Research in Developmental Disabilities 104 (2020) 103720

Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Do typically and atypically developing children learn and generalize novel names similarly: The role of conceptual distance during learning and at test

Arnaud Witt[a,*], Annick Comblain[b], Jean-Pierre Thibaut[a]

[a] LEAD-CNRS, UMR 5022, Université de Bourgogne Franche-Comté, Pôle AAFE – Esplanade Erasme, 21065 Dijon, France
[b] Département de Logopédie, Université de Liège, Belgique

ARTICLE INFO

No. of reviews completed is 2.

Keywords:
Object and relational categories
Comparisons
Conceptual distance
Intellectual disabilities

ABSTRACT

There is a large body of evidence showing that comparison of multiple stimuli leads to better conceptualization and generalization of novel names than no-comparison settings in typically developing (TD) children. By contrast, the evidence regarding this issue remains scarce in children with intellectual disabilities (ID). Children with intellectual disabilities (ID) and TD children matched on mental age with the Raven's coloured progressive matrices were tested in several novel name learning comparison conditions, with familiar objects. We manipulated the conceptual distance between the learning stimuli in the learning phase and between the learning and generalization phase stimuli for object and relational nouns. Results showed that both populations had rather similar performance profile when matched on their cognitive skills (low- vs. high-functioning). Unexpectedly, ID children's performance was equivalent for relations and better for objects compared to their TD peers' performance. However, when controlling for chronological age, the difference between ID and TD children disappeared in the case of object categories and was better understood by TD children in the case of relations. We discuss the role of conceptual distance on participants' conceptual generalization as a function of their intellectual abilities and cognitive functioning.

1. Introduction

It is generally claimed that lexical development starts at the same mental age (MA) in typically developing (TD) children and in children with intellectual disability (ID) and that MA is a good predictor of lexical development (Fazio, Johnston, & Brandl, 1993). Comparing people with ID and people in MA-matched TD groups often reveals that the identified factors in studies on TD children play the same role in ID people. For instance, lexical and conceptual development in ID people shows the same typicality effects (typical members are easier to learn than atypical ones) and the same taxonomy effects (basic level categories are easier to learn than both superordinate and subordinate categories) (see Barrett & Diniz, 1989 for a review). Lexical development of people with ID seems to have the same cognitive underpinnings as those observed in TD children (Zampini, Salvi, & D'odorico, 2015). This suggests that similar novel name learning methods should be accurate for TD and ID children. For instance, the use of multiple "core members" (prototypes) of a category are a good way to promote category acquisition for both TD and ID children (Hupp & Mervis, 1982).

Abbreviations: ID, intellectual disabilities; TD, typically developing; MA, mental age; RCPM, Raven's coloured progressive matrices

* Corresponding author at: LEAD, CNRS UMR5022, Pôle AAFE, Esplanade Erasme, BP 26513, 21065, Dijon Cedex, France.
E-mail address: arnaud.witt@u-bourgogne.fr (A. Witt).

https://doi.org/10.1016/j.ridd.2020.103720
Received 14 November 2019; Received in revised form 4 June 2020; Accepted 14 June 2020
Available online 01 July 2020
0891-4222/

However, what the characteristics of an optimal learning format, that is how to introduce the learning items, remains an open question. In TD children, there is extensive evidence showing that the opportunity to compare exemplars from the same category improves learning and generalization performance (Augier & Thibaut, 2013; Gentner & Namy, 1999; Namy & Gentner, 2002). Would the benefits of a comparison setting be the same for TD and ID children?

In order to answer this question, the present experiment compared ID children and MA-matched TD children in a lexical learning task for object and relational categories. Conceptual distance (see below) was systematically manipulated during learning (close or far distance between learning items) and at test (near or distant generalization). Semantic distance is an important factor because it is related to the structure of knowledge. It has been argued that young children might first generalize on the basis of salient and sometimes irrelevant perceptual similarities and would, later, shift to conceptually-based, relational information. Rattermann and Gentner (1998) define this relational shift as "a shift from early attention to common object properties to later attention to common relational structure" (p.455). "The relational shift is not age-determined but knowledge-related, (…) it can occur at different ages in different domains, depending on domain knowledge" (p. 456). In this respect, comparing TD children around five years of age with ID children around 10 years of age is interesting because both age groups will know the objects we selected, but they might differ in their expertise regarding these objects. Thus, despite the fact they will be matched on mental age, they might differ in their knowledge of the world.

Because comparison situations involve monitoring costs (Augier & Thibaut, 2013; Thibaut & Witt, 2015) and require executive functions which are known to be impaired in various deficiencies (e.g., Lanfranchi, Jerman, Dal Pont, Alberti, & Vianello, 2010; Schuiringa, van Nieuwenhuijzen, Orobio de Castro, & Matthys, 2017), we predicted that ID children should have lower results than TD children.

We expected ID children to be particularly impaired in comparison conditions involving higher cognitive costs, that is in the case of a distant conceptual distance, between-learning items and between learning and transfer items. This is because conceptually distant objects might be more difficult to unify under the same concept. In addition, ID children might have more difficulties to conceptualize relations between objects than object categories because relations are not defined by intrinsic properties (i.e., perceptually stable properties) (see Gentner, Anggoro, & Klibanoff, 2011 for discussion) and because relations involve more comparisons since each learning and generalization example is composed of an operator (e.g. knife) and an entity (e.g., orange). The present experiment aimed to test these hypotheses.

Before we come to the specifics of our design, we describe former experiments that compared ID and TD children and manipulated conceptual factors such as typicality and the hierarchical structure of categories (Murphy, 2004; Rosch, 1975).

1.1. Categorization and generalization in ID children

Earlier studies on conceptual development in populations with ID focused on both the hierarchical and the internal structure of categories, that is the idea that an object can be categorized at different levels of inclusiveness (e.g., as Rottweiler, a dog, a mammal, an animal) and might be more or less typical of their category (e.g., an eagle is judged to be a more typical bird then a hen is). Mervis (1990; Rosch, 1978) pointed out that the first nouns referring to objects acquired by ID and TD children refer to basic level categories of objects which are the easiest to conceptualize, most likely, as suggested by Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976), because they are both distinct from other basic level categories and relatively homogeneous. In terms of the hierarchical nature of categories, it means that ID children, like TD children, have more difficulties to conceptualize both superordinate (e.g., food) and subordinate (e.g., golden apple) level categories than basic level categories (apple). This has been shown by verbal association tasks (Harrison, Budoff, & Greenberg, 1975) or categorization tasks (Tager-Flusberg, 1985). Using a matching-to-sample procedure in ID, autistic and TD children, Tager-Flusberg (1985) showed that the three groups categorized better stimuli from basic level categories (e.g., car, chair, or dog) than from biological and artifact abstract superordinate level categories (respectively, vegetables, fruit, animal and vehicles, clothing, furniture). Although children with ID had more difficulties with superordinate level categories compared to the other groups (possibly due to a global lower IQ level), they all produced more categorization errors for the peripheral than for the typical members of the categories. This pattern revealed a similar influence of prototypicality on categorization judgments in the three groups.

These categorization skills similarities between people with different cognitive status led the author to conclude that "*conceptual representation and processing of conceptual information are highly constrained universal aspects of human cognition*" (p. 465). Most studies reported similar typicality effects in ID and TD children and effects of the hierarchical nature of categories and argued for their generality in conceptual development. For instance, Mervis (1984) and Tager-Flusberg (1986) observed respectively that Down Syndrome (DS) and ID children from various etiologies exhibited typicality effects when they had to extend object names. They underextended object names for peripheral referents and overextended them for inappropriate referents which shared perceptual or functional features with the typical referents of the object categories. They also showed typicality effects in object naming tasks, with more naming errors when participants labeled atypical rather than typical referents (see also Hupp, Mervis, Able, & Conroy-Gunter, 1986, for typicality effects in a receptive task). As a conclusion, Barrett and Diniz (1989) speculated that these results may have important implications for cognitive remediation programs in ID children. Since both children with and without ID seem to develop prototypical conceptual representations, they should benefit more from initial exposure to typical rather than to atypical category members. Another remediation issue, dealing with the construction of conceptual representations, is related to the optimal number of examples children with (and without) ID need to be exposed to for better categorization and generalization performance. These are the questions we address in the following section.

1.2. The use of good learning examples

Typicality effects in ID children have been observed by Hupp and Mervis (1982) in a category learning task. The authors showed positive effects of the goodness-of-example on the acquisition of basic object categories by prelinguistic children with severe ID. In their study, Hupp and Mervis (1982) also examined the effect of the number of training examples. They showed that children with ID benefited from exposure to multiple (three) examples rather than to a single example during category acquisition. However, this benefit was mainly observed when examples were typical instantiations of the categories (good category members) and not for heterogeneous examples (typical, intermediate and peripheral). Using an object labeling task in children with severe ID, Hupp (1986) tested whether exposure to five good examples would result in better generalization performance than exposure to three good examples. The authors computed the increase of generalization performance between the first post-test (after training with three examples: a poor, a moderate and a good example of each category to learn) and the second post-test (after training with either three or five good examples of each category). Although the degree of improvement in generalization was not significantly different between the two post-test conditions ($p = .08$), increase in performance was greater after the five- (16 %) than after the three-good-examples condition (5%). Overall, these results fit well with the prototype theory of concepts (e.g., Rosch, 1978). The central claim of this view is that exposure to multiple "core members" of the category is optimal for category acquisition in ID children. More recently, Hayes and Conway (2000) examined the effect of category size in children with mild ID and showed that prototype abstraction was enhanced by exposure to a larger set of category exemplars with both children with ID and their chronological- and mental-age matched peers, suggesting that exposure to a larger set of training exemplars led to a better understanding of conceptual similarities and differences between training exemplar features.

In these studies, however, the category size effect in ID has been observed when children were explicitly asked to pay attention to target dimensions (hands, body, arms, legs) which varied on binary values (two shapes or two motifs according to the dimension), in Hayes and Conway, or in the case of basic object categories, that is the easiest level of categorization in Hupp and Mervis (1982). The questions of the acquisition of more inclusive categories that share much less salient perceptual features, or when learners are not told on which features they should focus remain open. Increasing the number of typical exemplars might not be sufficient, especially when potentially relevant dimensions have not been explicitly identified or are not salient, and with simultaneous presentations rather than sequential ones, as it is usually the case. We address this question in the next section.

1.3. Comparisons and novel name learning

In TD children, a large body of evidence suggests that the opportunity to compare exemplars belonging to the same category improves learning and generalization performance (Augier & Thibaut, 2013; Gentner & Namy, 1999; Namy & Gentner, 2002). In their seminal study, Gentner and Namy (1999) introduced pictures of objects belonging to familiar taxonomic categories (e.g. fruits) to 4-year-old children and tested them in a novel name generalization task. When a single familiar standard was introduced (e.g. an apple that was labeled *blicket*) children extended this new label significantly more often to a perceptually similar object (e.g. a balloon) than to a taxonomically related but perceptually different object (e.g. a banana). In contrast, when they were shown two standards (e.g. an apple and an orange that were named *blicket*), children extended the novel name to the taxonomically related object more often. In preschoolers, the benefits of comparison has been described for a wide variety of linguistic categories, such as names for parts (Gentner, Loewenstein, & Hung, 2007), adjectives (Waxman & Klibanoff, 2000), action verbs (e.g., Childers & Paik, 2009), and relational nouns (Gentner et al., 2011; Thibaut & Witt, 2015).

However, not all comparison conditions are created equal. It has been shown recently that conceptual distance between the learning items and between the learning and the generalization items, matter for both objects and relational nouns (Gentner et al., 2011; Thibaut & Witt, 2015; Thibaut, Stansbury, & Witt, 2018). Interestingly, comparison of conceptually distant exemplars from a category (e.g., an apple and an orange) led to higher performance than close exemplars (e.g., two apples) (Thibaut & Witt, 2015). Beyond that, it has been shown that comparisons involve cognitive costs (Augier & Thibaut, 2013) because comparisons involve alignments which must be kept and updated in working memory. Irrelevant salient dimensions of each individual objects might also be inhibited, and flexibility is required to switch from irrelevant to pertinent dimensions. Monitoring these cognitive costs has been associated with executive functions which have been described to be impaired in ID syndromes (e.g., Lanfranchi et al., 2010), as well as in children with mild to borderline ID (Schuiringa et al., 2017). Thus, ID children might benefit less from comparison situations than TD children.

1.4. Object concepts and relational concepts

When it comes to relational concepts, the difficulty is that relational nouns apply to very different objects (e.g., *neighbor*). In order to investigate learning of relational nouns, Gentner et al. (2011) introduced learning pairs that were built around two familiar objects connected by a familiar relation (e.g., "*cutter for*"), one being the operator (e.g., a *knife*), the other the entity (e.g., a *watermelon*) with a novel relational term, “the knife is the *dax* for the watermelon”. At test, a new entity (e.g., a *sheet of paper*) was introduced and children were asked to show which stimulus among a set of options (e.g., a relational match– *a pair of scissors*–, a taxonomic match– *a pile of sheets of paper*–, and a thematic match– *a pencil*–) “is the *dax* for the piece of paper”.

In general, relational categories are learned later than many object categories because they are not unified by intrinsic, perceptually stable properties (Gentner et al., 2011). Entity nouns are frequent in the 8- to 16-month period whereas relational nouns tend to appear between 17 to 30-months. Moreover, it has been shown that children often misunderstand relational terms as referring to object categories (e.g., Hall & Waxman, 1993), because children focus on object's properties at the expense of their relations.

However, the case of relational categories (compared to objects) makes the role of cognitive costs of comparisons more meaningful because examples of relational categories (e.g., home for) are usually instantiated by a pair of objects (e.g., bird and nest). This requires to pay attention to more objects (entities and operators, see above) than in the case of object categories.

To the best of our knowledge, there is only one, recent, study assessing the role of comparisons of learning exemplars in the case of persons with ID, and children with autism by Hetzroni, Hessler, and Shalahevich (2019). They presented pairs of objects that were defined by arbitrary relations such as "identical objects but different color" in a no-comparison and a comparison design. For example, participants saw two identical cats, one white and one black, one above the other. In the comparison design, two identical dogs, one black and one white, would be added. In both cases, the transfer stimuli might be two identical camels of different colors displayed in the same spatial arrangement (the relational match) and a dark dog together with a dark cat, both coming from the training stimuli. The three groups generalized the novel word ("these are zubans") more accurately in the comparison conditions, showing that children from various etiologies can benefit from comparisons in spatially defined relational categories. In this study, arbitrary relations were the focus of the study. This design tells us nothing about the role of semantic distance between items in learning and at test, which is the focus of our study.

1.5. Aims of the experiment

The present study will contrast ID children and TD MA-matched children in a comparison lexical learning task. To our knowledge, our study is the first to systematically manipulate the role of conceptual distance between learning items and between learning items and generalization items, in the context of ID.

1.5.1. Main hypotheses

One main hypothesis is that ID children should have lower results than TD children because comparison situations involve monitoring costs (Thibaut & Witt, 2015; Augier & Thibaut, 2013) and require executive functions that are known to be impaired in various intellectual deficiencies (e.g., Lanfranchi et al., 2010; Schuiringa et al., 2017). More specifically, comparison conditions that involve far learning items or distant generalization items, which might be more difficult to unify, again, might impede ID children's performance.

We also hypothesized that differences between TD and ID children might be more important for relational categories than for object categories. Indeed, relational concepts are more difficult than object concepts because they are not defined by intrinsic properties (e.g., perceptually stable properties) (see Gentner et al., 2011 for discussion). Moreover, children have to manipulate more stimuli and perform more comparisons since each learning and generalization example is composed of an operator (e.g. knife) and an entity (e.g., orange).

1.5.2. Alternative assumptions

By contrast, focusing on knowledge development might lead to the opposite hypothesis because chronological development is associated with more world experience. Thus, ID children, who have encountered and manipulated a wider variety of objects, relations, and events than their MA-matched younger children, might have a more developed object and relational lexicon (Chapman, 1995). For instance, Chapman, Schwartz, and Bird (1991) showed that adolescents with ID (Down-Syndrome) had a better lexical knowledge than MA-matched TD adolescents. Given that our categories are familiar to children and that ID children have more experience with the world, they might more easily grasp the underlying concepts of the compared items.

Lastly, difficulties may be more related to the level of cognitive functioning than to the group per se (TD or ID) because these two groups were matched on mental age which might predict an absence of difference between them (ID and TD groups). Another hypothesis is that differences would be observed between high- and low-functioning participants (defined in terms of their RCPM score, Raven, 1965) independently of the group they belong to, either TD or ID. In other words, low functioning participants (including both TD and ID) would be significantly lower than high functioning participants (again including TD and ID). Relatedly, one might also predict an interaction between level of functioning and generalization distance (see below). Indeed, more distant items are expected to involve higher cognitive costs because they are conceptually more heterogeneous than close items (see Thibaut & Witt, 2015).

2. Material and methods

2.1. Participants

Ninety-two children participated in the experiment. Forty-six were TD preschoolers[1] (mean age = 5 years, 6 months; range:

[1] The choice of 5-year-old-children could be surprising regarding the apparent simplicity of the task and the use of familiar categories. However, pilot investigations revealed that the task was more difficult than expected at first sight. In this task, children do not just need to understand the category of fruit but they have to learn the meaning of new words (e.g., buxy) that are used to label different objects and to understand what this common label designates, that is the subset of common conceptual or common perceptual features. Related to this issue is that the paradigm used a perceptual lure (instead of a thematic or an unrelated choice, for instance). It has been shown that perceptual lures have to be inhibited, a skill that

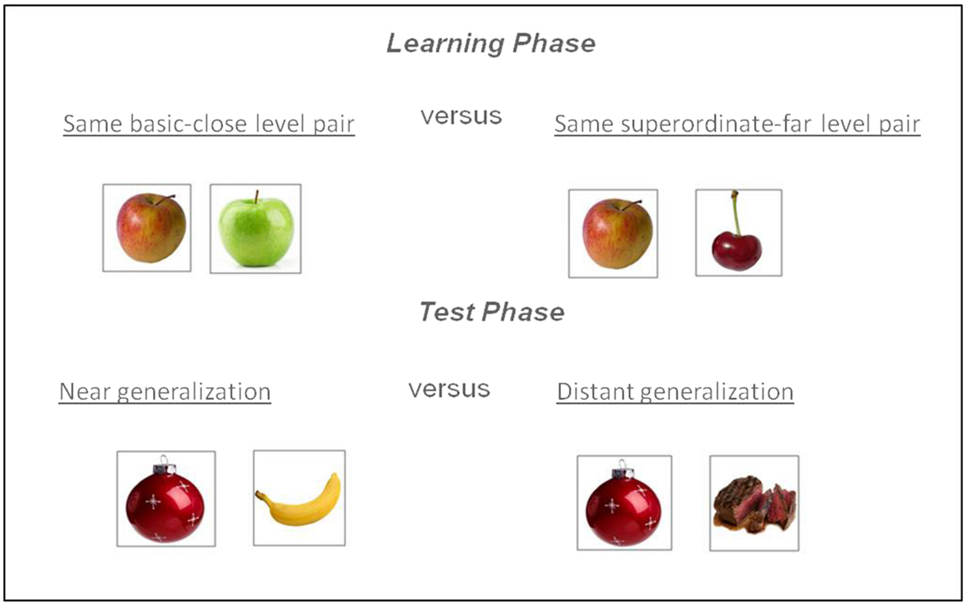

Fig. 1. Illustration of the four experimental conditions: 2 learning (same basic-*close* versus same superordinate-*far*) x 2 test (*near* versus *distant*) conditions.

4,9 − 6,2) and forty-six were children with mild or moderate ID (mean age = 11,6 ; range : 9,3 - 14,5). Children with ID were first tested on mental age with the Raven's Coloured Progressive Matrices (RCPM; (Raven, 1965)) and were matched with typically developing children of the same mental age. In a second step, in an a posteriori analysis, both groups of participants (ID and TD children) were evenly split in low- and high-functioning children. That is, ID children were divided into two groups on the basis of their Raven score, a first group being constituted of ID participants with a High Raven score, the second group, of an equivalent size, being constituted of participants with a Low Raven score. The same principle was applied to the typically developing children. Thus, the resulting distribution was as follows, in the ID group, the mean RCPM score for the “Low ID group” was 15 (N = 23) and 26 (N = 23) for the “High ID group”. In the TD group, the mean RCPM score for the “Low TD group” was 17 (N = 23) and the mean RCPM score for the “High TD group” was 26 (N = 23). Thus, these two factors (Group, TD and ID) and Cognitive functioning (High-Low) could be used as independent crossed factors in the analysis. Note that local institutional constraints during the experiments did not allow us to assess participants’ vocabulary skills. We could not match our TD and ID children on language skills. However, post-test control revealed that all the participants, in both groups, could name the stimuli they were presented with during the experimental.

2.2. Materials

2.2.1. Object categories

We built twelve experimental sets (categories) of pictures, each composed of familiar objects, six sets for the *close* learning situations and six sets for the *far* learning situations; each learning situation was subdivided into 3 *near* and 3 *distant* test conditions. Each trial was composed of a learning pair, either *close* (i.e., from the same basic category, e.g., two apples) or far (i.e., from the same immediate superordinate category, e.g., an apple and a cherry) and a pair of generalization stimuli composed of a perceptually-similar-but-conceptually unrelated item (e.g., Christmas ball) and a same-superordinate-but-perceptually-dissimilar category, either *near* (e.g., banana) or *distant* (e.g., meat) (see Fig. 1). The twelve sets were counterbalanced across learning and test conditions. Twelve different bisyllabic labels (pseudo-words like “*buxi*” for instance) were used to name the categories. The order of presentation of the categories was counterbalanced, and the labels were interchanged among pairs across participants. For the purpose of our experiment, close learning items (e.g., apple 1 and apple 2) had to be conceptually closer to each other than far learning items (e.g., an apple and a cherry). In the same way, the near generalization items (e.g., banana) had to be closer to the learning items (e.g., apple 1, apple 2 or cherry) than the distant generalization items (e.g., meat). It was also important that the generalization items (e.g., banana and meat) were perceptually less similar to the learning items (e.g., apple 1, apple 2 and cherry) than the perceptual lures (e.g., Christmas ball). Conceptual and perceptual similarity ratings on a 7-point scale were obtained from 54 students. They showed that members of close learning pairs were conceptually closer one to the other than those from the far learning pairs, and that the near generalization items were conceptually closer to the learning stimuli than distant generalization items. In addition, perceptual

(*footnote continued*)
heavily relies on the maturation of executive functions. In everyday life, children do not have systematic lures to inhibit, might be confronted to a larger number of training items, that will make the task easier.

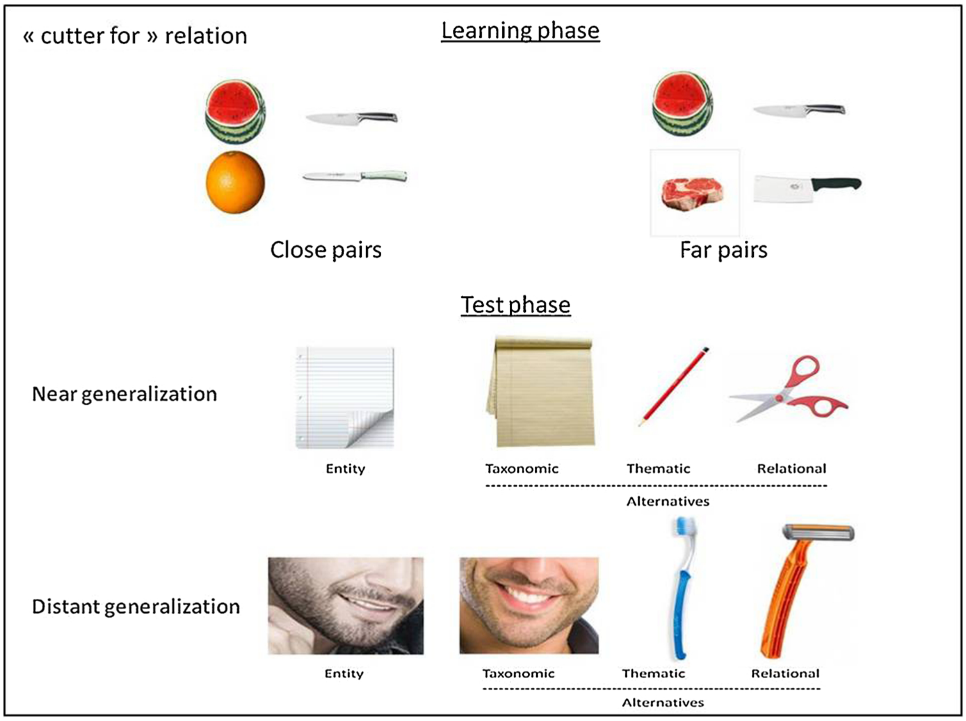

Fig. 2. Sample set depicting a *cutter for* relation, in the *close* and *far* learning, and in the *near* and *distant* generalization conditions.

lures were rated as more perceptually similar to the learning items than the taxonomic choices were (all $p_s < .01$, these ratings have been obtained and described by Thibaut & Witt, 2017).

2.2.2. Relational categories

Twelve sets of pictures were built. Each set illustrated one relational category (*cutter for*, *home for*, *food of*, *baby of*, etc.). The *close* learning condition was composed of two conceptually similar, close, pairs of items (e.g., *knife1-watermelon* and *knife2–orange*), while the *far* learning condition was composed of two less conceptually similar pairs of items (e.g., *knife1-watermelon* and *cleaver-piece of meat*). The learning pairs were all composed of an operator (e.g., a *knife*) and an entity (e.g., *watermelon*) in order to instantiate the targeted relation (e.g., is *the cutter for*). At test, a new entity was presented with three candidate pictures among which the operator to unify with the entity in order to match the relation instantiated by the learning pairs. The test pictures consisted of 4 pictures for both the *near* and the *distant* conditions: (a) the “entity to be operated upon” (e.g., either sheet of paper for the *near* condition or bearded face1 for the *distant* condition), (b) a taxonomic choice (e.g., pile of sheets of paper –*near*; bearded face2–*distant*), (c) a thematic choice (e.g., pencil-*near*; toothbrush-*distant*), (d) a relational choice (e.g., scissors–*near*; razor–*distant*) (see Fig. 2). The twelve sets were counterbalanced across learning and test conditions.

As for objects, we assessed and compared the conceptual distance between items in close learning trials and the conceptual distance between items in far learning trials. We also assessed the conceptual distance between the entity and the relational choice (operator) in the near generalization condition and the conceptual distance between the entity and the relational choice than in the distant generalization case. Independent ratings were obtained from 54 university students. They completed a Pair-Rating task and an Item-Rating task in which they were asked to rate conceptual similarity on a 7-point scale. For the Pair-Rating task, they rated the similarity between close pairs one to the others (e.g., knife1-watermelon, knife2-orange) and between far pairs one to the others (e.g., knife1-watermelon, cleaver-piece of meat), as well as between the three learning pairs (e.g., knife1-watermelon, knife2-orange and cleaver-piece of meat) and either the near generalization pairs (e.g., scissors-sheet of paper) or the distant generalization pairs (e.g., shaver-bearded face). The Pair-Rating task confirmed that close learning pairs were more conceptually similar one to the others than far learning pairs and that near generalization pairs were more similar to learning pairs than distant generalization pairs. In the Item-rating task, they evaluated the similarity between entities (e.g., watermelon and orange - close case- or watermelon and meat -far case-) and between operators (e.g., knife1 and knife2 - close case- or knife1 and cleaver -far case-) in the learning pairs, as well as between learning and generalization entities (e.g., watermelon, orange and meat compare to sheet of paper - near case - or compared to bearded face -distant case-) and between learning and generalization operators in the learning and the generalization pairs (e.g., knife1, knife2 and cleaver compared to scissors - near case- or compared to shaver - distant case -). The Item-Rating task confirmed that close entities were more similar one to the others than far entities and that close operators were more similar one to the others than far operators. Results also confirmed that entities or operators in the near generalization pairs were more similar to the entities or operators in the learning pairs than entities and operators in the distant generalization pairs (all $p_s < .05$, see Thibaut et al., 2018 for more details).

2.3. Procedure

2.3.1. Object categories

We used a puppet in order to enhance the task attractiveness. The following instructions illustrate the case of fruit categories (in the close learning condition; they were identical in the far condition). "*Hello, we are going to play a game together. In this game we are going to learn the language of Yoshi. Yoshi is leaving far away from here". We are going to show him what a "buxy" means.*" The two objects of a learning pair appeared in a row on the top of a computer screen. The location (right-left) of each object was determined randomly. The learning pairs remained in view until all the learning pairs defining one trial had been shown, and the learning pairs were still visible during the test phase. The test, generalization, phase started with these instructions: "*Now let's look at all of them* (gesturing across the learning items – apple1 and apple2). *You see how these are "buxis". Now it's your turn."* The test items appeared at the bottom of the screen (location was determined randomly). "*Which one of these* (gesturing across the test items – perceptual choice: Christmas ball, taxonomic choice: banana) *is also a "buxi"?*"

2.3.2. Relational categories

Our procedure was as followed, for the "*cutter for*" relational category in the *close* learning and *near* generalization conditions. A puppet was also used. The instructions were "*Hello, we are going to play a game together. In this game we are going to teach Sammy the word "Soma". We are going to show him what "Soma" means.*" "*Look! This knife* (the knife1 was displayed on the computer screen) *is the "soma" for the watermelon (*the watermelon was displayed, left side of the knife1)*." "This knife* (the knife2 was displayed, below the knife 1) *is the "soma" for the orange* (the orange was displayed, left side of the knife2)." The test started with these instructions: "*Now let's look all of them (gesturing across all the training pairs). You see how these are "somas"? Now it's your turn. Which one of these* (pointing to the test materials – taxonomic: pieces of paper; thematic: pencil; relational: scissors –) *is the "soma" for the paper in the same way?*" Children chose among the three test pictures by pointing which is the "soma" for the paper. Half of the participants started with the novel names learning task for object categories and the other half with the learning task for relational names, with a one-week delay between the two tasks.

2.4. Design and data analysis

TD (N = 46) and ID children (N = 46) were compared. Within these groups, children were equally divided ($N_s = 23$) according to their level of cognitive functioning (23 high-level and 23 low-level, see participants section). The between-subjects Group (TD or ID) and Cognitive functioning (high or low) factors were crossed with Learning distance (*close* vs. *far* comparison) and Generalization distance (*near* vs. *distant*) which were within-subject factors. Therefore, a 2 (Group: *ID* or *TD* children) x 2 (Cognitive functioning: *low* or *high*) x 2 (Category: *objects* vs. *relations*) x 2 (Learning: *close* or *far*) x 2 (Test distance: *near* or *distant*) analysis of variance (ANOVA) was carried out on the taxonomic (for objects) and relational (for relations) choices (see Figs. 1 & 2). In addition, an ANCOVA was run with chronological age as a continuous variable. Planned comparisons were run to contrast Group, Cognitive functioning, Categories, Learning and Test distance conditions. We also compared the proportions of correct responses to chance (objects = 50 % and relations = 33.33 %), with t-tests, with a Bonferroni correction for multiple comparisons (significance at .0025, because the alpha threshold of .05 was divided by the number (20) of independent comparisons with chance we ran during the analyses of the data).

3. Results

A 2 (Group: *ID* or *TD* children) x 2 (Cognitive functioning: *low* or *high*) x 2 (Category: *objects* vs. *relations*) x 2 (Learning: *close* or *far*) x 2 (Test distance: *near* or *distant*) analysis of variance (ANOVA) was carried out on the taxonomic (for objects) and relational (for relations) choices. Fig. 3 depicts the entire pattern of results.

3.1. TD vs. ID children's learning and generalizing of novel names for objects and relations

Our ANOVA revealed that ID children ($M = .71$) were marginally better than TD children ($M = .65$), $F(1, 176) = 3.67, p = .06$, $\eta^2_P = .02$. It also showed that high-functioning children (.71) were significantly better than low-functioning children (.65), $F(1, 176) = 4.36, p < .05, \eta^2_P = .02$. Children's performance was higher for relational ($M = .76$) than for object categories ($M = .61$), $F(1, 176) = 20.69, p < .0001, \eta^2_P = .10$. The Group*Category interaction was also significant, $F(1, 176) = 5.8, p < .05, \eta^2_P = .03$, and revealed that ID children ($M = .70$) outperformed TD children ($M = .53$) for object categories, $F(1, 176) = 14.46, p < .001$, $\eta^2_P = .08$, while the two groups had similar performance for the relational categories (see Fig. 4). When age as a continuous variable was added as a covariate, the effect of Group turned out to be non-significant for object categories, while it became significant for relational categories (respectively, $p = .63$ and $p < .05$).

Comparisons with chance confirmed that only ID children performed significantly above chance for object categories, $t(45) = 5.76, p < .001$, while the two groups performed above chance for relational categories, ($p_s < .001$).

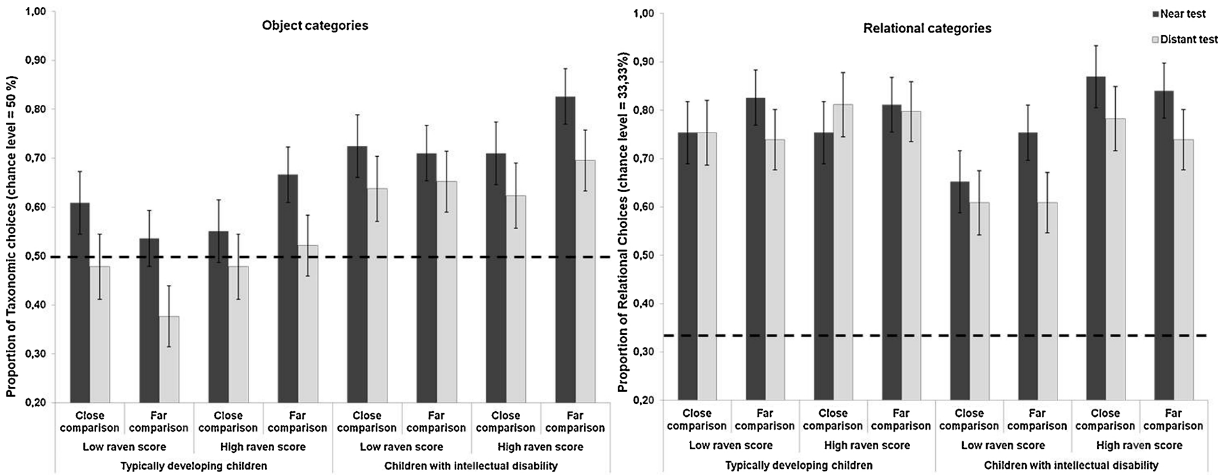

Fig. 3. Mean proportions of correct responses for the Objects (taxonomic choices) and Relational categories (relational choices) generalization task as a function (Group: *ID* or *TD* children) x 2 (Cognitive functioning: *low* or *high*), Learning (2: close vs. far), Test distance (2:near vs. distant). The error bars are standard error of the means. Dashed lines = chance levels (50 % in the object case, and 33.33 % for relational words).

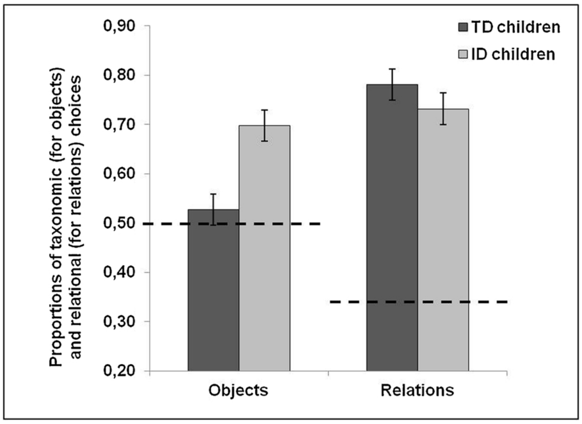

Fig. 4. Mean proportions of taxonomic (for objects) and relational (for relations) choices as a function of Group (*TD* vs. *ID* children) and Category to learn and generalize (*Objects* vs. *Relations*). The error bars are standard error of the means. Dashed lines = chance levels (50 % in the object case, and 33.33 % for relational words).

3.2. Conceptual distance between learning items

One key question was whether conceptual distance would interact with group, that might differ in the far learning condition.

The results revealed a Learning distance x Cognitive functioning x Category interaction (see Fig. 5). This three-way interaction, $F(1, 176) = 5.23, p = .02, \eta^2_P = .62$, showed that high-functioning children generalized objects' names better in far ($M = .67$) than in close learning condition ($M = .59$), $F(1, 176) = 5.57, p < .05, \eta^2_P = .03$, but the low-functioning children did not ($M_{\text{Close}} = .61$ $M_{\text{Far}} = .57$), $F(1, 176) = 1.39$, $p = .24$, $\eta^2_P = .008$. In the far condition, high-functioning ($M = .68$) outperformed low-functioning children ($M = .57$), $F(1, 176) = 5.09$, $p < .05$, $\eta^2_P = .03$, while the two cognitive functioning groups did not differ ($M_{\text{High}} = .59$ $M_{\text{Low}} = .61$) in the close condition, $F < 1$. For relational categories, there was no effect of Learning distance for both groups. High-functioning (M = .80) outperformed low-functioning children (M = .69) in the close learning condition, $F(1, 176) = 4.14, p < .05$, $\eta^2_P = .02$, but not in the far learning condition ($M_{\text{Low}} = .73$ $M_{\text{Far}} = .80$), $F(1, 176) = 1.83$, $p = .18$, $\eta^2_P = .01$.

Comparisons with chance revealed that, for objects, only the high-functioning children in the far learning condition performed beyond chance, $t(45) = 4.17$, $p < .001$, whereas, for relations, low- and high-functioning children performed significantly above chance in both learning conditions ($p_s < .0001$).

3.3. Conceptual distance between learning and generalization items

Another important question was whether generalization distance would interact with group, that might differ in the distant generalization condition.

The results showed that performance was significantly higher for near (.72) than for distant (.64) targets, $F(1, 176) = 20.34$, $p <$

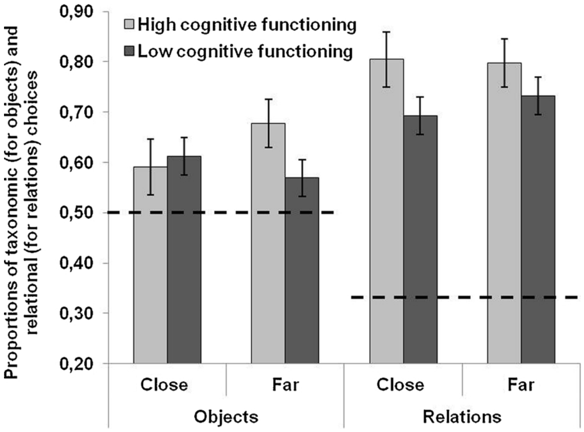

Fig. 5. Mean proportions of taxonomic (for objects) and relational (for relations) choices as a function of Learning type (*close* vs. *far*), Cognitive functioning level (*low* vs. *high*) and the Category to learn and generalize (*Objects* vs. *Relations*). Error bars correspond to one standard error and the dashed lines represent chance levels (50 % or 33.33 %).

.0001, $\eta^2_P = .10$. Test distance also interacted marginally with the Group and Category factors, $F(1, 176) = 2.80, p = .096, \eta^2_P = .02$ (see Fig. 6). For objects, TD and ID children generalized novel names better for near than for distant targets, ($M_{\text{NearTD}} = .59$ $M_{\text{DistantTD}} = .47$) $F(1, 176) = 12.58, p < .001, \eta^2_P = .07$ and ($M_{\text{NearID}} = .74$ $M_{\text{DistantID}} = .65$) $F(1, 176) = 6.42, p < .05, \eta^2_P = .04$, and ID children outperformed TD children in both generalization conditions, near, $F(1, 176) = 9.61, p < .01, \eta^2_P = .05$, and distant, $F(1, 176) = 12.33, p < .001, \eta^2_P = .07$. For relational categories, the near and distant test conditions did not differ significantly in the TD group ($M_{\text{NearTD}} = .79$ $M_{\text{DistantTD}} = .77$), $F < 1$, whereas ID children generalized novel names significantly better in the near ($M = .78$) than in the distant test condition ($M = .68$), $F(1, 176) = 6.94, p < .01, \eta^2_P = .04$. TD and ID children did not differ significantly in the near test distance, $F < 1$, while the TD children marginally outperformed the ID children in the distant test condition, $F(1, 176) = 2.85, p = .09, \eta^2_P = .02$. No other significant effect was observed.

Comparisons with chance revealed that ID children performed above chance in the both near and distant test conditions ($p_s < .001$), while TD children performed at chance. For relational categories, TD and ID children performed above chance whatever the test conditions ($p_s < .00001$).

In summary, children better learned and generalized relational than object categories, contrary to expectations. Another surprising result was that ID children learned and generalized object categories better than TD children, but not relational categories, while high-functioning participants is associated with better generalization whatever the category type, object or relational. High-functioning children also performed better in far than in close learning conditions, at least for objects. Finally, results suggested that ID children were less efficient than TD children to extend relational concepts to distant domains.

4. Discussion

We compared children with ID and TD children in a novel word learning task and contrasted comparison conditions in which we manipulated the conceptual distance between stimuli (close or far) in the learning phase and between the learning and the

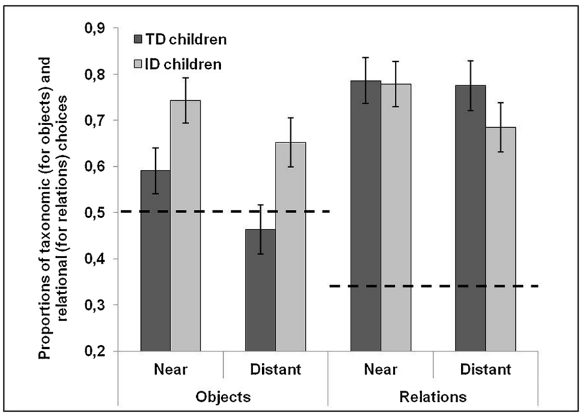

Fig. 6. Mean proportions of taxonomic (for objects) and relational (for relations) choices as a function of Group (TD vs. ID children), Test distance (near vs. distant), and the Category to learn and generalize (Objects vs. Relations). The error bars correspond to one standard error and the dashed lines represent chance levels (50 % or 33.33 %).

generalization stimuli (near or distant) for object and relational nouns. We hypothesized that comparisons involving far (compared to close) learning items and distant (compared to near) generalization should benefit to TD children but might impede ID children. Another hypothesis was that cognitive costs could be more associated with the level of cognitive functioning rather than to type of participants (TD or ID) per se. We predicted that far learning items (compared to close) and distant generalization (compared to near) should benefit high-functioning children's performances but might impede low-functioning children's performances. Because, relational concepts are conceptually more difficult than object concepts, we hypothesized that the type of category (object or relation) should interact with the "intellectual status" (TD or ID) and level of cognitive functioning (high or low). Our experiment is the first one to systematically manipulate these factors. Indeed, previous experiments mostly dealt with the role of typicality and the relative difficulty of levels of categorization, which is also fundamental.

4.1. Intellectual deficiencies and conceptual development

Contrary to expectations, the results revealed that ID children outperformed TD children in the novel object nouns learning task. This suggests that ID children's lexical learning and generalization mechanisms are functional. ID children, who are significantly older than TD children, probably relied on their more developed world knowledge to learn and extend novel names about these stimuli that came from familiar categories as already described by Chapman et al. (1991). Further experiment should contrast learning/generalization of novel names for real (familiar) and abstract (unfamiliar) objects in ID and TD children in different learning comparison situations. We expect interactions between Group*Type of objects because children with ID could not compensate their ID with world knowledge.

However, ID children did not outperform TD children for relational categories. The two groups performed at the same, high, level. In the case of relational concepts, the difficulty is that the same relational noun can be applied to very different objects (e.g., neighbor, symmetry), that is relations are not grounded in stable perceptual properties. Kemler (1982) showed that classifications in children with ID were predominantly driven by perceptual similarity rather than by conceptual relationships. Most likely, this means that more experience with the world is probably not sufficient for the discovery of nonobvious properties over salient irrelevant properties, what is a crucial issue for the understanding of relational concepts. This is probably the reason why ID children performed equal with their MA-matched counterparts in the novel relational nouns learning task (but did not outperformed them, like for objects). Since we did not match the ID and the TD group on the basis of both Raven and Peabody scores, we could not test this assumption (see limitations, below).

We also investigated the effect of distance at test. Our results reported that near generalization was significantly better than distant generalization. Test distance also interacted with Group (TD or ID). Contrary to TD children, ID children had more difficulties in distant than in near generalization condition for relational concepts and results showed that ID children, slightly, underperformed TD children. It is unlikely that the lower performance of ID children for the distant generalization condition results from higher cognitive costs in this generalization condition because the results for object categories suggest that cognitive costs are associated with cognitive functioning rather than with intellectual status. One might however hypothesize that generalization of relational dimensions to distant targets is a particular case which combined difficulties that have been associated with ID, that is difficulties to conceptualize abstract relational knowledge (Fazio et al., 1993) at a superordinate level of categorization categories (Tager-Flusberg, 1985).

4.2. Cognitive costs and cognitive functioning

Considering the effect of conceptual distance between the learning exemplars, this factor interacted with the level of cognitive functioning in the object nouns learning task. High-functioning children outperformed low-functioning participants in the far learning condition whereas they did not differ in the close learning condition. This suggests that low-functioning individuals had more difficulties to conceptually unify dissimilar stimuli. This is consistent with the idea that comparisons of dissimilar exemplars involve cognitive costs (Augier & Thibaut, 2013; Thibaut & Witt, 2015). Consequently, ID children had no problem generalizing novel names per se. The crucial point was the level of intellectual deficit (cognitive functioning) and its interaction with conceptual distance. Nevertheless, for relational concepts, learning distance did not affect performance and did not interact with Group or Cognitive functioning. This result is quite surprising because the cognitive costs of comparisons was supposed to be higher for relations than for objects because relations require manipulating more stimuli (operators and entities) and performing more comparisons. This factor may no longer play a crucial role above a (high) given level of performance (remember that performance was higher for relations than for objects).

Although a limited number of learning stimuli is required (Augier & Thibaut, 2013; Thibaut & Witt, 2015), adding one or two more examples might benefit to generalization in distant domains. Thibaut and Witt (2015) found that a three-pair condition was the best compromise between informativeness and cognitive demands. This allows to introduce both close and far stimuli which is the minimum condition to elicit progressive alignment between learning exemplars. According to the authors, the beneficial effect of a progressive alignment design could result either from the use of different and complementary components of the generalization process or from gradual reduction of the distance between learning and generalization stimuli. Future studies should investigate the learning set size effect (1 vs. 2 vs. 3 examples at least) in comparison setting in children with ID.

4.3. Objects and relational categories' learning and generalization

Another intriguing result was that ID and TD both learned and generalized better relational than object nouns. This result conflicts with the observation that relational categories are acquired later than nouns for objects as shown by the MacArthur Communicative Development Inventory database (Fenson et al., 1993). A possible explanation comes from a methodological difference between the two tasks. This issue will be discussed in the "Limitations of the study" sub-section.

Considering relational categories, Hetzroni et al. (2019) observed that TD children outperformed ID children, while we observed the same level of performance between the two groups (except for distant generalization of relational concepts). Although the authors manipulated the familiarity of objects involved in the relations (known, partially known or unknown animals) and showed that familiarity affected performance in both TD and ID children, their targeted relational categories (e.g., mirroring) were less familiar than those we used (e.g., being the cutter for). However, these conflicting results support our hypothesis that ID children's lexical generalization skills heavily rely on their more developed world knowledge about familiar categories, which is also consistent with Chapman et al. (1991). By contrast, they underperformed TD children when they dealt with unfamiliar categories. Further studies should compare learning and generalization of familiar and unfamiliar categories in ID and TD children in order to better understand and separate cognitive and environmental factors that underpin conceptual development in ID children.

Note also that Hetzroni et al. (2019) use perceptual choices as distractors in their matching-to-sample task. The use of perceptual alternatives at test may have contributed to increase the differences between the groups, at the expense of TD children who might have difficulties inhibiting perceptual distractors as a consequence of their impaired executive functions (Lanfranchi et al., 2010; Schuiringa et al., 2017). Our experiment does not enable us to decide which of these two hypotheses, familiarity or role of distractors, accounts for the discrepancy between the present experiment and previous findings.

4.4. Limitations of the study

As mentioned, our experimental design and methodology may have influenced the results and limit the scope of our findings and their applications to practice.

First, ID children, who were significantly older than TD children, probably relied on their greater world knowledge and/or language skills. Unfortunately, it was not possible to assess language skills for a large number of participants, which precluded to use language performance as a covariate. Because chronological age is associated with world knowledge and lexical development in TD as well as in ID children (Chapman, 1995), another way to assess the role of world knowledge, indirectly though, is to include chronological age as a continuous covariate variable. When controlling for chronological age, it seems that ID children's greater experience with the world allowed them to compensate their deficits and to reach a similar level of performance for objects than TD children, since ID vs. TD children effect disappeared for object categories. Further investigations should integrate two TD children control groups, one matched on the Raven scores, and one on a vocabulary measure that would tell us more about their level of world knowledge.

Secondly, discrepancy between the object and relational categories learning tasks may explain why ID and TD both learned and generalized relational nouns better than object nouns. At test for objects categories, children had to pick the correct item target among two choices for objects: a perceptual choice and a taxonomic (target) choice, whereas there was no perceptual distractor for relations. Perceptual choices are known to be more difficult to inhibit than thematic and taxonomic alternative choices, for both children and adults, as argued by Rattermann and Gentner (1998), because shape similarities play a crucial role in early lexical learning (e.g., Landau, Smith, & Jones, 1988). Considering now thematic and taxonomic alternative choices as distractors stimuli, they are not a priori more salient than relational targets because all three of them have semantic relations and similarities with the operators or the learning stimuli. In sum, object or relational categories need to be modified to allow their joint investigation in further studies. For instance, it is possible to keep constant the number and the type of alternative choices (one perceptual, one thematic, one unrelated lures for instance) at test and to control associative strengths between learning and test choices in both the object and relational categories tasks.

4.5. Applications to practice: design learning methods for ID children

Although a central role is increasingly given to pictorial materials in teaching methods for ID children (Räty, Kontu, & Pirttimaa, 2016), little work has been done on learning and teaching through pictures (Gentner, 2010; Hegarty, 2015) and there is currently no comprehensive, evidenced-based design approach ensuring their educational effectiveness (Postigo & Pozo, 2004). Considering teaching methods such as augmentative and alternative communication (AAC) modeling methods which are used in cases of communication difficulties in ID children (e.g., Biggs, Carter, & Gilson, 2018; Waddington et al., 2014; Foreman & Crews, 1998), it is clear that the use of pictures, as it is used in these methods, might not be optimal. Indeed, in many of these training situations, there is only one illustrating exemplar-picture (e.g., picture books), while we know that the comparison of several learning examples is a highly effective tool for learning (Alfieri, Nokes-Malach, & Schunn, 2013). However, up to now, there was no available evidence regarding the effectiveness of this learning format in the case of children with ID and further studies are needed for a systematic cognitive approach to instructional design. One hypothesis was that their cognitive deficits lead to poorly organized comparisons, which might have impeded learning. Contrary to our expectations, results showed that ID children were as efficient or even better than TD children in our comparison learning formats. This means that the benefits of comparison in TD children are generalizable to ID children. This suggests that nothing should preclude the use of comparison formats in ID children.

Comparison format being now established as effective in ID children, we must address recommendations regarding the materials to compare because the selection of the pictures to compare often remains empirical with no reference to cognitive processes. One key motivation for contrasting different types of comparisons was that informativeness competes with cognitive load. In other words, adding more relevant conceptual information also generates more cognitive costs (Augier & Thibaut, 2013; Richland, Morrison, & Holyoak, 2006; Thibaut & Witt, 2015). Interestingly, conceptual distance between learning examples did not interact with Group (ID vs. TD) but rather with cognitive functioning (low- vs. high-functioning). This result suggests that comparisons should be tuned to the cognitive efficiency of the targeted population.

Thus, all these findings together emphasize that designing learning situations that are well suited to various groups of children requires systematically studying how their cognitive characteristics (e.g., executive functions limitations) interact with the tasks.

5. Conclusions

To conclude, MA matching did not allow to observe any deficit due to ID in relational categories learning and even a better performance in ID than in TD children for objects. This suggests that conceptual and lexical learning mechanisms are preserved in ID individuals. Interestingly, the fact that learning distance interacts with the level of cognitive functioning for objects suggests that a high level of cognitive functioning is crucial to compensate conceptual deficits and allows learning concepts in ID children as efficiently as in TD children. However, interaction between test distance and group (TD or ID) for relational concepts suggests that generalization was more difficult in ID for concepts that apply to very different objects. Reduced access to abstract concepts in ID children compared to TD children may have limited the extension of relational concepts to distant domains in the former group. Far generalization of relational concepts is the most relevant aspect of conceptual development for educational outcomes (Goldwater & Schalk, 2016). Identifying methods to specifically improve this kind of conceptual learning/reasoning could be quite important for educational interventions with the population. Further studies are needed to test learning design which could help to learn and generalize relational concepts (see for instance Rattermann & Gentner, 1998).

Acknowledgements

The authors are very grateful to Marion Mallot, Marion-Eve Guillard, Léa Gillier and Cassandra Nestre for their help in constructing the stimuli, conducting the experiment and/or analyzing the data. The authors wish to thank the children and parents who participated in the study, as well as the psychologists and any other professional of the Medical Educational Institutes and Special Education and Home Care Services (PEP21). We also thank Eleanor Stansbury for her very careful correction of the English of the manuscript. This research was supported by a grant from the Conseil Régional de Bourgogne Franche-Comté (Projet intégré de recherche-innovation du PARI II COGSTIM) and by an ANR grant from the French Ministry of Research (ANR-18-CE28 COMPARE).

References

Alfieri, L., Nokes-Malach, T. J., & Schunn, C. D. (2013). Learning through case comparisons: A meta-analytic review. *Educational Psychologist, 48*(2), 87–113.

Augier, L., & Thibaut, J. P. (2013). The benefits and costs of comparisons in a novel object categorization task: Interactions with development. *Psychonomic Bulletin & Review, 2*, 1126–1132.

Barrett, M. D., & Diniz, F. A. (1989). Lexical development in mentally handicapped children. *Language and Communication in Mentally Handicapped People,* 3–32.

Biggs, E. E., Carter, E. W., & Gilson, C. B. (2018). Systematic review of interventions involving aided AAC modeling for children with complex communication needs. *American Journal on Intellectual and Developmental Disabilities, 123*(5), 443–473.

Chapman, R. S. (1995). Language development in children and adolescents with Down syndrom. *In P. Fletcher, & B. MacWhinney (Eds.), The handbook of child language (pp. 641–663). Oxford, UK: Blackwell.*.

Chapman, R. S., Schwartz, S. E., & Bird, E. K. R. (1991). Language skills of children and adolescents with Down syndrome: I. Comprehension. *Journal of Speech Language and Hearing Research, 34*(5), 1106–1120.

Childers, J. B., & Paik, J. H. (2009). Korean- and English-speaking children use cross-situational information to learn novel predicate terms. *Journal of Child Language, 36*(01), 201.

Fazio, B. B., Johnston, J. R., & Brandl, L. (1993). Relation between mental age and vocabulary development among children with mild mental retardation. *American Journal on Mental Retardation, 97*(5), 541–546.

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J. P., et al. (1993). *The MacArthur communicative development inventories: User's guide and technical manual.* San Diego: Singular.

Foreman, P., & Crews, G. (1998). Using augmentative communication with infants and young children with Down syndrome. *Down Syndrome Research and Practice, 5*(1), 16–25.

Gentner, D. (2010). Bootstrapping the mind: Analogical processes and symbol systems. *Cognitive Science, 34*(5), 752–775.

Gentner, D., & Namy, L. L. (1999). Comparison in the development of categories. *Cognitive Development, 14*(4), 487–513.

Gentner, D., Loewenstein, J., & Hung, B. (2007). Comparison facilitates children's learning of names for parts. *Journal of Cognition and Development, 8*(3), 285–307.

Gentner, D., Anggoro, F. K., & Klibanoff, R. S. (2011). Structure mapping and relational language support children's learning of relational categories. *Child Development, 82*(4), 1173–1188.

Goldwater, M. B., & Schalk, L. (2016). Relational categories as a bridge between cognitive and educational research. *Psychological Bulletin, 142*(7), 729–757.

Hall, D. G., & Waxman, S. R. (1993). Assumptions about word meaning: Individuation and basic-level kinds. *Child Development, 64*(5), 1550–1570.

Harrison, R. H., Budoff, M., & Greenberg, G. (1975). Differences between EMR and nonretarded children in fluency and quality of verbal associations. *American Journal of Mental Deficiency, 79*(5), 583–591.

Hayes, B. K., & Conway, R. N. (2000). Concept acquisition in children with mild intellectual disability: Factors affecting the abstraction of prototypical information. *Journal of Intellectual and Developmental Disability, 25*(3), 217–234.

Hegarty, M. (2015). *Learning from technical animated systems. Keynote communication. EARLI conference, SIG 2. Comprehension of text and Graphics.* Rotterdam, Augusr 2015.

Hetzroni, O. E., Hessler, M., & Shalahevich, K. (2019). Learning new relational categories by children with autism spectrum disorders, children with typical development and children with intellectual disabilities: Effects of comparison and familiarity on systematicity. *Journal of Intellectual Disability Research, 63*(6), 564–575.

Hupp, S. C. (1986). Use of multiple exemplars in object concept training: How many are sufficient? *Analysis and Intervention in Developmental Disabilities, 6*(4), 305–317.

Hupp, S. C., & Mervis, C. B. (1982). Acquisition of basic object categories by severely handicapped children. *Child Development, 53*, 760–767.

Hupp, S. C., Mervis, C. B., Able, H., & Conroy-Gunter, M. (1986). Effects of receptive and expressive training of category labels on generalized learning by severely mentally retarded children. *American Journal of Mental Deficiency, 90*, 58–65.

Kemler, D. G. (1982). Classification in young and retarded children: The primacy of overall similarity relations. *Child Development,* 768–779.

Landau, B., Smith, L. B., & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development, 3*(3), 299–321.

Lanfranchi, S., Jerman, O., Dal Pont, E., Alberti, A., & Vianello, R. (2010). Executive function in adolescents with Down syndrome. *Journal of Intellectual Disability Research, 54*(4), 308–319.

Mervis, C. B. (1984). *Early lexical development: The contributions of mother and child. Origins of cognitive skills.* 339–370.

Mervis, C. B. (1990). *Early conceptual development of children with Down syndrome. Children with Down syndrome: A developmental perspective.* 252–301.

Murphy, G. (2004). *The big book of concepts.* MIT press.

Namy, L. L., & Gentner, D. (2002). Making a silk purse out of two sow's ears : Young children's use of comparison in category learning. *Journal of Experimental Psychology General, 131*, 5–15.

Postigo, Y., & Pozo, J. I. (2004). On the Road to Graphicacy: The learning of graphical representation systems. *Educational Psychology, 24*(5), 623–644.

Rattermann, M. J., & Gentner, D. (1998). More evidence for a relational shift in the development of analogy: Children's performance on a causal-mapping task. *Cognitive Development, 13*(4), 453–478.

Räty, L., Kontu, E. K., & Pirttimaa, R. (2016). Teaching children with intellectual disabilities: Analysis of research-based recommendations. *Journal of Education and Learning, 5*.

Raven, J. C. (1965). RCPM: Guide to Using the Colored Progressive Matrices. *New York, NY, Psychological Corp*.

Richland, L. E., Morrison, R. G., & Holyoak, K. J. (2006). Children's development of analogical reasoning: Insights from scene analogy problems. *Journal of Experimental Child Psychology, 94*, 249–271.

Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology General, 104*(3), 192.

Rosch, E. (1978). Principles of categorization. In E. Rosh, & B. Lloyd (Eds.). *Cognition and categorization* (pp. 169–215). Hillsdale, NJ: Erlbaum.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8*(3), 382–439.

Schuiringa, H., van Nieuwenhuijzen, M., Orobio de Castro, B., & Matthys, W. (2017). Executive functions and processing speed in children with mild to borderline intellectual disabilities and externalizing behavior problems. *Child Neuropsychology, 23*(4), 442–462.

Tager-Flusberg, H. (1985). The conceptual basis for referential word meaning in children with autism. *Child Development,* 1167–1178.

Thibaut, J. P., & Witt, A. (2015). Young children's learning of relational categories: Multiple comparisons and their cognitive constraints. *Frontiers in Psychology, 6*, 643.

Thibaut, J. P., & Witt, A. (2017). Generalizing novel names in comparison settings: Role of conceptual distance during learning and at test. In G. Gunzelman, A. Howes, T. Tenbrink, & E. Davelaar (Eds.). *Proceedings of the 39th Annual Meeting of the Cognitive Science Society* (pp. 3314–3319). .

Tager-Flusberg, H. (1986). Constraints on the representation of word meaning: Evidence from autistic and mentally retarded children. *In The development of word meaning (pp. 69-81). Springer, New York, NY*.

Thibaut, J.-P., Stansbury, E., & Witt, A. (2018). Generalization of novel names for relations in comparison settings: The role of conceptual distance during learning and at test. In C. Kalish, M. Rau, T. Rogers, & J. Zhu (Eds.). *Proceedings of the 40th Annual Meeting of the Cognitive Science Society* (pp. 1114–1119). .

Waddington, H., Sigafoos, J., Lancioni, G. E., O'Reilly, M. F., Van der Meer, L., Carnett, A., et al. (2014). Three children with autism spectrum disorder learn to perform a three-step communication sequence using an iPad®-based speech-generating device. *International Journal of Developmental Neuroscience, 39*, 59–67.

Waxman, S. R., & Klibanoff, R. S. (2000). The role of comparison in the extension of novel adjectives. *Developmental psychology, 36*(5), 571–581. https://doi.org/10.1037//O012-1649.36.5.571.

Zampini, L., Salvi, A., & D'odorico, L. (2015). Joint attention behaviours and vocabulary development in children with Down syndrome. *Journal of Intellectual Disability Research, 59*(10), 891–901.