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Individual cognitive training of reading disability improves word identification and sentence comprehension in adults with mild mental retardation

David Cohen [b,*], Monique Plaza [b,d], Fernando Perez-Diaz [c], Odile Lanthier [b], Dominique Chauvin [b], Nicole Hambourg [b], Anna J. Wilson [b,e], Michel Basquin [b], Philippe Mazet [b], Jean Philippe Rivière [a]

[a] *Université René Descartes, 39, rue des Saints Pères, 75006 Paris, France*
[b] *Département de Psychiatrie de l'Enfant et de l'Adolescent, Centre Référent Langage, Groupe-Hospitalier Pitié-Salpêtrière, AP-HP, 47-83, Boulevard de l'Hôpital, 75651 Paris Cedex 13, France*
[c] *CNRS UMR 7593, Groupe-Hospitalier Pitié-Salpêtrière, AP-HP, 47-83, Boulevard de l'Hôpital, 75651 Paris Cedex 13, France*
[d] *CNRS UMR 8605, Université René Descartes, 71, avenue Édouard Vaillant, 92774 Boulogne, France*
[e] *INSERM U562, Service Hospitalier F Joliot, CEA, F91401 Orsay, France*

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Abstract

Reading therapy has been shown to be effective in treating reading disabilities (RD) in dyslexic children, but little is known of its use in subjects with mild mental retardation (MR). Twenty adult volunteers, with both RD and mild MR, underwent 60 consecutive weeks in a cognitive remediation program, and were compared with 32 untreated control subjects. The experimental group showed a significant improvement in word identification, as measured by oral production ($p = 0.0004$) or silent reading ($p = 0.023$), and sentence comprehension ($p = 0.0002$). Adults with MR appear to benefit from new approaches in the field of RD.

Keywords: Mild mental retardation; Reading disability; Cognitive remediation

* Corresponding author. Tel.: +33 1 42162332; fax: +33 1 42162331.
E-mail address: david.cohen@psl.ap-hop-paris.fr (D. Cohen).

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1. Introduction

Whatever the underlying causes of mental retardation (MR), adults with mild MR exhibit numerous deficits in terms of academic achievement, which worsen their social prognosis. However, these subjects are never assessed in studies on reading disability (RD) or illiteracy (Kish, Jurgeblut, Jenkins, & Kolstad, 1993; Shalla & Schellenberg, 1998). Thus, little is known about their ability to read, although learning to read is an important and achievable goal for children and adults with mental retardation. Reading is acquired during childhood through education, and involves several skills: visual, auditory, and motor. In terms of cognitive processing, one of the crucial steps is written word identification or recognition (Broom & Doctor, 1995; Goswami & Bryant, 1990). Two word identification strategies or routes are used: the first being a grapho-phonologic conversion, or assembling strategy, which depends on converting grapheme into phonemes and then blending those phonemes to form a word; the second being an orthographic or lexical strategy, which enables readers to target the whole word in a stock of familiar written words and to access the corresponding lexical entry (Humphreys & Evett, 1985). While necessary, word identification is evidently not sufficient for reading. Reading also involves the use of syntax rules and the assimilation of specific characteristics of written texts. This factor is why literacy measures usually assess sentence and connected text comprehension as well as word identification. Comprehension reading tasks can be classified into two main groups: the first requiring high-level processing with a fine-grain analysis of syntactic, semantic, and pragmatic cues; the second requiring low-level processing – such as use of graphical cues or understanding of the logic of a table or list – in order to extract selective information in specific forms, lists, tables or programs (Rivière, 2002).

In a previous descriptive study, we assessed reading in a group of 67 unselected adults with mild MR, using high- and low-level comprehension tasks, together with other specific tasks related to word identification and syntax (sentence comprehension) (Rivière et al., 1999; Cohen et al., 2001). All subjects exhibited reading deficits: 61% had a severe impairment in word identification tasks (less than 50% of words read correctly) and 80% in the syntax task (comprehension of sentences below 30%). On high- and low-level comprehension tasks, most of the subjects had a severe or moderate impairment. Furthermore, for most of them, reading speed was very slow, indicating that word identification was not an automated process, and that assembling was the main cognitive strategy used. In this sample, word identification scores appeared to be correlated with both total and verbal IQ scores (Cohen et al., 2001).

However, in children with normal intelligence, IQ does not predict reading skills whatever the task (global reading, syntax or word identification) (Share, McGee, & Silva, 1989; Siegel, 1989); and similarly, reading disability is not related to IQ score (Siegel, 1989). During the past 30 years, reading therapy has been shown to be effective in treating RD in dyslexic children (Lovett, Ransby, Hardwick, Johns, & Donaldson, 1989). Most data come from treatment studies designed to confirm a particular theoretical hypothesis. Consequently, remediation programs have been limited to a few specific points and have focused on the presumed underlying deficit: visual strategy (Geiger, Lettvin, & Fahle, 1994), phonology (Gittelman & Feingold, 1983; Hurford et al., 1994), perceptive temporal processing of auditory stimuli (Merzenich et al., 1996; Tallal et al., 1996), cognitive strategies (Das, Mishra, & Pool, 1995), or balance and motor control (McPhillips, Hepper, & Mulhem, 2000). Of note, in clinical practice, reading therapy is mostly individualized, and adapted to the patient according to his/her main areas of dysfunction. Treatments usually include training and exercises related to different cognitive aspects, and many current practitioners tend to include a specific focus on phonological awareness and naming speed (Wolf, Miller, & Donelly, 2000), which are two significant predictors of reading in many alphabetic languages (Plaza & Cohen, 2003; Plaza & Cohen, 2004; Wolf et al., 2002).

We did not find a systematic study of the treatment of RD in adults with MR in the literature although some recent reports investigated the abilities underlying decoding impairments in children with mental retardation. In children with Down's syndrome, a positive association between phonological awareness and reading skills has been found (Conners, Atwell, Rosenquist, & Sligh, 2001; Cupples & Iacono, 2000; Fletcher & Buckley, 2002). This association is not unique, as other cognitive skills such as memory and general intelligence are associated as well (Byrne, MacDonald, & Buckley, 2002). When intelligence is substantially limited, the ability to rehearse phonological codes in working memory may play a major role in determining children's success in learning to read (Conners et al., 2001). However, Cossu, Rossini, and Marshall (1993) provided evidence that reading acquisition might be possible in children with Down's syndrome and poor phonological awareness. Several methodological issues have been raised regarding this study, and other groups have not replicated its results (for details see Cupples & Iacono, 2000). Finally, regarding therapeutic approaches, it has been suggested in several case reports that the use of phonological awareness training alone (Kennedy & Flynn, 2003), or in association with analytic reading instruction (Cupples & Iacono, 2002) might improve reading skills in children with Down's syndrome.

Given the frequency of RD in adults with mild MR, and the impact of this deficit on their social prognosis, it is important to test if they are able to benefit from recent findings concerning cognitive remediation of dyslexic children. In the current study, we assessed the effectiveness of a cognitive remediation program administered by a reading specialist by comparing the reading progress of 20 adult volunteers with mild MR who participated in training to that of 32 untreated control subjects. Our program and treatment algorithm was designed according to a model of reading that considers (i) word identification as the first step and knowledge of syntax rules as the second (i.e. Nicolson, 1986; Plaza & Cohen, 2003; West, Stanovitch, Feemon, & Cunningham, 1983) and (ii) phonological awareness and naming speed as major components in reading acquisition (i.e. Goswami & Bryant, 1990; Wolf et al., 2000).

2. Method

2.1. Subject selection (Fig. 1)

Given the variety of factors that may influence treatment response, we decided to focus on a population with fairly good social adaptation and employment levels. Subjects for the study were recruited from a group of 67 subjects who had been recruited in a sheltered workshop in Paris to take part in a separate descriptive study of reading disability in subjects with mild mental retardation (Cohen et al., 2001; Rivière et al., 1999). Of note, admission to sheltered workshops in France is decided by an independent state commission, leading to little selection of subjects within institutions. All volunteers ($n = 22$) for a treatment of their reading impairment were selected from the descriptive sample. Subjects with French as a second language ($n = 1$), or with a severe impairment in expressive speech ($n = 1$) were not included in the study. Thus, 20 subjects took part in the study. After written consent was obtained, the subjects were given bi-weekly sessions ($n = 60$, see below) with a reading specialist. Given the number of sessions, the remediation process took place from 1999 to 2001. During 2001, the remaining 45 subjects from the original descriptive sample were contacted for a second evaluation of their reading skills to assess how sensitive the reading measures used were to time and other effects (e.g. improving

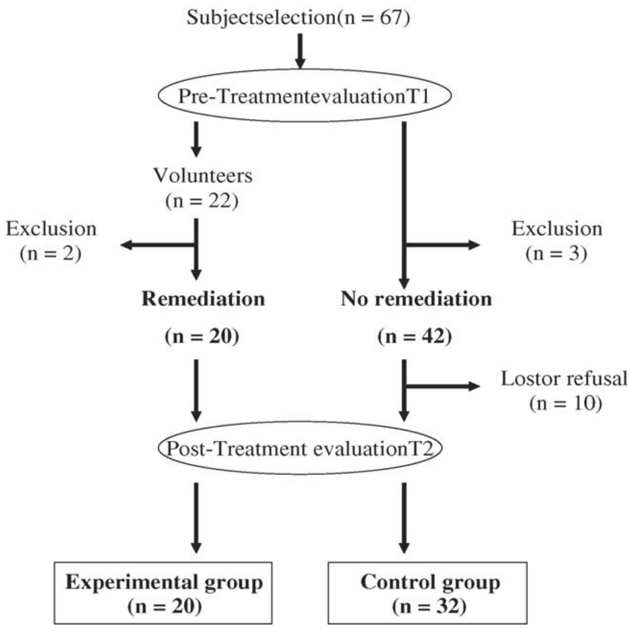

Fig. 1. Study design.

scores by repeating a task twice). Five subjects could not be contacted, three were excluded because of a severe impairment in expressive speech, and five more refused the second evaluation. Thus, 32 subjects were included in the comparison group.

2.2. Evaluation of participants

The evaluation started with a clinical interview, including assessment of neuro-psychiatric status, and examination of medical records to retrospectively assess the subjects' development, education, and social background. In all cases, ICD-10 diagnoses were generated for the following sections: psychiatry, neurology, psycho-social. A history of comorbid medical conditions was also obtained. All subjects were administered the Wechsler Adult Intelligence Scale—Revised (WAIS-R) to assess their IQ scores (Wechsler, 1974), and a 2-h test battery (described below) administered by a reading specialist to assess their reading abilities. After the treatment phase, the same evaluation was given to assess the improvement in reading.

2.3. Assessment of reading skills

Four reading tasks were proposed: word identification, syntax (sentence comprehension), narrative comprehension, and information seeking (for details, see Rivière et al., 1999). Word identification was assessed with two tests: (i) the *Mesure d'Identification de Mots* (MIM) [Word Identification Measure] (Mousty, Leybaert, Alegria, Content, & Morais, 1994). This task assesses oral reading. The subject is asked to read 48 words aloud which vary in terms of frequency, length, and complexity, and 24 non-words which vary in the same characteristics except for frequency. (ii) The *Iconographic Test* (ICO) (Rivière, 1998). In this task, the rater presents a series of 20 pictures with the corresponding words included in five multiple choice answer options. Foil words include errors designed to assess spelling stability, inference strategies, visual distinction, grapho-phonological confusion, and knowledge of the written code. Each word identification task is scored using the percentage of words correctly read by subjects. Sentence comprehension was assessed with the *Test de compréhension de phrase* [Sentence Comprehension Test] (Rivière, 1998): this task uses a picture/sentence matching task, with five sentences each of which lacks a word. The absent words are presented in various contexts, which differ only in terms of syntactic properties (negation, tense, number, etc.). For each picture/sentence, the subject is asked to choose among four answer options. The task is scored by the percentage of correct answers. Text comprehension tasks included the evaluation of two types of texts that require high- and low-level processing (see Section 1). Narrative comprehension was assessed using two written prose texts: *Mortelle matinée*, a long but easy text (507 words, seven multiple choice questions with four answer options) (Mesnager, Rivière, & Bentolila, 1994), and *Jacques Lentide*, a shorter but complex text (151 words, four multiple choice questions with four answer options) (Rivière, 1998). Global comprehension and comprehension of contradictions, actions, resolution, history, etc., in the narrative are assessed using a multiple-choice question paradigm. Both tasks are scored by the percentage of correct answers. Finally, the TV schedule test (Mesnager et al., 1994) is a task that requires a selective understanding of written information. In the task, the subject is asked to seek information in a document (TV schedule for 1 day). Several abilities are tested: scanning by using graphical features (bold, italic, etc.), understanding of the logic of a list or a table, and comparison of time slots. Seven multiple choice questions are administered, and the task is scored by the percentage of correct answers.

2.4. Cognitive intervention

The remediation program was defined according to a hierarchical and adaptative plan and based on an algorithm of increasing level of complexity starting at the phonological level and ending at the global reading task level (Fig. 2). For each subject in the study group, individual remediation allowed us to adapt the treatment plan and to recommend some specific areas for remediation, which were identified according to the subject's cognitive reading dysfunction as assessed at baseline. For each step of the algorithm, a specific module of remediation was conducted. Each subject went from one step to another according to the reading specialist's decision to work on another module. Thus, all subjects were not supposed to receive all the modules. The number of modules depended on their assessment at baseline and their ability to assimilate the remediation. Subjects were given bi-weekly sessions with a reading specialist for 60 consecutive weeks.

2.5. Details of the step by step intervention (Table 1)

2.5.1. Phonological abilities

These activities focused on phonological training and included exercises on alliteration detection, phoneme isolation, segmentation of words into syllables, and perception and detection of rhymes. All exercises were based on PHONORAMA, which is a commercially available program used in a number of clinics (Issofuly & Primot, 1998). In this task, exercises are given with the goal of helping the subject to become aware of phonological units (syllables, rhymes, phonemes), and based on a huge set of pictures that are presented in A4 sheets containing one to eight pictures maximum. For example, for detection of rhymes, the investigator presents several pictures and the subject is asked to (i) extract all pictures that rhymed with a target one; (ii) to

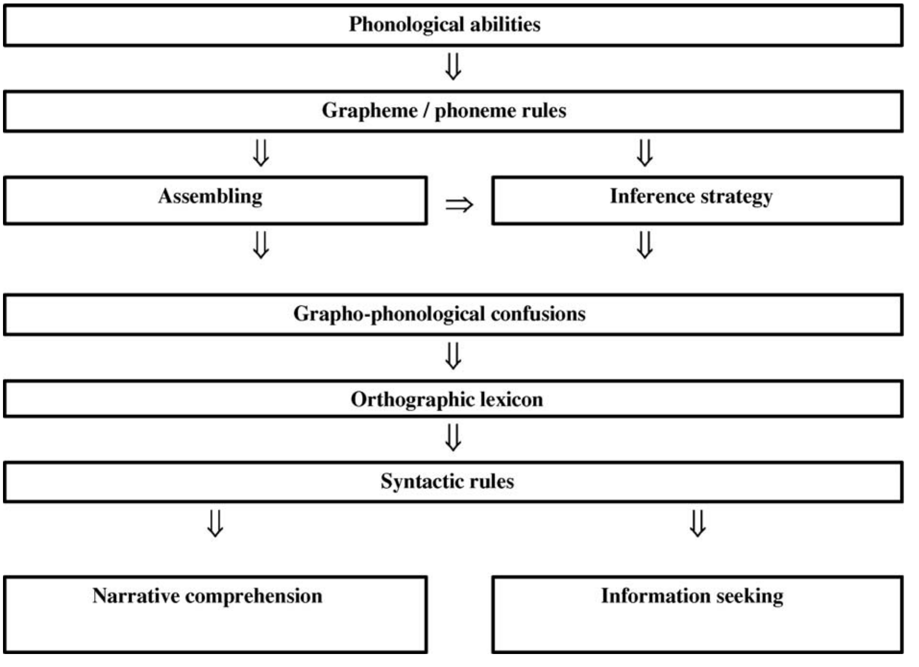

Fig. 2. Modules of the intervention program conducted in hierarchical fashion.

Table 1
Summary of technical characteristics of the cognitive remediation of reading by increasing level of complexity

Module	Specific training	Reference
Phonological abilities	Alliteration detection; phoneme isolation; segmentation; perception and detection of rhymes	Issofuly and Primot (1998)
Grapheme/phoneme rules	Oral–manual principles; reading and writing non-words	Borel-Maisonny (1973)
Assembling	Grapheme/phoneme rules for complex graphemes; written forms depending on context	LEXIDATA (1998)
Inference strategy	Word/picture paradigm using words with identical first syllables; reading of words with identical first syllables; generating words with identical first syllables	Geymant et al. (1996)
Grapho-phonological confusion	Phonetic characteristics of graphemes with overlapping pairs of letters; perception of visually close phonemes	Geymant et al. (1996) and GRIP (1995)
Orthographic lexicon	Reading of keywords with fast presentation; reading of words related to the social domain	Appendices A and B
Syntactic rules	Searching for semantic or morphemic oddballs; organizing lists of words into categories; ordering words into phrases; completing sentences with missing words	Autegarden et al. (1997) and LEXIDATA (1998)
Narrative comprehension	Punctuation rules; agents, place of action, tense; selecting main utterances (macro-structural characteristics)	Le Boeuf (1976) and Gasparini (1971)
Information seeking	Visual scanning; structural characteristics of common documents; graphical clues in a document	Subjects' documents

match pairs of pictures based on similar rhyme; and (iii) select pictures that rhymes with a word produced by the investigator.

2.5.2. Word identification processes

Aside from phonological abilities, we focused on word identification processes and naming speed. These activities included exercises related to grapheme/phoneme rules in French such as training reading and writing of non-words according to oral–manual principles (Borel-Maisonny, 1973). The tasks also included exercises training assembling: learning of grapheme/phoneme rules for complex graphemes (e.g. in French, graphemes such as oin, ion, ien or ein), reading of written forms which depend on context (e.g. in French, the corresponding phonemes of letters "c", "g", and "s" depend on vocalic context). In a third activity, subjects were asked to add letters in order to complete incomplete words. These tasks were extracted from SEDIDACTA—module *De l'écoute du son à la lecture*—(LEXIDATA, 1998) which is a commercially available program, including several sets on specific topics, used in a number of clinics in France and Canada. In cases of existing grapho-phonological confusions as shown by ICO test and MIM, treatment of the subject's confusions was also necessary, and was adapted by the investigator depending on subjects' baseline assessment. Activities included training for perception of visually close phonemes, and for phonetic characteristics of graphemes opposing confounded pairs of letters. All exercises related to the above tasks were taken from two computer programs used in many clinical settings in France named *l'Aventurier des confusions* (GRIP, 1995) and *Audiolog* (Geymant, François, Ternon, & Sampo, 1996). The first program presents exercises limited to reading input since questions and answer options are written. The subjects have to discriminate different written words by choosing from two to four choices. Distracters are non-words with overlapping graphemes (e.g. the subjects read *Quand on a faim, on doit* . . . [When one is angry, one must . . .] and are asked to choose between two written proposals *mancher* [non-word] and *manger* [to eat]). This program cannot be used with subjects who do not have minimal word recognition. The second program presents exercises with auditory discrimination of words using a correspondence with either pictures or written words (e.g. (1) the subject hears *jupe* [skirt] and sees a picture of a skirt, and he is asked to answer true or false (for confusion between/j/ and /ch/); (2) the subject hears *veuve* [widow] and he is asked to choose between two similar written words, *veuve* and *veuf*.

A frequent error shown in adult populations in word recognition is the use of an inference strategy as a result of prior reading instruction (Rivière et al., 1999). For example, when given multi-syllable words, the reader may recognize properly the first syllable, but guess the consecutive ones, leading to incorrect word identification. Treatment of inference strategies included exercises such as a matching words to pictures paradigm with a choice between words with identical first syllables, reading words with identical first syllables in a computerized paradigm (increasing speed of presentation), and generating words with identical first syllables. All these exercises were given with the goal of helping the reader to become aware of the inference strategy and of its possible bad consequences in terms of word recognition. The pairs of words were extracted from an available list in *Audiolog*. Duration was adapted by the reading specialist depending on the subject's metacognition of the problematic strategy. Finally, we focused on the orthographic lexicon trying to enhance the number of words identified with an orthographic or lexical strategy. These activities included reading of keywords in fast presentation (presented by computer with an adjustable speed of presentation), with a choice between multiple homophones (e.g. *bar* [bar]; *barre* [bar-rod]; *barré* [blocked-closed]). Of note, we focused on (i) syntactic indicators (n = 107) that are crucial for narrative comprehension (see below) and (ii) several frequent words ($n = 50$) related to the social domain and of importance for subjects with MR (Appendices A and B).

2.5.3. Syntactic rules

For subjects capable of word identification at baseline or during the treatment course, we also focused on syntactic rules. These subjects were given different sets of activities at the word level (50%): they were asked to search for semantic or morphemic oddballs in list of words, or to organize lists of words into categories. All these tasks were taken from *La chasse aux indices*, a commercially available set of tasks (Autegarden et al., 1997). Other exercises were related to short sentence organization (50%) such as ordering words into phrases or completing sentences with missing words. Sentences to organize or complete were constructed to improve syntactic rules (sense of tense, gender, number . . .). All exercises were from SEDIDACTA – module *A l'approche des textes – Jeux de lecture* (LEXIDATA, 1998) which is a commercially available program used in a number of clinics in France and Canada.

2.5.4. Global reading tasks

As explained above, for the subjects who had reached good accuracy in word identification, we focused on two types of reading tasks. Of course, global reading tasks used for the evaluation of reading were excluded from training.

For prose comprehension, subjects were trained with a sample of short texts included in a collection of texts with images that are used in academic settings with illiterate adults (Uze, 1989). The texts have the following characteristics: 20 sentences maximum length, simple syntactic forms, and no unnecessary details. Subjects were asked (i) to select keywords and quotes (macro-structural characteristics) from the text; (ii) to identify the main theme of the text (e.g. by giving a title to each paragraph); (iii) to repeat the meaning of the text orally in their own words; and (iv) to reread the text to enhance understanding. Specific morphosyntactic exercises were also given when appropriate depending on the meaning of the text: on the use of keywords (adverbs for tense, coordinating conjunctions . . .) (Appendix A), and on the understanding of tense and course of actions (by identifying agents, place of action, tense). These exercises ($n = 20$) were taken from two sets of tasks: the first asking the rater to match reading with images (Le Boeuf, 1976); the second giving a list of sentences fragments that the rater is asked to put in order (Gasparini, 1971). Finally, each text gave the opportunity to work on the lexicon by associating written forms of words related to the theme of the text, as well as the opportunity to enhance punctuation rules.

For information seeking in a document, subjects were trained with a sample of various types of documents (e.g. catalogue, table of contents, phone book, train ticket, bus map, telephone bill, bank statement, etc.). All documents were related to the subject's social activities in order to maintain motivation by highlighting the positive consequences of improving this kind of reading on everyday life. Therefore, this aspect of the training could not be standardized since documents were not the same for all subjects. Whatever the documents, subjects were trained (i) to be aware of the utility of visual scanning; (ii) to recognize the structural characteristics of common documents (e.g. list, table . . .); and (iii) to explore how to use graphical cues (e.g. bold, italics . . .) in a document.

2.6. Statistical analysis

For a description of the two study groups and comparison of pre- and post-treatment measures within the experimental and control groups, we used parametric and non-parametric comparison tests as necessary. For assessment of treatment efficacy, data were also analyzed by means of repeated measure ANOVAs, with group (experimental versus control) as a between-participant factor. Based on the evaluation of reading, six treatment efficacy variables were available for analysis. Instead of using absolute improvement [Variable after treatment (Vpost) − Variable before treatment (Vpre)] as a between-participant factor, a new variable, relative improvement [(Vpost − Vpre)/(1 − Vpre)], was calculated for each subject because of the heterogeneity of the pre-treatment measurements within subjects.

3. Results

3.1. Characteristics of the experimental group (Table 2)

Twenty subjects, 10 women and 10 men, aged 21–46 years (mean age = 33.4 years; S.D. = 7.71), were included in the treatment group. For all subjects, intelligence fell in the range for mild mental retardation (mean IQ = 66; S.D. = 8.48; range: 51–79). The causes of mental

Table 2
Characteristics of the study groups before and after cognitive remediation of reading

	Experimental group ($n = 20$)	Control group ($n = 32$)	Statistical comparison (p)
Socio-demographic			
Age	33.4 (7.71)	33.1 (7.60)	0.9[a]
% male	50	64.5	0.3[a]
Total IQ	66 (8.48)	62.6 (9.30)	0.19[a]
Verbal IQ	64 (8.03)	63.5 (9.14)	0.86[a]
Performance IQ	72.6 (11.01)	65.4 (12)	0.034[a]
Pre-treatment measures			
MIM	0.47 (0.38)	0.63 (0.34)	0.15[a]
ICO	0.60 (0.29)	0.70 (0.25)	0.23[a]
Syntax	0.53 (0.41)	0.61 (0.35)	0.45[a]
Short text	0.15 (0.27)	0.15 (0.26)	0.95[a]
Long text	0.25 (0.16)	0.34 (0.21)	0.2[a]
Information seeking	0.25 (0.25)	0.26 (0.29)	0.92[a]
Post-treatment measures			
MIM	0.56 (0.35)	0.54 (0.35)	0.89[a]
ICO	0.69 (0.26)	0.66 (0.32)	0.78[a]
Syntax	0.81 (0.25)	0.61 (0.38)	0.038[a]
Short text	0.19 (0.29)	0.18 (0.29)	0.91[a]
Long text	0.29 (0.31)	0.43 (0.24)	0.09[a]
Information seeking	0.28 (0.26)	0.27 (0.26)	0.90[a]
(Vpost − Vpre)/(1 − Vpre)			
MIM	0.24 (0.26)	−0.08 (0.27)	0.0004[b]
ICO	0.24 (0.40)	0.12 (0.46)	0.023[b]
Syntax	0.41 (0.41)	0.09 (0.46)	0.0002[b]
Short text	−0.033 (0.36)	−0.034 (0.40)	0.675[b]
Long text	−0.02 (0.55)	0.00 (0.40)	0.81[b]
Information seeking	−0.06 (0.43)	−0.14 (0.42)	0.473[b]

IQ: intellectual quotient; MIM: Mesure d'Identification de Mots (word identification score); ICO: Iconographic Test (word identification score).
[a] Comparison: t-test or χ^2-test.
[b] ANOVA: experimental group interaction.

retardation were diverse, although cause remained unknown for eight subjects. Along with mental retardation, five subjects had a comorbid psychiatric diagnosis [schizophrenia ($n = 2$), or pervasive developmental disorders ($n = 3$)], and four a neurological diagnosis [hemiplegia ($n = 1$), seizures ($n = 1$), hemiplegia comorbid with seizures ($N = 1$), and frontal lobe syndrome ($n = 1$)]. All comorbid conditions were stable and adequately treated when necessary. Eleven subjects had received special education during childhood, and four had received a course for adults with reading disabilities in the preceding years, but without any improvement.

The initial reading evaluation showed that all subjects had reading impairment at the level of global reading tasks. As defined in Rivière et al. study (1999), eight subjects had severe impairment in word identification and were illiterate; six were able to recognize written words, and sometimes to read short or simple sentences, but were weak in reading common documents (functionally illiterate); finally, six subjects were able to read at the level of global tasks, but made many errors. Details of pretreatment reading characteristics are given in Table 2.

3.2. Characteristics of the control group (Table 2)

Thirty-two subjects were included in the control group. Table 2 shows the main characteristics of the two groups. It should be noted that there was no statistically significant difference between groups at inclusion for all variables including the reading ones, except for performance IQ. The control group was also heterogeneous in terms of causes of mental retardation. Eleven subjects had a comorbid psychiatric diagnosis [schizophrenia ($n = 1$), anxiety disorder ($n = 4$), personality disorder ($n = 3$), pervasive developmental disorders ($n = 2$), pervasive developmental disorder comorbid with schizophrenia ($n = 1$)], and nine a neurological diagnosis [hemiplegia ($n = 2$), other motor impairment ($n = 2$), and seizures ($n = 5$)].

3.3. Details of the treatment modules received according to assessment at baseline

Given the heterogeneity of initial reading skills, treatment goals depended on each subject's initial level. For illiterate subjects, the main goals were to allow reading and comprehension of simple sentences related to social domains. Remediation covered the very first modules of the algorithm: phonology, assembling, and orthographic permanency of a few frequent words. For subjects who were already capable of word identification but functionally illiterate, the main goals were to allow reading and comprehension of short texts. Remediation progressed from phonology and assembling to other modules designed to improve reading speed by increasing the lexical inventory and by treating grapho-phonological confusions and inference strategies. Finally, for subjects who were already readers, the main goal was to enhance reading comprehension. Remediation focused on speed of word identification, understanding of syntax rules (including tense, gender, and number), information seeking techniques, and comprehension of a narrative text. Specific training on more basic modules was also given depending on the subject's baseline dysfunction.

3.4. Efficacy of the cognitive remediation of reading

Among the experimental group, the relative improvement in both word identification tasks and the syntax task was 24% and 41%, respectively (Fig. 3). The results of a paired *t*-test using pre- and post-treatment measures of the experimental group showed that there was a statistically significant improvement in three of the six study measures: word identification in oral production

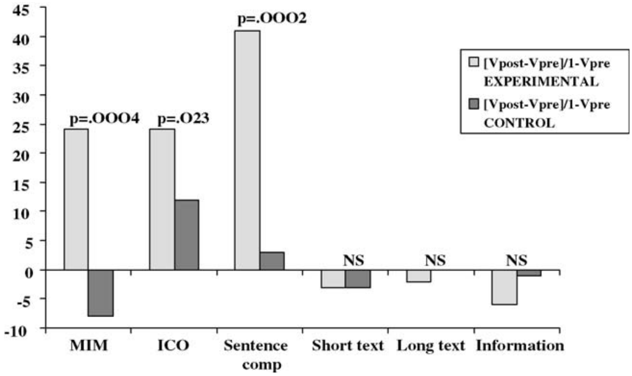

Fig. 3. Relative improvement of word identification (MIM, ICO), syntax (sentence comprehension), and global reading tasks (comprehension of short and long texts, information seeking) after cognitive remediation of reading.

(MIM) ($p = 0.0003$), word identification in silent reading (ICO test) ($p = 0.0295$), and syntax (sentence comprehension) ($p = 0.0008$). No significant pre/post difference was obtained in scores for comprehension of a long prose text or information seeking in a document. Furthermore, no significant pre/post difference was obtained for any scores within the control group (Table 2).

Using repeated measure ANOVAs with group (experimental versus control) as a between-participant factor and relative improvement as the dependant variable, we found significant improvement of word identification and syntax. A highly significant interaction for word identification in oral production (MIM) ($p = 0.0004$) and syntax ($p = 0.0002$), was found with only the experimental group showing a significant improvement. There was also a significant interaction for word identification in silent reading (ICO test) ($p = 0.023$), again with only the experimental group showing the significant improvement. There was no significant improvement for global reading tasks (comprehension of texts and information seeking in a document) (Table 2 and Fig. 3).

4. Discussion

4.1. *Efficacy of training*

To the best of our knowledge, the treatment of reading impairment in adults with mild mental retardation has never been systematically evaluated. The results of the study suggest that a cognitive treatment based on the same principles as used in dyslexic children is effective, although the improvement is limited to word identification and syntax, and does not permit subjects with MR to reach a high level of reading skills. Our program and treatment algorithm was conducted according to a model of reading that considers (i) word identification as the first step and knowledge of syntax rules as the second (i.e. Nicolson, 1986; Plaza & Cohen, 2003; West et al., 1983) and (ii) phonological awareness and naming speed as major components in reading acquisition (i.e. Goswami & Bryant, 1990; Wolf et al., 2000). We trained phonological abilities, grapheme/phoneme rules, assembling, grapho-phonological confusions, orthographic lexicon, syntactic rules, narrative comprehension, and information seeking according to a step-by-step algorithm (Fig. 2). The treatment required a careful evaluation of reading, the selection of an individual treatment plan, bi-weekly sessions with a reading specialist, and a relatively long duration. Many of these steps were related to word identification mechanisms in order to improve their efficacy and speed. Furthermore, we focused on the treatment of inappropriate inference strategies since these are a frequent decoding dysfunction in adults with MR as a result of reading instruction (Rivière et al., 1999).

Given the logic of our algorithm, it is not surprising that the two variables that did not change within the experimental group or in comparison to the controls were narrative comprehension and information seeking, as they represent a higher level of performance. Furthermore, the global reading tasks chosen in the present study are the same ones used for the French National Literacy Study (still ongoing) (Rivière, 2002), and presupposed a high level of reading skills. Knowing that IQ subscores related to narrative comprehension were low in the experimental group, it is possible that most of the subjects were not able to access comprehension because of the cognitive retardation itself. It may also be the case that there were not enough subjects who could reach this level of performance. Although we did not find any significant improvement at the group level, individual profile analysis of global reading tasks indicated that in the subgroup of subjects with minor impairment in word identification measures ($n = 6$), three subjects dramatically improved (+40%) their comprehension scores for a long text after treatment; moreover, two subjects dramatically improved (+50%) their scores for information seeking in a document, while three more showed a moderate improvement (+20%).

4.2. Limitation of the study

Despite the encouraging results, several limitations of the study should be kept in mind. Firstly, the experimental group was not randomized because only 22 volunteers could be selected. In adulthood, time-consuming treatment is feasible only with motivated individuals. Therefore, if randomization had been performed, experimental and control groups would have been limited to 10 subjects each, making statistical comparison weak. Secondly, we are aware that it is difficult to attribute the improvement to any one sub-aspect of the program content, since comparisons of alternative treatment approaches were not undertaken, and the groups were heterogeneous. This study was not intended to show the efficacy of a unique and simple task, but rather to test the hypothesis that illiterate adults with mild mental retardation could benefit from recent findings concerning cognitive remediation in dyslexic children. However, one can note that while our results have to be attributed to the treatment as a whole, several modules related to phonology and word identification processes were given to all subjects: phonology, assembling, inference strategy and grapho-phonological confusions (Fig. 2). Third, the two groups were heterogeneous in terms of etiology, comorbid conditions, and reading skills. Generalization to specific subgroups of persons with MR should be made cautiously.[1]

4.3. Questions remaining and future research

Many questions are left unanswered by the current study, some of which we plan to address with future research. Firstly, we do not know whether the intensive remediation program induces

[1] However, this last point calls for specific comments: (i) the study population was very close to that of clinical practice since no selection was undertaken; (ii) when subgroups of persons are selected because of a common etiology, heterogeneity is frequent as relation between phenotype and underlying etiology is weak for many causes of MR and/or developmental disorders (Cohen et al., 2005).

a temporary benefit or a permanent improvement. We plan to assess subjects' reading skills again, some months after the end of remediation, in order to shed light on this question.

Secondly, we need to study the statistical correlates between reading improvement and other subject characteristics. Several studies conducted on school-age children have established that reading acquisition appears to be influenced by two main cognitive competencies: phonological awareness (Goswami & Bryant, 1990; Share, 1995), and working memory (Crain, Shankweiler, Macaruso, & Bar-Shalom, 1990; Rossof, 1988; Torgensen, 1985). Similarly, the role of phonological awareness and memory for reading acquisition in children with MR has been described recently (Byrne et al., 2002; Conners et al., 2001; Cupples & Iacono, 2000; Fletcher & Buckley, 2002). Three possible predictive variables will be tested within the experimental group as measured with specific tests before remediation: IQ, memory, and phonological awareness. The study of predictive variables is important, as subjects with MR are a heterogeneous group, and it may help clinicians to select the best candidates for remediation, regardless of their etiological diagnoses, by assessing carefully the cognitive expressed phenotypes.

Third, we did not include in our program specific balance and motor control training for subjects with persistent primary reflexes, because we did not assess this dimension. The recent demonstration of the potential role of this early neurodevelopmental system in reading acquisition (McPhillips et al., 2000) has opened a stimulating area of research in the field of mental retardation as well, since these subjects frequently exhibit a neurological dysfunction. The application of specific motor training as described by McPhillips et al. should be investigated in children and adults with mild MR.

Finally, it should be of interest to study whether improvement of reading competencies is associated with better self-esteem and better social adaptation. Within the experimental group, this was our clinical impression although it was not specifically evaluated. In most of the subjects who were treated, the impact on word identification and sentence comprehension had a beneficial effect on their ability to function socially. For example, (1) B.M. was unable to read any words before remediation; after treatment, he scored 32% and 40%, respectively, on the two word identification tasks, and 60% on the syntax task, which means that he was able to take the subway without help, to order for himself in a restaurant, and so on. (2) J.P. was not illiterate when he started the remediation program, but his narrative comprehension and writing improved dramatically after treatment. When he stopped training, he said, 'I now feel normal, because I can read subtitles in foreign movies'. The reading specialists also pointed out that their one-on-one relationships with subjects permitted them to help the subjects with their negative feelings and their low self-esteem when dealing with written texts. However, this point should be assessed systematically.

5. Conclusion

Individual cognitive treatment of RD in subjects with mild MR is possible and may be effective, even during adulthood, using principles of reading therapy of dyslexic children. More research in this field should be done to confirm this preliminary data, and to identify variables that predict improvement as this may help in selecting the best candidates for remediation.

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Appendix A. List of keywords ($n = 107$) crucial for narrative comprehension

à [*at*], ainsi [*thus*], alors [*then*], après [*after*], assez [*enough*], au [*at*], aussi [*too*], avant [*before*], avec [*with*], beaucoup [*a lot of*], bien [*good*],bientôt [*soon*], ce, celle, celui, ces, cet, cette [*this, that*], chaque [*each*], combien [*how much*], comme [*as*], comment [*how*], dans [*in*], de [*of*], déjà [*already*], des, donc [*therefore*], du [*some*], elle [*she*], en [*in*], encore [*again*], est [*is*], et [*and*], il [*he*], jamais [*never*], je [*I*], jusque [*until*], la, le, les [*the*], laquelle, lequel, lesquelles, lesquels [*which*], leur, leurs [*their*], lui [*him*], ma, mon [*my*], mais [*but*], même [*same*], mes [*mine*], moi [*myself*], moins [*less*], ne [*not*], nos, notre [*our*], nous [*we*], on, par [*by*], pas [*not*], pendant [*during*], peu [*little*], plus [*more*], pourquoi [*why*], puis [*then*], quand [*when*], que [*that*], quel [*which*], qui [*who*], rien [*nothing*], sa, son, ses [*his, her*], sans [*without*], soi [*himself*], sous [*under*], sur [*on*], ta, ton, vos, votre [*your*], tellement [*so*], toi, tu, vous [*you*], toujours [*always*], tous, tout, toute [*all*], très [*very*], trop [*too*], un, une [*a*], vers [*to*].

Appendix B. List of words ($n = 50$) related to social domains

adresse [*address*], âge [*age*], arrivée [*arrival*], avenue [*avenue*], avion [*airplane*], banlieue [*suburb*], bar [*bar*], billet [*ticket*], boulanger [*baker*], boulevard [*boulevard*], bus [*bus*], café [*cafe*], charcutier [*delicatessen*], chien méchant [*beware of the dog*], cinéma [*theatre*], coiffeur [*hair dresser*], correspondance [*transfer*], départ [*departure*], direction [*direction*], fermez la porte [*close the door*], non fumeur [*no smoking*], garage [*gas station*], hôpital [*hospital*], hôtel [*hotel*], journaux [*newspapers*], lettre [*letter*], ligne [*line (of bus/train)*], métro [*train*], né le . . . à . . . [*born on . . . in . . .*], nom [*name*], paquet [*packet*], Paris [*Paris*], pharmacie [*drug store*], piéton [*pedestrian*], police [*police*], pompiers [*firemen*], poste [*mail*], pousser [*push*], prénom [*first name*], province [*province*], quai [*platform*], restaurant [*restaurant*], rue [*street*], SAMU [*emergency services*], secours [*assistance*], SNCF [*French National Railway Company*], sonnez [*ring*], sortie [*exit*], tabac [*tobacconist*], taxi [*cab*], tél. [*telephone*], théâtre [*theater*], tirer [*pull*].

References

Autegarden, S., Deflandre, C., Dreyfus, J. L., Martin, P., Servant, J. M., & Voust, M. (1997). *La chasse aux indices*. Les Mureaux: Société d'Edition et de Diffusion.

Borel-Maisonny, S. (1973). *Langage oral et écrit I. Pédagogie des notions de bases*. Neuchâtel: Delachaux et Niestlé.

Broom, Y. M., & Doctor, E. A. (1995). Developmental phonological dyslexia: A case study of the efficacy of a remediation program. *Cognitive Neuropsychology, 12*, 725–766.

Byrne, A., MacDonald, J., & Buckley, S. (2002). Reading, language and memory skills: A comparative longitudinal study of children with Down syndrome and their mainstream. *British Journal of Educational Psychology, 72*, 513–529.

Cohen, D., Pichard, N., Tordjman, S., Baumann, C., Burglen, L., Excoffier, S., et al. (2005). Specific genetic disorders and autism: Clinical contribution towards identification. *Journal of Autism and Developmental Disorder, 35*, 103–116.

Cohen, D., Rivière, J. P., Plaza, M., Thompson, C., Chauvin, D., Hambourg, N., et al. (2001). Word identification in adults with mild mental retardation: Does IQ influence reading achievement? *Brain and Cognition, 46*, 69–73.

Conners, F. A., Atwell, J. A., Rosenquist, C. J., & Sligh, A. C. (2001). Abilities underlying decoding differences in children with intellectual disability. *Journal of Intellectual Disability and Research, 45*, 292–299.

Cossu, G., Rossini, F., & Marshall, J. C. (1993). When reading is acquired but phonemic awareness is not: A study of literacy in Down's syndrome.. *Cognition, 46*, 129–138.

Crain, S., Shankweiler, D., Macaruso, P., & Bar-Shalom, E. (1990). Working memory and comprehension of spoken sentences: Investigations of children with reading disorder. In G. Vallar, & T. Shallice (Eds.), *Neuropsychological impairments of short-term memory.* Cambridge: Cambridge University Press.

Cupples, L., & Iacono, T. (2000). Phonological awareness and oral reading skill in children with Down syndrome. *Journal of Speech, Language and Hearing Research, 43*, 595–608.

Cupples, L., & Iacono, T. (2002). The efficacy of 'whole word' versus 'analytic' reading instruction for children with Down syndrome. *Reading and Writing, 15*, 549–574.

Das, J. P., Mishra, R. K., & Pool, J. E. (1995). An experiment on cognitive remediation of word-reading difficulty. *Journal of Learning Disability, 8*, 66–79.

Fletcher, H., & Buckley, S. (2002). Phonological awareness in children with Down syndrome. *Down Syndrome Research and Practice, 8*, 11–18.

Gasparini, J. L. (1971). *Puzzles de lectures*. Paris: L'Ecole.

Geiger, G., Lettvin, J. Y., & Fahle, M. (1994). Dyslexic children learn a new visual strategy for reading: A controlled experiment. *Vision Research, 34*, 1223–1233.

Geymant, G., François, C., Ternon, I., & Sampo, M. (1996). *Audiolog*. Paris: Flextoft.

Gittelman, R., & Feingold, I. (1983). Children with reading disorders. I. Efficacy of reading remediation. *Journal of Child Psychology and Psychiatry, 24*, 167–191.

Goswami, U., & Bryant, P. (1990). *Phonological skills and learning to read.* Hillsdale, NJ: Lawrence Erlbaum.

Groupe d'Etudes et de Réalisations Informatiques Pratiques. (1995). *L'aventurier des confusions*. Franconville: GERIP.

Humphreys, G. W., & Evett, L. J. (1985). Are there independent lexical and non lexical routes in word processing? An evaluation of the route theory of reading. *Behavior and Brain Sciences, 8*, 689–739.

Hurford, D. P., Johnston, M., Nepote, P., Hampton, S., Moore, S., Neal, J., et al. (1994). Early identification and remediation of phonological processing deficits in first-grade children at risk for reading disabilities. *Journal of Learning Disabilities, 7*, 647–659.

Issofuly, N., & Primot, B. (1998). *PHONORAMA: Materiel d'entrainement de la competence métaphonologique*. Molighem: Ortho Editions.

Kennedy, E. J., & Flynn, M. C. (2003). Training phonological awareness skills in children with Down syndrome. *Research in Developmental Disabilities, 24*, 44–57.

Kish, S., Jurgeblut, A., Jenkins, L., & Kolstad, A. (1993). *Adult literacy in America: A first look at the findings of the National Adult Literacy Survey.* Washington, DC: National Center for Education Statistics.

Le Boeuf, C. (1976). *Raconte . . . en images*. Paris: L'Ecole.

LEXIDATA. (1998). *Module: A l'approche des textes – Jeux de lecture; Module: De l'écoute des sons à la lecture*. Pointe-Claire: Marketing A.B. International Inc.

Lovett, M. W., Ransby, M. J., Hardwick, N., Johns, M. S., & Donaldson, S. A. (1989). Can dyslexia be treated? Treatment-specific and generalized treatment effects in dyslexic children's response to remediation. *Brain and Language, 37*, 90–121.

McPhillips, M., Hepper, P. G., & Mulhem, G. (2000). Effects of replicating primary-reflex movements on specific reading difficulties in children: A randomised, double-blind, control trial. *Lancet, 355*, 537–541.

Merzenich, M. M., Jenkins, W. M., Johnson, P., Schneider, C., Miller, S. L., & Tallal, P. (1996). Temporal processing deficits of language-learning impaired children ameliorated by training. *Science, 71*, 77–80.

Mesnager, J., Rivière, J. P., & Bentolila, A. (1994). *Réseaux des observatoires locaux de la lecture*. Paris: Université René Descartes.

Mousty, P., Leybaert, J., Alegria, J., Content, A., & Morais, J. (1994). BELEC: Une batterie d'évaluation du langage écrit et de ses troubles. In J. Grégoire, & L. Piérart (Eds.), *Acquisition de la lecture et troubles associés*. Brussels: De Boeck.

Nicolson, T. (1986). Reading is not a guessing game. The great debate revisited. *Reading Psychology, 7*, 197–210.

Plaza, M., & Cohen, H. (2003). The interaction between phonological processing, syntactic awareness, and naming speed in the reading and spelling performance of first-grade children. *Brain and Cognition, 53*, 287–292.

Plaza, M., & Cohen, H. (2004). Predictive influence of phonological processing, morphological/syntactic skill, and naming speed on spelling performance: A longitudinal study from grade 1 to grade 2.. *Brain and Cognition, 55*, 368–373.

Rivière, J. P. (1998). *Tests d'évaluation des performances en lecture et en orthographe*. Paris: Ministère de la défense.

Rivière, J. P. (2002). *L'illettrisme.* Paris: Gallimard.

Rivière, J. P., Cohen, D., Chauvin, D., Hambourg, N., Lanthier, O., Chatelet, L., et al. (1999). L'illettrisme chez l'adulte déficient intellectuel: Résultats préliminaires d'une étude pilote. *Neuropsy, 14*, 197–203.

Rossof, A. (1988). Non compliant or illiterate? *Lancet, i*, 362.

Shalla, V., & Schellenberg, G. (1998). *The value of words: Literacy and economic security in Canada*. Ottawa: Statistics Canada, Information on Products and Services Catalogue.

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55*, 151–218.

Share, D. L., McGee, R., & Silva, P. A. (1989). IQ and reading progress: A test of the capacity notion of IQ. *Journal of the American Academy of Child and Adolescent Psychiatry, 28*, 97–100.

Siegel, L. S. (1989). IQ is irrelevant to the definition of learning disabilities. *Journal of Learning Disabilities, 22*, 469–486.

Tallal, P., Miller, S. P., Bedi, G., Byma, G., Wang, X., Nagarajan, S. S., et al. (1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science, 271*, 81–84.

Torgensen, J. K. (1985). Memory processes in reading disabled children. *Journal of Learning Disabilities, 18*, 350–357.

Uze, M. (1989). *On y va!*. Paris: Fleurus.

Wechsler, D. (1974). *Échelle d'intelligence pour adultes*. Paris: Centre de Psychologie Appliquée.

West, R. F., Stanovitch, K. E., Feemon, D. J., & Cunningham, A. E. (1983). The effect of sentence context on word recognition in second and six-grade children. *Reading Research Quarterly, 19*, 6–15.

Wolf, M., Goldberg O'Rourke, A., Gidney, C., Lovett, M., Cirino, P., & Morris, R. (2002). The second deficit: An investigation of phonological and naming-speed deficits in developmental dyslexia. *Reading and Writing: An Interdisciplinary Journal, 15*, 43–72.

Wolf, M., Miller, L., & Donelly, K. (2000). Retrieval, Automaticity, Vocabulary Elaboration, Orthography (RAVE-O): A comprehensive, fluency-based reading intervention program. *Journal of Learning Disabilities, 33*, 375–386.