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Children with intellectual disabilities may be impaired in encoding and recollecting incidental information

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ABSTRACT

Children with intellectual disabilities (ID) and controls were exposed to an incidental learning phase, where half of the participants received highly implicit instructions at test while the other half received explicit instructions. When learning was assessed for simple chunks of information, children with ID performed better with implicit instructions than with explicit ones, while the typically developing (TD) children performed equally well in the two test conditions. When more complex chunks were considered, performance was degraded for all children in the implicit instructions condition, while the TD children took advantage of receiving explicit instructions at test. Additionally, only TD children succeeded in a subsequent recognition test. These results suggest that intentional retrieval of complex information, even when learned implicitly, is deficient in children with ID. This argues towards the well-foundedness of educational methods preventing the recourse to intentional and effortful retrieval processes and complex material.

1. Introduction

Impairments in children with intellectual disabilities (ID) were first attributed to general low intellectual capacities and to a lack of cognitive flexibility (Kounin, 1941a, 1941b; Lewin, 1936), before becoming the object of more specific functional assumptions, like a short-term memory deficit (Ellis, 1963), attentional limitations (Zeaman & House, 1963) or altered executive functions (Belmont & Butterfield, 1971). Moreover, children with ID generally adapt to learning situations less efficiently than mental-age matched typically developing (TD) children. However, children are routinely subjected to a large variety of contexts, which need our separate attention. Two basic types of memory and learning processes have been indeed distinguished. Squire (1987) separated explicit memory from implicit memory, the former being involved in intentional recall and recognition of information, the latter operating without any explicit references to past episodes. A similar dissociation was suggested between implicit and explicit learning processes. Implicit learning (IL), contrary to explicit learning, does not involve hypothesis-testing processes or conscious monitoring processes during the learning task (Reber, 1993; Seger, 1994). Contrary to explicit processes, IL has been reported as invariant with age (e.g., Reber, 1993), ageing (e.g., Howard & Howard, 1992), neuropsychological disorders (e.g., Abrams & Reber, 1988; Nissen, Willingham, & Hartman, 1989), with regards to individual differences (Reber, Walkenfeld, & Hernstadt, 1991), and for our particular concern, with ID (e.g., Atwell, Conners, & Merrill, 2003). We can wonder to what extent IL capacities are robust enough in children with ID to motivate designing new approaches to reeducation.

Interestingly, most studies investigating the relation between IL processes and intellectual capacities have failed to report significant correlations between IQ and learning performance. IL capacities have been found to be invariant with regards to

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IQ in a wide range of tasks such as artificial grammar learning[1] tasks (López-Ramón, Introzzi, & Richard's, 2009; McGeorge, Crawford, & Kelly, 1997; Reber et al., 1991), serial reaction time[2] tasks (Atwell et al., 2003; Feldman, Kerr, & Streissguth, 1995; Vicari, Bellucci, & Carlesimo, 2001), computer control tasks (Myers & Conner, 1992), the three-at-a-time task (Gebauer & Mackintosh, 2007), or graphomotor tasks (Vinter & Detable, 2003, 2008). These IQ-independent results suggest that preserved implicit learning capacities offer promising implications for creating new educative or reeducative methods dedicated to children with ID.

However, some notable findings still obfuscate our understanding of IL processes. Fletcher, Maybery, and Bennett (2000) showed that IL performance may sometimes correlate with IQ scores. We therefore have to identify in which conditions IL capacities are efficient or impaired in children with ID, before designing educational programmes based on implicit learning processes. It has been suggested that IQ-dependent IL performance could be due to the contamination of learning processes by conscious interferences, especially during the task used at test (Meulemans, 1998; Vinter & Perruchet, 1999). Indeed, in most cases, the unconscious influences that are thought to operate during implicit training are measured, at test, on the basis of a behavioural performance on which the participants explicitly focus. However, the explicit processes are known to be more efficient in older than in younger children and to be influenced by IQ: children with mental retardation are known to exhibit deficits in explicit processes (Bebko & Luhaorg, 1998; Bray, 1979; Ellis, 1970; Meador & Ellis, 1987). Therefore, children with low IQs may underscore at test because of the intervention of explicit processes during this phase. This hypothesis has yet not been tested with children with ID.

The present study aims to investigate whether allowing explicit influences during the test procedure of an incidental learning task can lead to performance differences between children with ID and TD children, whereas limiting such influences should enable them to perform similarly. In this scope, we confronted both groups of children to the same learning task, an incidental learning task of sequences of colours arranged in flags, generated by an artificial grammar (see Witt & Vinter, 2011). Both groups were divided into two subgroups according to the instructions they received at test. The instructions elicited either implicit or explicit information recollection processes. Explicit information recollection processes are impaired in children with ID (e.g., Bebko & Luhaorg, 1998; Bray, 1979; Bray & Turner, 1986; Meador & Ellis, 1987). In our experiment, the test required the children to generate sequences of colours composing "nice flags" (implicit instruction in the sense that it did not made reference to the flags seen during the learning phase) or flags seen during the exposure phase (explicit instruction). According to Gardiner and Java (1993), a generation test with implicit instructions does not require participants to make any intentional efforts to retrieve information, unlike an explicit generation test. Therefore, our general hypothesis was that IL effects similar to those observed in TD children were likely to be observed in children with ID when the test procedure avoided contaminations due to explicit processes, but not when the instructions at test activated explicit processes. Furthermore, we also introduced a recognition test, following the generation test under explicit instructions. A recognition task rests on two possible mechanisms: either on a feeling of familiarity involving implicit memory processes or on intentional retrieval processes of information (Gardiner & Java, 1993). The former processes are supposed to be preserved in children with ID, while the later are known to be altered (e.g., Perrig & Perrig, 1995; Takegata & Furutuka, 1993). So, we wondered whether the children with ID were able to adapt to the testing situation by using familiarity judgments, resting on preserved implicit memory capacities, or whether they would fail to adapt their strategy, having recourse to impaired intentional information retrieval processes, as they just did in the prior explicit generation test.

In brief, the original contribution of this study is to demonstrate that the possible intrusion of explicit influences during the task may constrain children with ID to perform lower than mental-age matched TD children during an incidental learning episode. Reversely, we expected children with ID to perform similarly to TD children in response to purely implicit instructions. It ensures that in both groups, incidental learning performance should be significantly above chance level in the implicit condition, while only the TD children should behave above chance level in the explicit condition. Additionally, provided they adopted the suitable strategy, children with ID should perform above chance, and similarly to TD children, in the recognition test.

2. Method

2.1. Participants

Forty Caucasian children (19 female and 21 male) participated in the experiment. Half of them ($N = 20$) were children with intellectual disabilities and the other half ($N = 20$) were typically developing children. Within each group, the participants were randomly assigned either to implicit ($N = 10$) or explicit instructions ($N = 10$) at test. Table 1 presents the characteristics of the groups.

[1] In this paradigm, participants are usually exposed to a subset of grammatical strings generated by a finite-state grammar in which, for instance, the strings can be composed of printed consonants. The grammar defines the transition rules between events. Participants are then tested to see whether they can discriminate between new grammatical and nongrammatical strings. The results show that participants recognize grammatical strings at a significantly above-chance level, as if they had discovered the rules of the grammar.

[2] In this paradigm, the participants are asked to react as quickly as possible to the appearance of stimuli by pressing keys corresponding to the locations of the targets on the screen. Without them knowing it, the participants are shown a repeated sequence of target locations interspersed by a number of random trials. The results show that reaction times improve on repeated compared to random sequences.

Table 1
Characteristics of the groups (GRAM = grammatical, RAND = random, F = female, M = male, children with intellectual disabilities: ID, typically developing children: TD, MA = mental age).

Children	Mean age (years, months)	Mean MA (years, months)	IQ	Test instruction	Number	Sex (F–M)
ID	10, 2	7, 3	50–70	Implicit	10	6 – 4
TD	7, 2	7, 2	/		10	4 – 6
ID	10, 9	7, 2	50–70	Explicit	10	6 – 4
TD	7, 3	7, 3	/		10	4 – 6

The participants with ID were attending Medical Educational Institutes or looked after by Special Education and Home Care Services. The diagnosis of mental retardation was established in accordance with the DSM-IV criteria (APA, 1994). Different IQ measures (K-ABC and/or WISC-IV) assessed during the 6 months preceding the experiment were available from the children's medical records. We selected children presenting mild ID (IQ varying between 50 and 70) due to organic causes. Most of these children were Down's syndrome patients ($N = 34$), while the other 6 presented ID due to unknown genetic or neurological causes. Before the experiment, their receptive vocabulary age was assessed using the Peabody Picture Vocabulary Test (PPVT; Dunn, Thériault-Whalen, & Dunn, 1993). Although this test is known to overestimate the IQ scores of children with ID (Facon & Facon-Bollengier, 1997), it is often used because of its simplicity (e.g., Natsopoulos, Stavroussi, & Alevriadou, 1998). It also enabled us to ensure that the participants were able to understand the verbal instructions given during the learning task. The PPVT was also administered to the TD children in order to obtain a common measure for matching children with and without ID on mental age. For the children with ID, the mean verbal MA on the PPVT was 6 years 10 months and the verbal MA range was 5 years 11 months to 7 years 2 months in the implicit test condition. In the explicit test condition, the mean verbal MA was 7 years 1 month and the verbal MA range was 5 years 8 months to 6 years 11 months. The mean PPVT IQs were respectively 64 and 59. The PPVT IQs ranges were 51–72 and 50–75. For the typically developing children, the mean verbal MA on the PPVT was 7 years, and the MA range was 6 years 7 months to 7 years 3 months in the implicit test condition. In the explicit test condition, the verbal MA range was 7 years 1 month and the verbal MA range was 6 years 10 months to 7 years 10 months. The mean PPVT IQs were respectively 107 and 104, and the PPVT IQs ranges were 92–120 and 90–116. The differences in means on the PPVT verbal MA between the two groups were not significant, whatever the test condition, $t_s < 1$. All the children had normal or corrected to normal vision and were asked to name the five colours employed during the game. This experiment was conducted in accordance with the ethical standards set out in the 1964 Declaration of Helsinki and written parental consent was obtained for each child. The study was approved by an institutional review board.

2.2. Material

We employed an attractive computer game involving the presence of 3-, 4- and 5-colour flags (see Fig. 1 in Witt & Vinter, 2011). Basically, this game consisted in a "tug-of-war" tournament in which teams of pandas identified by their flags played one against the other during the incidental learning phase. The flags were generated by a finite state grammar including five colours (blue, B; green, G; red, R; yellow, Y and turquoise, T). By switching the positions of the colours in the grammar, each child was presented with a different outcome, but all the outcomes shared the common grammatical structure (for an example of the grammar, see Fig. 2 in Witt & Vinter, 2011). The participants were incidentally exposed to a series of 8 training flags, two 3-colour flags, three 4-colour flags and three 5-colour flags, each of them shown 5 times. An example of a learning series was: BYY, RGG, BYYG, BYGR, RGGY, BYYBT, RGGYY and RGGYB. The 8 flags always contained 7 grammatical bigrams, 10 grammatical trigrams and 8 grammatical quadrigrams. The material used at test when children were asked to build themselves flags included 25 coloured squares (5 B, 5 G, 5 R, 5 Y and 5 T) and 3 templates representing flags of 3, 4 or 5 colours in the case of the implicit test condition.

2.3. Procedure

A 20-min phase of incidental exposure phase to the material opened the experimental session, followed by a 5-min interruption and a 10-min test phase. The learning phase started with prerecorded instructions that announced the tug-of-war tournament between pandas, asking children to press keys in order to launch each game. During this phase, which was identical for all children regardless of their subsequent test conditions, the participants saw the 8 flags generated by an artificial grammar 5 times each, with the colours of the flag appearing one-by-one from left to right, once every 1000 ms. Completed flags were removed from the screen after 1500 ms. All the timing parameters, including the speech speed of the prerecorded voice, were determined with pilot tests on children with ID. We also adapted the procedure to enable repetitions of the instructions if the participants with ID did not understand the task demands that had just been explained to them.

After this common learning phase, the test phase started with the prerecorded voice announcing one of two different stories depending on the test condition, implicit or explicit instructions, to which the participants were assigned. Children in the implicit test condition were told that it was now the monkeys' turn to play "tug of war", but that the monkeys had forgotten to put colours on their flags. They were asked to help the monkeys by placing colours on the monkeys' flags. They had to build 2 flags of 3, 4 and 5 colours, in a random order of production.

By contrast, children in the explicit test condition were first asked to build a flag which they were absolutely sure to have seen during the pandas' game, without any constraint about the length of the flag. Children were tasked to build only one flag because the instructions strongly insisted on the confidence the participants should have in the accuracy of their response. The children were then introduced to the recognition test, monitored through the computer game. The children saw puzzled pandas in front of a flags' mound and they listened to the following instructions: ''After the tournament, the pandas' flags were mixed with those of other animals. Help the pandas find their own flags!'' The recognition test began by displaying a first flag held by a puzzled panda, accompanied with the following instruction: ''Is this a flag that you have already seen and that belonged to the pandas?'' The participants answered orally to the questions and the experimenter recorded the answers pressing keys according to the choice of the children (yes or no). Oral answers were preferred to manual ones in order to avoid manipulation errors. The experimenter was ignorant to the flags seen by children in the training phase. Pressing keys automatically induced the continuation of the game. Eight flags were successively shown to the children, four were taken from the training series and four random flags paired on the frequencies of occurrences of colours in the grammatical series. The order of appearance of the flags was random. Each flag remained visible until the child completed the question. An animation congratulated the child at the end of the game.

Finally, the experiment ended with a questionnaire phase. The questions dealt with the experimenter's intentions and the children's explicit perception of the properties of the flags. None of the children who performed the implicit test spontaneously linked the test episode to the training phase, while most of those assigned to the explicit condition explicitly linked the training phase to the test episode. Questionnaire did not provide any other interesting information and was not analysed further.

2.4. Coding of the data

As classically done in similar experiments (e.g., Dulany, Carlson, & Dewey, 1984; Perruchet, 1994; Perruchet & Pacteau, 1990; Servan-Schreiber & Anderson, 1990), we analysed the frequencies of grammatical bigrams and trigrams of colours present in the flags built by the children. The bigrams and trigrams were coded as grammatical when they contained the same sequence of colours as those seen during the learning phase (e.g., the generated flag BYRG contains one grammatical bigram, BY, seen in the training item BYGR, while YR and RG are ungrammatical, i.e. never seen in the training items). The frequencies of grammatical bigrams and trigrams were computed as a function of flag length. For instance, a grammatical bigram in a 4-colour flag scored .33 (1 occurrence out of 3 possible bigrams), while a grammatical trigram scored .50 (1 occurrence out of 2 possible trigrams). In the example reported above, the generated flag BYRG took the score 1/3 = .33 for the grammatical bigrams' counting, because it embeds 3 bigrams (BY, YR and RG) while only one of these bigrams is grammatical, i.e. contained in one of the training flags.

The theoretical proportions of grammatical bigrams and trigrams were computed using an analytical approach. The analytical approach computed the precise theoretical probabilities of producing correct bigrams and trigrams in different cases. In our experiment, the children were presented with 25 coloured squares and were then asked either to produce flags of different lengths (3, 4 and 5 colours) or only one flag (of 3, 4 or 5 colours). Because each draw during the generation test reduced the chance of drawing the same colour at chance, the programme simulated a drawing-without-replacement condition using a set of 25 coloured squares (e.g., for 3-colour flags: $25 \times 24 \times 23$ possibilities). We thus generated the entire set of 3-, 4- and 5-colour flags for the implicit test condition, and the entire set of flags of the length produced by the participant in the explicit condition. Finally, the programme counted the number of correct bigrams and trigrams in the theoretically generated set. In the recognition task, we counted the number of correct answers produced by the children.

The extent to which the participants learned incidentally the sequences of colours shown during the learning phase was assessed by comparing the proportions of grammatical bigrams and trigrams observed in the flags built at test and the theoretical proportions corresponding to chance level performance, using Student's *t*-tests. Furthermore, ANOVAs with Participants (ID or TD children) and Test instructions (implicit or explicit) as between-subjects factors were carried out on the ratios between the observed proportions and the corresponding theoretical proportions of grammatical bigrams and trigrams. The ANOVAs estimate whether the amount of incidental learning varied as a function of the children's groups and test instructions, regardless of whether or not their respective performance differed from chance level. In addition, the frequencies of correct answers in the recognition test were compared to chance (50%) using Student's *t*-tests in the two groups of children.

3. Results

Considering first the grammatical bigrams' production, when implicit instructions were employed at test, all the children, with or without ID, performed significantly above chance, respectively $t(9) = 3.07$, $p < .05$ and $t(9) = 3.20$, $p < .05$. By contrast, the TD children differed from chance in the explicit test condition, $t(9) = 3.21$, $p < .05$, but not those with ID, $t < 1$. Regarding the production of grammatical trigrams, both children with ID and the mental-age matched TD children performed at chance level in the implicit test condition, respectively $t(9) = 1.02$, $p = .33$ and $t(9) = 1.65$, $p = .13$. When they received explicit instructions, the ID children still failed to produce grammatical trigrams beyond chance, $t < 1$, while the TD children generated these units at a significantly higher frequency than predicted by chance, $t(9) = 4.6$, $p < .01$.

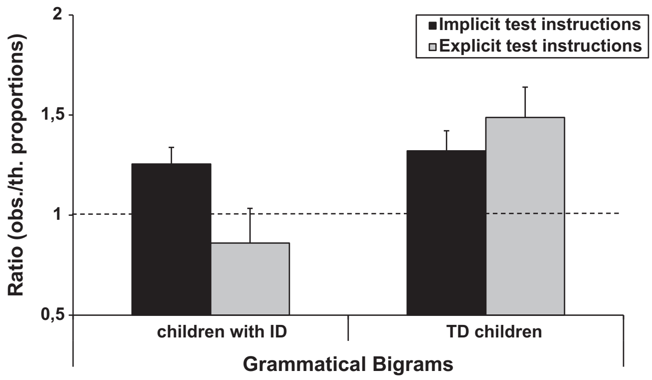

Fig. 1. Ratios between observed and theoretical proportions of grammatical bigrams as a function of Participants (2: intellectual disabilities, ID; typically developing, TD) and Test instructions (2: implicit, explicit). The error bars correspond to one standard error and the hatched line represents chance level (ratio between observed and theoretical proportions = 1).

ANOVAs were carried out on the ratios between observed and theoretical proportions of grammatical bigrams or trigrams. The results are presented in Fig. 1 for the bigrams' production and in Fig. 2 for the trigrams' production.

With regard to the production of grammatical bigrams, the Test instructions effect was not significant, $F < 1$, while the Participants factor and the Participants by Test instructions yielded significant effects, respectively $F(1, 36) = 6.85$, $p < .015$, $\eta^2 = .16$ and $F(1, 36) = 4.5$, $p < .05$, $\eta^2 = .11$. As revealed by this significant interaction, the children with ID benefited from the use of implicit test instructions, performing higher in this condition ($M = 1.32$, SD = .32) than in the explicit instructions condition ($M = .86$, SD = .55), $F(1, 18) = 4.22$, $p = .05$, $\eta^2 = .19$. Regarding the TD children, their performance did not differ significantly between the implicit ($M = 1.25$, SD = .26) and the explicit ($M = 1.49$, SD = .48) conditions, $F < 1$.

Considering the trigrams' production, as depicted in Fig. 2, the Test instructions, the Participants and the Participants by Test instructions interaction effects reached significance, respectively $F(1, 36) = 4.24$, $p < .05$, $\eta^2 = .10$, $F(1, 36) = 14.43$, $p < .01$, $\eta^2 = .29$ and $F(1, 36) = 10.44$, $p < .01$, $\eta^2 = .22$. The interaction revealed that, contrary to what occurred for the bigrams' production, the children with ID did not improve their performance in the implicit instructions condition ($M = 1.13$, SD = .9), as compared to the explicit instructions ($M = .84$, SD = 1.08), $F < 1$, while the TD children took advantage of receiving explicit ($M = 4.08$, SD = .2.12) rather than implicit ($M = 1.7$, SD = 1.43) instructions at test, $F(1, 36) = 14.43$, $p < .01$, $\eta^2 = .29$.

Finally, we analysed the recognition capacities shown by the participants who received explicit test instructions in the generation test, in order to observe whether children with ID were able to shift their strategy from an intentional recall strategy, as induced by the previous generation test, to a familiarity strategy, as could also be used in a recognition test. The results are presented in Fig. 3.

Student's *t*-tests were carried out to compare the frequencies of correct recognition responses with chance (50%). As shown in Fig. 3, the children with ID performed the recognition task ($M = 55\%$, SD = 14.7) at chance level, $t(9) = 1.08$, $p = .31$, while the mental-age matched TD children ($M = 65\%$, SD = 18.4) performed significantly above chance, $t(9) = 2.57$, $p < .05$.

4. Discussion

This experiment investigated the encoding and recollection of information incidentally learned, as a function of the intellectual status of the participants. Children with and without ID incidentally learned regular sequences of colours

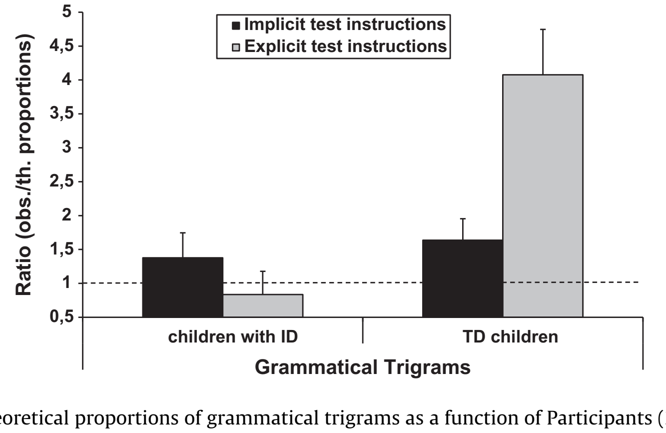

Fig. 2. Ratios between observed and theoretical proportions of grammatical trigrams as a function of Participants (2: intellectual disabilities, ID; typically developing, TD) and Test instructions (2: implicit, explicit). The error bars correspond to one standard error and the hatched line represents chance level (ratio between observed and theoretical proportions = 1).

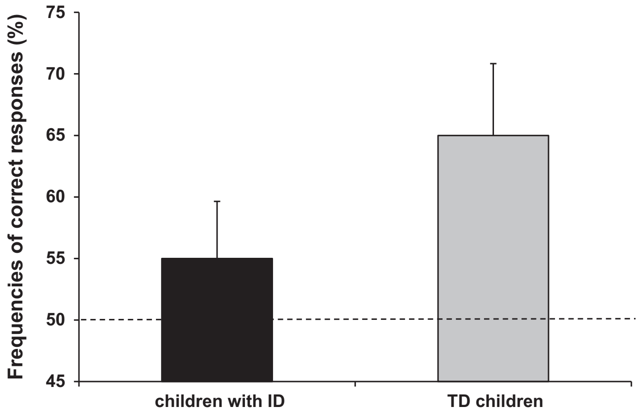

Fig. 3. Mean frequencies of correct responses (%) at the recognition test as a function of participants (2: intellectual disabilities, ID; typically developing, TD). The error bars correspond to one standard error and the hatched line represents chance level (50%).

and then performed in a generation test under implicit or explicit instructions, with the explicit generation test followed by a recognition test. When learning performance was assessed with short chunks, i.e. bigrams, the children with ID performed higher in the implicit than in the explicit test condition, while TD children recollected information equally well in the two test conditions. When assessed with longer chunks, i.e. trigrams, all the children failed to perform above chance under implicit test instructions, and only the TD children benefited from the explicit instructions condition. In addition, the ID children did not succeed in the recognition task, contrary to the TD children. The discussion focused on the relation between ID, encoding/recollection processes and the capacity to shift strategies as a function of the task.

4.1. Mental retardation, encoding and recollection of information incidentally learned

There is agreement in the literature that children with ID should perform worse on explicit tasks than TD children (e.g., Borkowski, Reid, & Kurtz, 1984; Bray, 1987; Bray & Turner, 1986; Meador & Ellis, 1987). To borrow Bebko and Luhaorg (1998, p. 385): "The more effortful and language-loaded the task, the greater the difficulty children and adults with ID are likely to experience, and the poorer their performance will be". In our experiment, we predicted that a test procedure without any references to the previous training phase (implicit instruction condition) should benefit to learning performance equally in children with and without ID, while explicitly connecting the test to the previous training (explicit instruction condition) should lead children with ID to perform lower than TD children.

Our results are consistent with such assumption. Children with ID performed just as well as TD children following implicit test instructions. By contrast, only the TD children attested for efficient IL in case of explicit test instructions. These results suggest that IL capacities are invariant in children whatever their intellectual abilities (Reber, 1993), provided the task prevents children to deploy hypothesis testing processes or information recollection processes, because these processes are deficient in children with ID (Bebko & Luhaorg, 1998; Bray, 1979; Meador & Ellis, 1987). Thus, the children with ID took advantage of receiving highly implicit test instructions as compared to explicit instructions, while the TD children performed efficiently regardless of the type of test instructions.

In addition, unexpected results showed that the children with and without ID failed to produce grammatical trigrams above chance in the implicit instructions condition, while only the TD children performed above chance in the explicit test instructions. Thus, assessing IL on the basis of larger or more complex chunks seemed to impact performance. Complexity effects have been already reported in serial reaction time tasks (Stadler, 2008; Soetens, Melis, & Notebaert, 2004) or in case of artificial grammar learning (Meulemans & Van der Linden, 1997; Van den Bos & Poletiek, 2008). The better performance of the TD children in the explicit than in the implicit test condition could suggest that explicit information recollection processes are more efficient that implicit ones to recollect complex information. However, the unchanged performance in children with ID in the two test conditions did not allow discriminating whether they failed to encode complex units or to access the resulting representations. Indeed, the limited apprehension of the material to bigrams by children with ID is consistent with their restricted executive control capacities (Baumeister, 1997; Berkson, 1993; Brooks, Sperber, & McCauley, 1984), their impaired patterns of visual exploration (Spitz, 1969) and their tendency to shape information into short chunks (Spitz & Webreck, 1972). Nevertheless, the assumption of inefficient recollection processes for complex information cannot be excluded. These two explanations could be separated in future research, for instance by testing whether longer exposure periods with more repetitions (i.e. facilitating information encoding) would enable children with ID to learn larger chunks from the training material. In this view, Thomas et al. (2004) revealed that TD children needed a longer exposure phase to the structural components of the situation in order to perform equally well as adults.

4.2. Are children with ID able to evaluate and adapt their strategy?

Children in the explicit test condition performed a recognition test. We wondered whether children with ID were able to switch their strategy, from intentional retrieval of information as elicited in the explicit generation test to a strategy based on a familiarity feeling as possibly induced by a recognition test (Gardiner & Java, 1993).

The results showed that children with ID failed to recognize the flags seen during training, contrary to the TD children. These results are consistent with those reported by Vinter and Detable (2008) in a forced-choice explicit test relying on recognition, showing that switching strategies were impaired in children with Down's Syndrome. Familiarity feeling appears to be a non-analytical information processing strategy (Kinder, Shanks, Cock, & Tunney, 2003), that can be elicited by the very repetition of the material seen during the incidental learning phase. This non-analytical strategy is likely involved in implicit memory which is known to be preserved in children with ID (e.g., Wyatt & Conners, 1998). Thus, these children could have succeeded in the recognition test as well as the TD children, provided that they were able to adopt this non-analytical strategy, and not the analytical explicit strategy used during the preceding test. As argued by Vinter and Detable (2008), the difficulty to switch strategies in children with ID may come from impairments in executive functions (Pennington & Bennetto, 1998) or in metacognitive processing (Bebko & Luhaorg, 1998). However, inefficient executive functions or metacognitive processing are unlikely to influence familiarity processing because familiarity, an implicit process, does not involve intentional processes (Perruchet & Vinter, 1998). According to Kinder et al. (2003), non-analytic strategies intervene when analytic strategies are inefficient. This view presumes that the participants are able to evaluate their behaviour and to connect it with the desired goal. Conformingly to the deficient self-regulation assumption in individuals with ID (e.g., Haelewyck & Nader-Grosbois, 2004; Whitman, 1990), these very abilities seemed to be impaired in ID participants. If the deficit in self-regulation processes in ID participants can account for their failure in the recognition test, further research could test the efficiency of reeducational programmes dedicated to train self-regulation capacities (e.g., Lanfaloni, Baglioni, & Tafi, 1997) on more general cognitive abilities.

To conclude, it is worth pointing the potential value of designing new learning methods based on implicit processes, at least in cases where the aim is to promote the behavioural adaptation of individuals to their environment (Vinter, Pacton, Witt, & Perruchet, 2010). Implicit processes could help children build cognitive representations that are isomorphic to the structure of a learning situation and help develop their feeling of familiarity with the material to be learned, thereby making its processing more fluent (Kinder et al., 2003). It is tempting to suggest that learning any new skills should start with teaching techniques based on IL processes given the assumption that an "immersion" learning phase guided by implicit processes should facilitate later explicit learning. Further research is needed to explore the potential of IL-based educational methods.

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