participants (22 girls and 8 boys)	10–24 years (mean = 11.03 years)	Down syndrome	English		Reading acquisition and progression were possible but exist an extreme variability: used decoding word (half of this sample) Deficit in reading comprehension

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
						Possible predictors: ID severity (precondition), letter knowledge, phonological awareness (rime), phonological memory and receptive vocabulary
Næss et al. (2012)	Meta-analysis of 8 studies	Children	Down syndrome	English	Reading level	Reading is possible: used sublexical route (good decoding) *Possible predictors:* deficit in phonological awareness and vocabulary (most predictor), grapheme-phoneme conversion and phonological memory
Garayzábal and Cuetos (2008)	12 children (7 girls and 5 boys)	8–15 years (mean = 12.45 years)	Williams syndrome (mean IQ = 50.6)	Spanish	Mental age	Similar performance (accuracy) to control group but slowly in reading words, pseudowords *Possible predictors*: difficulty in lexical recuperation and relative phonological awareness
Groen et al. (2006)	KS's case (girl)	Longitudinal study	Down syndrome	English	1: readers with DS	Very good word recognition (level of 8 years) and decoding ability (grapheme–phoneme conversion) but relative comprehension-

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
		1: 8.2 years			2: chronological age	*Possible predictors:* good phonological skills (rime) and relative strengths in visual and verbal short-term memory
		2: 8.4 years			3: good and poor comprehenders	
		3: 8.6 years				
Deficit in both procedure: lexical and sublexical						
Channell et al. (2013)	17 children and adolescents (11 girls and 6 boys)	12.58–19.25 years (mean = 15.88 years)	Mild to moderate mixed-etiology ID (mean verbal mental age = 7.41; mean IQ = 55.12)	English	Receptive vocabulary	Reading difficulties to use lexical and sublexical routes *Possible predictors:* inadequate reading instruction, deficit in phonological processing (phonological awareness and phonological memory) and ID severity
Temple (2003)	Emily's case (girl)	13 years	Williams syndrome (IQ = 44 and mental age = 5.4 years)	English	Mental age	Deficit to read non-word and difficulty using a lexical route (partially established): similar profile to developmental deep dyslexia

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
						Possible predictors: relative letters knowledge and phonological skills (implicit and explicit)
Majerus et al. (2003)	4 children (3 girls and 1 boy)	10.1–12.7 years (mean = 11.4 years)	Williams syndrome (mean IQ = 63)	French	Chronological age	Reading difficulties: impairment to use sub-lexical and lexical routes (impairment of the phonological and lexical representations)
					Receptive vocabulary	*Possible predictors:* deficit in phonological awareness, good receptive vocabulary, preserved phonological short-term memory
Menghini et al. (2004)	16 adolescents and young adults (6 girls and 10 boys)	10.9–30.2 years (mean = 17.7 years)	Williams syndrome (mean mental age = 7 years)	Italian	Mental age	Deficit using sublexical routes (nonword reading and grapheme-phoneme conversion) but lexical procedure fragilities and deficit comprehension: similar profile to phonological dyslexia
						Possible predictors: deficit in phonological awareness

Table 1 (continued)

Studies	Number of participants	Chronological age	ID severity and/or syndrome with ID	Language	Control groups	Reading abilities and possible predictors
Nash and Heath (2011)	13 children and young adults (12 girls and 1 boys)	11.4–19.3 years (mean = 15.6 years)	Down syndrome	English	Reading level	Deficit to use sublexical route (decoding) but fragilities to use lexical route and deficit reading comprehension
					Comprehension age	*Possible predictors:* difficulty in receptive vocabulary, deficit in verbal short-terms memory and visuo-spatial skills
					Poor comprehension age	

in this population, which probably stems from the broad age ranges sampled (Nash and Heath 2011; Ratz and Lenhard 2013). Inspired by Frith's model (1985; taken up by Valtin 2000) of the three developmental stages of reading acquisition (logographic, alphabetic and orthographic), Ratz and Lenhard (2013) studied 1612 participants with mild-to-profound ID of known etiology between the ages of 6 and 21 years. These authors found that 29.3% could not read, 6.8% read at a logographic level, 31.9% at an alphabetical level, and 32% at an orthographic level, of whom 38.5% had reached the orthographic stage by 11 years, and 41.1% by 16 years. Other studies of ID have drawn on Coltheart (1978)'s dual-route reading model. This model identifies two independent but complementary routes: (1) the *lexical* route, whereby the reader quickly *probes* the written word (known and irregular), in order to identify each of its components (graphemes, phonemes) and retrieve the corresponding orthographic representation stored in the mental lexicon; and (2) the sublexical route, which allows unknown words (and pseudowords) to be decoded using grapho-phonological correspondences (segmentation of the word into individual graphemes, conversion of each grapheme into its corresponding phoneme units, then merging of the different phonemes to form the word) (Anthony et al. 2007). For example, Cohen et al. (2001)'s descriptive study among 61 adults with mild ID aged 18–56 years found that they had a very slow reading speed and considerable difficulty with word identification tasks (61% of participants). Results suggested that the readers with ID in their sample preferred to use the sublexical procedure (despite slow decoding) rather than the lexical path (no automatization), as observed in Williams syndrome (WS; Barca et al. 2010; Garayzábal and Cuetos 2008; Steele et al. 2013).

However, some individuals with ID have difficulty implementing the sublexical procedure. For example, Temple (2003) observed that a 13-year-old with WS had difficulty using both the lexical and sublexical routes, compared with mental age (MA)-matched controls (see, for example, Menghini et al. 2004). Similarly, readers with WS aged 8–15 years are less likely to use lexical reading than MA-matched controls (Garayzábal and Cuetos 2008). Results differ for other syndromes. For example, (Boudreau 2002) found that *good readers* with DS aged 5–17 years used the lexical route just as well as typical controls of the same MA (3–5 years). Taken together, these results indicate that individuals with ID have difficulty mastering both the sublexical and lexical routes. Intra-syndromic differences have been observed, in addition to intersyndromic ones. For example, Conners et al. (2001) demonstrated in persons aged 8–12 years with light-to-profound ID of unknown etiology that *good decoders* have better word reading performances (88.9%) than *poor decoders* (54.5%), especially during identification via the sublexical route (75.1% vs. 9.3%). Finally, the second activity of reading (comprehension) remains relatively poor in ID. Berger (2002) found that despite their relatively good reading skills, 192 adolescents aged 11–15 years with ID (IQ 63–80) still had problems accessing semantic representations (for DS, see Groen et al. 2006; Nash and Heath 2011).

Despite their considerable heterogeneity (sample, age range, type of ID, syndrome, etc.), these initial studies indicate that individuals with ID have the capacity for reading acquisition. The originality of the present study lay in our exploration of the reasons for the obstacles they encounter, based on previous results concerning possible hindrances to the use of the two routes of written word identification, in both typically developing children and those with reading disorders (dyslexia), whether these stem from impairments in overall cognitive abilities (intellectual efficiency) or ones specific to reading (perception, oral language and lexicon, phonological processing, and memory).

Intellectual Efficiency

Reading levels differ according to the severity of ID, regardless of etiology (Conners et al. 2001; Saunders and DeFulio 2007; Wise et al. 2010; for DS, see Boudreau 2002).

When the ID is mild, reading skills are relatively poor but discernible. For instance, 80 children aged 6.8–12 years (mean age = 9.4 years) with ID (mean IQ = 61.39) of mixed etiology (fragile X syndrome, DS, or unknown) were able to correctly identify 18% of words (range 0–58.5%) and 7.5% of nonwords (0–46.7%) (Wise et al. 2010). Ratz and Lenhard (2013) reported that out of 529 adolescents (mean age 12.1 years) with mild ID of known etiology, 35.8% were at the alphabetic stage (sublexical route) and more than half (59%) at the orthographic stage (both routes). However, when 8- to 12-year-olds with ID (IQ = 53–56.7) were divided into *good decoders* ($n = 21$) and *weak decoders* ($n = 44$), results revealed differences of 34.4% in word identification and 65.5% in nonword decoding (Conners et al. 2001).

Conners et al. (2001) concluded that when IQ is below 40, individuals with ID can only identify letters and cannot access reading. More recent results have nuanced this finding. A study of 579 individuals (mean age = 13.5 years) with moderate ID showed that 45.5% were at the alphabetic stage and 30.2% at the orthographic stage (Ratz and Lenhard 2013). Among 259 individuals (mean age = 13.3 years) with severe-to-profound ID, Ratz and Lenhard (2013) found that 12.4% were at the logographic stage, 16.5% at the alphabetic stage, and 4.6% at the orthographic stage, although more than half (66.5%) had not yet embarked on the reading process. Finally, they indicated that out of 210 participants (mean age = 13.9 years) with profound ID, 99.6% had not yet embarked on reading, and the remaining 0.4% was still at the logographic stage.

Some authors, such as Boudreau (2002), have shown that in DS, reading is correlated with nonverbal IQ, but not with performance IQ (see also a study of 61 adults aged 18–56 years with mild ID; Cohen et al. 2001). In WS, by contrast, Levy et al. (2003) observed that in 20 young people aged 12.8–20.4 years (mean = 16.5 years) with the syndrome (IQ = 40–84), (1) verbal IQ and word reading were correlated, and (2) performance IQ was correlated with nonword decoding and language skills. By contrast, Saunders and DeFulio (2007), who were strongly criticized by the former on account of their small sample, failed to find a correlation between IQ and basic reading skills (7.8% for correct word identification and 6.6% for correct nonword identification) among 30 adults aged 21–58 years (mean = 35 years) with mild ID of unknown etiology (mean verbal IQ = 66.4 and mean performance IQ = 68.73), despite a correlation between IQ and phonological skills. Thus, when IQ is controlled for, research findings highlight variability in reading performance that can be attributed to other cognitive functions. In the case of mild ID, Levy's (2011) study of 19 young people aged 13–20.5 years with DS (mean IQ = 60.8) and 19 young people aged 13.3–21.8 years with ID of unknown etiology (mean IQ = 59.1) demonstrated that IQ mediates correlations between word decoding (sublexical route) and certain high-level cognitive functions (phonological short-term memory and phonological awareness). When ID is severe to profound, there is also a positive correlation between the severity of ID and the development of the cognitive skills underlying the act of reading (Ratz and Lenhard 2013).

In summary, individuals with ID are perfectly capable of accessing reading and its prerequisites. Studies explaining the reading difficulties observed in ID point to a delay in the acquisition of these prerequisites. The level of intellectual efficiency is therefore not the only predictor of reading performance (Conners et al. 2001; Levy 2011; Ratz and Lenhard 2013). There therefore appears to be a complex link between IQ and high-level processes (phonological, semantic and linguistic representations, memory and comprehension), which has an impact on the low-level processes (decoding) needed for reading (Conners et al. 2001; Levy 2011; Ratz and Lenhard 2013). The considerable inter- and intra-syndromic variability in the cognitive skills involved in reading, may also explain the heterogeneity of results for ID (Laws and Gunn 2002; Nash and Heath 2011).

Beyond the general hypothesis on intellectual efficiency outlined above, our review highlighted results concerning specific cognitive factors (language, phonological processing, perception, memory, and executive functioning) that may explain atypical cognitive characteristics and reading acquisition in ID.

Perceptual Abilities

The cognitive skills needed for reading acquisition include perceptual auditory skills (phonological processing of the word's oral sequence) and visual or visual-attentional abilities (Valdois et al. 2012).

At the auditory level, the categorical perception of speech sounds is correlated with the reading difficulties of individuals with dyslexic disorders (Bogliotti et al. 2008; Serniclaes et al. 2005). Serniclaes et al. (2005) demonstrated that hypersensitivity to acoustic variations within the same category of phonemes can prevent reading acquisition. Research in the wake of this study has reported atypical auditory functioning in several clinical cases of ID. Compared with typical controls matched on chronological age (CA), individuals with WS (IQ = 40–70), exhibit hypersensitivity to acoustic differences in sounds (Majerus et al. 2011; Zarchi et al. 2010). This type of discriminatory behavior is similar to the allophonic speech perception mode observed in prelinguistic children (phonological categories not established before the age of 6 months) (Kuhl 2004).

At the visual level, low-level processes (contrasts) and visual-attentional processing (all the letters in the sequence forming the written word) are also implicated in the difficulty that dyslexic individuals have identifying words (Valdois et al. 2012). Inspired by this work, several studies in ID have suggested that the specificities of reading can be explained by a deficit in visual-attention processing. For example, young people aged 5–15 years with WS were found to have atrophy of the parietal cortex involved in visual-attentional and visuospatial processing (see also the meta-analysis of 30 studies by Martens et al. 2008). Sarpal et al. (2008) postulated that visuospatial difficulties (face or object recognition task) in WS stem from a disconnection between the ventral visual pathway and the intraparietal fissure. More recently, Majerus et al. (2010) highlighted the processing of local rather than global visuospatial information in WS. This visual processing specificity could result in poor identification of written words, owing to lexicalization errors, visual substitution or the visual displacement of letters (see also Dessalegn et al. 2013).

We therefore suggest that, perceptual deficits in auditory and visual processing in the ID population hamper reading acquisition, preventing or slowing down the implementation of word identification procedures via the lexical or sublexical route.

Oral Language Development

In typical development, oral language skills are more important for acquiring the knowledge needed to learn to read than the sociocultural environment (Elbro and Scarborough 2003; Velleman and Vihman 2006).

Longitudinal studies of ID have shown that the babbling of 18-month-old infants with WS or DS is immature relative to their CA (Masataka 2001; Mervis and Bertrand 1997). For children with WS, the average age of acquisition of 100 words is 3 years (Mervis et al. 2003; for DS see, for example, Abbeduto et al. 2007), compared with 2.6 years in typical development (Fenson et al. 2007). Despite inter-syndromic differences (Mervis and Klein-Tasman 2000; Vicari et al. 2005), researchers generally observe a slowing of lexical development in ID, leading to difficulties with oral comprehension (Buckley and Bird 2002). Berger (2002) found that children with mild ID perform well on the identification and storage of lexical, infralexical, propositional and phrasal units during reading, but not on meaning construction.

In typical development, expert reading requires fast word recognition, but also automatic syntax calculation, in order to free up resources in working memory and thereby access high-level comprehension processes. Among beginning readers, *epilinguistic* manipulation (Hakes 2012) provides access to sentence semantics and allows learners to familiarize themselves with their sound configuration. However, the absence of a *syntactic ceiling* is another developmental specificity of ID (Laws and Bishop 2003). For example, children with DS continue to develop the ability to deal with the syntactic complexity of sentences up to the age of 20 years (Laws and Bishop 2003). Children with ID reach a mean verbal production length of three significant elements around the age of 9 (for SD, see Rondal 2009).

This slow and atypical development of oral language has an impact on the acquisition of other types of knowledge needed for reading, such as orthographic lexicon development and the development of metalinguistic knowledge (written language).

The lexicon plays a fundamental role in reading for two reasons: (1) the automatic processing of the orthographic form of the words is essential for the reading is fluid enough by accessing a harmonious understanding; and (2) knowledge of words and their meanings is a prerequisite for constructing mental representations of the situations described by the texts. However, there has been relatively little research on the extent and processing of the orthographic lexicon of individuals with ID. It seems that good readers with ID have an internalized knowledge of the orthographic representations accepted in their mother tongue, despite being sometimes delayed in their orthographic processing (for WS, see Garayzábal and Cuetos 2008; Menghini et al. 2004). There are currently two possible explanations for this delay (Baddeley 2000): (1) difficulty storing orthographic units in the mental lexicon; and (2) deficits in the retrieval and use of this information. Several arguments support the first explanation. Given the Matthew effect described by Stanovich (1986), children with ID are probably at a disadvantage when it comes to acquiring a written mental lexicon. The more we read, the larger our lexicon. Thus, because of their slower lexical development and comprehension difficulties, these children read less, and therefore have less opportunity to acquire and store new orthographic knowledge. As a result of this *vicious circle*, individuals with ID are slower at acquiring new vocabulary, which is detrimental to their reading (Boudreau 2002). Loveall and Conners (2013) recently found that individuals aged 13–33 years with ID of mixed etiology performed better on the orthographic recognition of nonwords after phonological decoding than after repetition.

Thus, the specificities of their lexical and syntactic restructuring seem to contribute to the atypical development of orthographic and semantic processing in individuals with ID. The above-mentioned hypotheses question the role of (1) phonological processing, and, (2) mechanisms of orthographic information storage and retrieval (working memory) in reading difficulties. In the following sections, we therefore look at the progress of research in these last two areas.

Development of Phonological Processing

In addition to the mastery of oral language, various studies have examined whether the metalinguistic (including phonological) knowledge of individuals with ID is sufficient to correctly develop writing skills. Researchers have highlighted a metacognitive deficit in individuals with ID related to phonological skills (Kennedy and Flynn 2003; Verucci et al. 2006). Good phonological skills (phonological awareness) are required for word recognition among typically-developing individuals (Nation et al. 2010), as well as those with ID (Blischak et al. 2004; Saunders and DeFulio 2007; Wise et al. 2010). Studies in ID show that phonological awareness is predictive of word and nonword decoding abilities (Saunders and DeFulio 2007; Wise et al. 2010). Verucci et al. (2006) observed that the scores of children with DS (mean MA = 6.2 years) on phoneme suppression and rhyming tasks were significantly correlated with nonword reading. *Good decoders* with ID are more efficient than *weak decoders* on phonological awareness tasks (Conners et al. 2001), although reading acquisition remains possible despite weak phonological awareness (Boudreau 2002; Cupples and Iacono 2002; Kennedy and Flynn 2003). Barker et al. (2013) found that among 294 children aged 7–10 years with mild ID (mean IQ = 63), correlations between phonological processing and reading skills were similar to those of typical children matched on MA. For example, young people with DS exhibit nonword decoding abilities despite lower phonological performances than MA-matched controls (Abbeduto et al. 2007; Kennedy and Flynn 2003; Roch and Jarrold 2008; Verucci et al. 2006; meta-analysis by Lemon and Fuchs 2010; Næss et al. 2012). Similarly, children with WS can partially use decoding skills despite poor performances on phonological awareness tasks, compared with CA- or lexical age-matched typical controls (Laing et al. 2001; Levy et al. 2003; Majerus et al. 2003).

Moreover, the results recorded by Wise et al. (2010) in children aged 7–9 years with DS (mild ID) led them to conclude that phonological awareness accounts for a significant amount of variance in word and nonword decoding speed after controlling for CA and vocabulary level. Gombert (2002)'s comparison of children with DS (CA = 13.9 years) and reading age-matched typical controls (mean reading age = 7.1 years) revealed positive correlations between measures of phonological awareness and word reading performance in both groups.

According to Gombert (2002), task complexity may partly explain the differences in results for phonological awareness between studies. In his study, he found that children with DS performed better on syllable segmentation and rhyme detection than on phoneme writing, counting and suppression. Tasks assessing phonological skills require explicit manipulation (high-level process) that is difficult for people with ID to implement. Gombert (2002) also demonstrated that individuals with ID perform just as well as reading age-matched typical controls on implicit phonological tasks. Similar results (performance equivalent to their CA and MA) are found for children and adolescents with WS on verbal fluency tasks, but not on rhyming judgment (e.g., the meta-analysis of Volterra et al. 2001). This raises the question of whether the reading acquisition difficulty observed in ID partly stems from difficulty using high-level processes (metaphonological skills).

Memory

Several studies in both typically developing and struggling readers have demonstrated that reading achievement is influenced by *working memory* (Cain et al. 2004; Loosli et al. 2012). Studies exposing working memory disorders in children and adolescents with ID (Channell et al. 2013; Conners et al. 2001; Henry and Maclean 2002; Henry and Winfield 2010; Schuchardt et al. 2011) are based on Baddeley (2007)'s multicomponent model. Children with ID have a working memory deficit in relation to their CA, with performances equivalent to an MA of 4–6 years (Bayliss et al. 2005; Henry and MacLean 2002; Hulme and Mackenzie 2014; Maehler and Schuchardt 2009; Schuchardt et al. 2011; van der Molen et al. 2010). For their part, Costanzo et al. (2013) observed more difficulties with verbal (digit span) and visuospatial (Corsi Block Test) memory among 15 young people with WS (mean CA = 17.6 years; mean MA = 6.7 years; mean IQ = 53) and 15 young people with DS (mean CA = 14.5 years; mean MA = 6.2 years; mean IQ = 53) than among 16 typical children (mean CA = 7.4 years) matched on MA (see also Henry and Winfield 2010; van der Molen et al. 2007). Poloczek et al. (2014) also found that the verbal memory span (object name span) of 34 children aged 10–12 years with mild ID (IQ = 65–81) was smaller than that of 34 typical children matched on MA (see also Henry and MacLean 2002; Henry and Winfield 2010). The explanation for these various results is that, beyond sample size and ID severity, individuals with ID are more familiar with numbers than with object names.

According to Baddeley (2007)'s model, the study of *phonological memory* in ID is central. Conners et al. (2001) reported that, among 65 children 8- to 12-year-olds with mild-to-moderate ID, phonological memory was correlated with word reading, but not with phonological awareness performances (see also Henry and Winfield 2010). Other studies have failed to find a clear link between phonological memory and reading in ID (Bayliss et al. 2005). In order to understand these divergent results, studies have focused on the different structural skills of phonological memory. Thus, difficulty storing and updating the phonological code of verbal information in DS (Baddeley and Jarrold 2007; Næss et al. 2011) is predictive of early reading skills (up to age 4–5 years), after controlling for CA and nonverbal skills (Bird et al. 2000; Laws and Gunn 2002). Similar findings are reported for young people aged 8.6–15.9 years with fragile X syndrome (Munir et al. 2000) and for people aged 9.9–15.6 years with moderate ID (Büchel and Paour 2005). Specifically, among individuals with mild ID, the variance in reading ability is explained by predominant use of the phonological loop compared with other components of working memory (Henry and Winfield 2010). It should be noted that in DS, Vicari et al. (2004) demonstrated the impact of a functional deficit in the phonological loop on verbal span. Thus, difficulty storing and updating phonological information in ID can be explained by little or no use of the phonological loop via subvocal rehearsal. Several studies assessing the use of this loop among people with mild ID have failed to observe any word-length effect (Conners et al. 2001; Hasselhorn and Mähler 2007; Henry and Winfield 2010; Hulme and Mackenzie 2014; Rosenquist et al. 2003). By contrast, other studies in individuals with mild ID have shown a significant word-length effect, but no interaction with the word's position in the list (Schuchardt et al. 2011; van der Molen et al. 2007). Another study by Poloczek et al. (2014) revealed word-length effects in a verbal serial recall task, but not in a cued recall task, when 34 young people aged 10 to 12 years with WS were compared with MA-matched controls (4–5 years). The variance in these results illustrates the effects of methodological bias in these studies of ID, characterized by small sample sizes, lack of a sufficiently sensitive test to reliably detect a word length effect at the same time as a significant interaction effect, and failure to take account of the fact that sequences of long versus short words take longer to pronounce, resulting in the first words disappearing faster from the phonological store than the last ones.

Nevertheless, these results suggest that the underuse of the phonological loop by individuals with ID depends on their level of mental development and the type of memory task (Conners et al. 2001; Henry and Winfield 2010; Poloczek et al. 2014). Moreover, the presence of a phonological similarity effect indicates that people with ID have good phonological representations stored in memory (Jarrold et al. 2000; Rosenquist et al. 2003; Schuchardt et al. 2011). Thus, their limited phonological store is linked to a low storage capacity rather than to a subvocal rehearsal deficit (Baddeley and Jarrold 2007). More generally, the development of verbal working memory in ID seems to follow that of MA, unlike the development of nonverbal working memory, which is correlated with other developmental factors (Danielsson et al. 2012). For example, studies have reported better performance on nonverbal (Corsi block test) versus verbal (word span) memory tasks in individuals with ID (Henry and Winfield 2010). Despite these results, very little research in ID has focused on *visuospatial memory* and the role of the visuospatial sketchpad in working memory difficulties (Henry and MacLean 2002). Vicari et al. (2004) demonstrated that, compared with typical children of the same MA, 56 young people with DS (mean IQ = 44.7; CA = 6.4–26.7 years) had impaired performances on visual and spatial span tasks, and 69 young people with WS (mean IQ = 52.7; CA = 4.6–29.8 years) had deficits in visuospatial span tasks (see also van der Molen et al. 2010). Working memory difficulties should therefore not be reduced either to the processing of visuospatial information or to anomalies in visual analysis. By contrast, Henry and MacLean's (2002) study showed that 53 children with ID (CA = 11.92 years; MA = 7.11 years) drew heavily on cognitive resources when using visuospatial memory, as did typically developing children aged 4–6 years (see also Henry and Winfield 2010; Schuchardt et al. 2011). The establishment of control processes (central administrator) in individuals with ID seems equivalent to that in children of the same MA (Henry and Winfield 2010; Schuchardt et al. 2011). This suggests to us that the links between short-term memory processes and attentional processes in reading mechanisms need to be considered in ID.

Long-term memory has also been extensively studied in ID (Vicari and Carlesimo 2002). Individuals with ID can rely on knowledge stored in long-term memory to support the short-term storage of new information (Henry 2010). In ID, fast naming tasks are correlated with performances on word and nonword reading and tasks measuring phonological awareness (Garayzábal and Cuetos 2008; Saunders and DeFulio 2007). As in typical development (Torgesen et al. 1997), these two processes (reading and rapid naming) require access to and retrieval of phonological information stored in long-term memory. However, sublexical phonological representations (phonemes and syllables) may have a specific organization in some cases of mild-to-severe ID (Majerus et al. 2003; Menghini et al. 2004; Roch and Jarrold 2008). For example, in WS, *weak decoders* (Roch and Jarrold 2008) exhibit an absent or inverted phonotactic frequency effect compared with *strong decoders* (Menghini et al. 2004). Finally, in relation to their MA, people with ID are recognized to perform more poorly on explicit long-term memory tasks (episodic and semantic)

(Jarrold et al. 2007), but at an equal level on implicit memory tasks (priming effect and procedural learning) (Bussy et al. 2011; Witt and Vinter 2013; see also the meta-analysis by Lifshitz et al. 2011).

All these results point to a deficit in the use of phonological memory inducing reading difficulties, including the learning of word pronunciation and the implementation of decoding. Poor retrieval and maintenance of information in working memory makes it difficult to store new learning (including reading) in long-term memory in ID. Beyond phonological retrieval from long-term memory, the development of patterns and orthographic regularity in individuals with ID may be hampered by the time it takes to activate letter representations. Moreover, there seem to be specificities in the implementation of visuospatial memory. We can relate this last observation to a general deficit in executive resources (memory, attention, inhibition, planning) among children with ID (Costanzo et al. 2013; Danielsson et al. 2012) and its impact on the automation of reading procedures (Majerus et al. 2010; Martens et al. 2008; Sarpal et al. 2008).

Discussion and Research Perspectives (cf. Fig. 1 and Table 1)

The purpose of the present review was to carry out an inventory of current knowledge on literacy acquisition difficulties in ID. Researchers have approached this domain in different ways, with some interested in the implementation of decoding, and others focusing on the development of associated skills (lexicon, phonological awareness, visuospatial processing, memory, etc.). The result is a high degree of heterogeneity in their results which, together with other variables influencing learning and development (family, sociocultural environment, medical diagnoses, etc.), makes the study of this ID population extremely challenging. Studies of homogeneous populations need to be carried out to understand the causes of these difficulties better.

Our review suggests that reading acquisition in ID is generally atypical and delayed. More specifically, weaknesses in decoding skills induce a delay in the reading acquisition of individuals with ID in relation to their CA and MA (Conners et al. 2001; Menghini et al. 2004; Næss et al. 2012; Nash and Heath 2011; Ratz and Lenhard 2013). Several authors have observed a delay in the acquisition of this skill compared with typical development (Abbeduto et al. 2007; Fenson et al. 2007), sometimes with a lack of automation (Barca et al. 2010; Conners et al. 2001; Næss et al. 2012; Roch and Jarrold 2008; Saunders and DeFulio 2007; Verucci et al. 2006). Studies also show that people with ID have difficulty decoding new words (sublexical route) and gaining access to reading comprehension (Boudreau 2002).

It should be noted that we began this article by explaining the usefulness of Coltheart (1978)'s dual-route model for understanding readers' different profiles. In the future, support from other models will be needed. Few of the studies mentioned here were based on theoretical models of reading (expert or learning models) (Coltheart et al. 2001; Frith 1985; Share 2004). They nevertheless provide evidence in favor of atypical functioning rather than a simple delay in reading acquisition. Several studies have shown that the deficits of individuals with ID concern the explicit skills (metaphonology, phonological awareness, visuospatial processing) necessary for learning to read rather than the implicit ones (visuospatial memory, lexicon) (Bussy et al. 2011; Gombert 2002; Lifshitz et al. 2011; Witt and Vinter 2013). They show that reading acquisition difficulties in ID are related to specificities in the implementation of high-level processes. For example, individuals with

ID have more difficulty performing tasks that require a high level of control and awareness of strategies than those requiring unintentional encoding (Atwell et al. 2003). Thus, implicit learning (as defined by Vinter et al. 2010) seems better preserved than explicit learning in ID.

A further aim of our review was to better understand the reading difficulties observed in ID by focusing on studies dealing with explanatory factors. We found that individuals with ID experience a general cognitive slowdown that causes a delay in the development of the cognitive and behavioral skills needed to acquire reading (Schuchardt et al. 2011). Atypical functioning is also observed in the main cognitive dimensions involved in learning to read, namely perception (Majerus et al. 2010), oral language (Laws and Bishop 2003; Rondal 2009), phonology (Saunders and DeFulio 2007; Wise et al. 2010), memory (Henry and Winfield 2010; Schuchardt et al. 2011), and attention (Danielsson et al. 2012; Martens et al. 2008). Learning to read therefore involves several interrelated variables. So far, very few studies have examined the impact of the specific neuropsychological profile of individuals with ID on the skills underlying reading, despite the hypothesis that the origin of reading difficulties in ID is multidimensional (Dessalegn et al. 2013). Future research should question the origin of differences in the cognitive profiles of individuals with ID, in order to understand their atypical development better. Longitudinal studies (using the developmental trajectory method) are rare, even though they would provide a means of exploring and understanding the strategies implemented by readers in comparison with non-ID readers during development. In the long term, such comparisons would help us to describe the processes underlying reading acquisition in ID, allowing us to better understand why some individuals with IDs are able to read and others not, and to pinpoint the origins of reading difficulties.

To date, there has been virtually no research assessing the contribution of these variables and how they may influence each other. Current research is generally concerned with the dimensions highlighted in research on typical learning and reading disorders. We have seen that much of this work has focused on the development of phonological skills in ID (Majerus et al. 2010; Saunders and DeFulio 2007; Wise et al. 2010). However, this development requires good perceptual abilities and working memory. Future research should clarify the possible indirect effects of certain cognitive dysfunctions on reading acquisition. Many questions remain open, concerning the links between the acquisition of oral language and that of written language, between visuospatial skills, memory and the storage of spelling information in memory, and between oral language development and family interactions around writing. To answer these questions, more longitudinal studies need to be conducted to highlight different learning profiles. For example, recent research among individuals with WS has highlighted the specific role of visuospatial deficits in learning to read (Dessalegn et al. 2013).

One of the difficulties of studying the acquisition of reading and its explanatory factors in ID is determining which group to use to compare the performances of individuals with ID, and which comparisons (structural, developmental, strategic, metacognitive, motivational) to run (Thomas et al. 2009). Should we compare them with CA, MA, typical readers or vocabulary level, different choices can lead to highly divergent results. For example, some studies of reading acquisition have included nonreading participants with ID (Laing et al. 2001), a method strongly criticized by Levy et al. (2003). Likewise, most of the time, comparisons are limited to other syndromic or functional pathologies (Costanzo et al. 2013; Dessalegn et al. 2013; Menghini et al. 2004), and involve a wide CA range (Cohen et al. 2001; Conners et al. 2011; Saunders and DeFulio 2007). There is also considerable heterogeneity of results at the interindividual level, even within the same syndrome. For example, in the WS population, some children learn to read (reading and understanding a few sentences) and some do not (letter recognition) (Levy et al. 2003).

Nevertheless, inter-syndromic comparisons and comparisons between different categories of *weak readers* are also interesting. Conners et al. (2011) focused on different memory profiles in DS, WS and fragile X syndrome, and their implications for reading acquisition. DS and WS were found to be characterized by relatively good immediate visual memory and good phonological retrieval. The difference between the two syndromes lay in poorer verbal working memory and phonological recoding abilities in DS than in WS. By contrast, fragile X syndrome was characterized by severe impairment of visual and verbal working memory. Despite specific memory profiles and very different linguistic abilities across the three syndromes, there is a common model: relatively good word recognition, but a very weak understanding of the sentences or words that are read. The authors suggested that reading instruction should be based on the memory strategies used for each of the three etiologies of ID. Given the importance of their results, further research of this type will need to be conducted in the years to come. For the time being, studies remain at the level of the theoretical hypothesis. For example, several studies have indicated that the reading profile in WS is reminiscent of dyslexia (Dessalegn et al. 2013; Menghini et al. 2004; Temple 2003). However, most of these are nongeneralizable case studies.

Overall, individuals with ID display a lack of interest in school subjects because of their comprehension difficulties (Odom et al. 2011). The motivation to learn therefore also has to be examined, as does the lack of stimulation in terms of parents' and teachers' expectations (Carter et al. 2009). Research has revealed differences in reading acquisition according to socio-environmental factors such as parental stimulation, motivation, and self-esteem (Buckley and Bird 2002). Developmental studies adopting the neuroconstructivist approach (Karmiloff–Smith 1998) are needed to observe the impact of schooling mode (inclusion, special school for children with ID, early intervention program, cognitive remediation, adult-mediated transition from implicit to explicit, etc.) on individuals with ID (Browder et al. 2008; Frankel and Gold 2007; Gayadeen 2014; Landesman-Ramey et al. 2007; Lehoux 2015). Chapman and Hesketh (2001) highlighted the lack of adequate stimulation for children with ID in school settings. For example, children with DS are known to rely more on visual input than on hearing for learning (Steele et al. 2013). However, it is important not to sequence the learning of reading for children with ID according to these modalities (e.g., the working on phonemes, then on graphemes) but to apply a holistic approach (Martini–Willemin 2013).

This review of the literature has allowed us to understand that there are multiple reasons why individuals with ID have difficulty learning to read. There is a link between reading skills and certain cognitive skills, namely perception, oral language, phonological processing, and working memory. There is no doubt that future research will allow us to ascertain whether the learning difficulties of individuals with ID are related to a general deficit or to more specific deficits, by exploring the links between reading skills and cognitive abilities. Moreover, the considerable heterogeneity of individuals with ID (severity, etiology, age, schooling, associated disorders) requires further inter- and intra-syndromic comparisons. If a longitudinal approach is adopted, this will make it possible to identify developmental trajectories in the learning of reading, whether or not they are specific to the syndrome. These explorations will allow for the implementation of adapted support and the improvement of learning and autonomy, and will open up new perspectives on schooling, training, and social and professional integration.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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