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

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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 (e.g., Gentner, 2010). So far, only one recent study questioned the benefit of comparison situations in children with intellectual disabilities (ID) (Hetzroni, Hessler, & Shalahevich, 2019). In the present research children with ID and TD children matched on mental age with the Raven's coloured progressive matrices (RCPM : Raven, 1965) were tested in several comparison conditions. We manipulated the conceptual distance between stimuli in the learning phase and between the learning and generalization phase stimuli for object and relational nouns. Results showed that overall both populations had rather similar performance profile when matched on their cognitive skills (low vs. high functioning). Unexpectedly, ID children's performance was equivalent or better than their TD peers. We discuss the role of conceptual distance on participants' conceptual generalization as a function of their intellectual abilities and cognitive functioning.

Keywords: object and relational categories, comparisons, conceptual distance, intellectual disabilities

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

Total number of words : 8037

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). Comparisons between people with ID and MA-matched TD groups often reveal 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 also seems to have the same cognitive underpinnings as those observed in TD children (Zampini, Salvi, & D'Odorico, 2015). As a consequence, recommendations for the design of learning methods should not differ between TD and ID children. For instance, the use of multiple "core members" of the category to learn has been identified as a good way to promote category acquisition for both TD and ID children (Hupp & Mervis, 1982). However, little is now about the optimal learning format to display the learning items. In TD children, the opportunity to compare exemplars from the same category improves learning and generalization performance (Augier & Thibaut, 2013; Gentner & Namy, 1999; Namy & Gentner, 2002). Is the benefit of a comparison setting format the same for both 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 and generalization task. Children had to learn and generalize novel names for objects and relational categories in a comparison learning format in which conceptual distance between learning items and between learning items and generalization items were manipulated systematically. 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, & 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. Similarities in the categorization skills of 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 typically effects when the participants were asked to name objects, making more naming errors when they labeled peripheral 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 practical implications for the design of 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 less-representative category members. Another practical issue, also related to the development of adequate conceptual representations, is the (sufficient) number of examples children with (and without) ID need to be exposed to for supporting good categorization and generalization performance. These are the questions we addressed in the following section.

1.2. The use of multiple good learning examples

Typicality effect in ID children has also been observed by Hupp and Mervis (1982) in a training task. The authors showed an effect 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 initial 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) but not when children with ID were presented with heterogeneous (typical, intermediate and peripheral) examples. Using an object labeling task in children with severe ID, Hupp (1986) tested whether exposure to five good examples would result in superior 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. This effect of the category size was observed in children with ID, as well as in their chronological- and mental-age matched peers, suggesting that exposure to a larger set of training exemplars led to a better computation of similarities (the prototypical features of the category) and differences (the idiosyncratic characteristics of examples) between training exemplar features.

A closer look on these studies revealed however that the category size effect in ID has been observed in very specific learning contexts. In Hayes and Conway (2000), children were explicitly asked to pay attention on identified dimensions (hands, body, arms, legs) which varied on binary values (two shapes or two motifs according to the dimension). In Hupp and Mervis (1982), the category size effect occurred for the acquisition of basic object categories, which is the easiest level of categories to identify perceptually. However, what would happen for the acquisition of abstract superordinate level categories for which the members do not share salient perceptual features, or when learners were not told on which features they should focus? Increasing the number of typical exemplars might not be sufficient, especially when potentially relevant dimensions have not been explicitly identified or are not salient.

It is interesting to note that multiple learning exemplars have been generally displayed according to a sequential presentation format in previous studies, while a simultaneous-comparison setting could have been more appropriate to compute the similarities and the differences between the learning exemplars. 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 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 (e.g., Waxman & Klibanoff, 2000), action verbs (e.g., Childers & Paik, 2009), and relational nouns (Gentner, Anggoro, & Klibanoff, 2011; Thibaut & Witt, 2015). When it comes to relational concepts, their difficulty is that relational nouns apply to very different objects (e.g., neighbor). This points out the question of the conceptual distance between categories members which is a key factor that has been manipulated experimentally.

Indeed, 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 object and relational nouns (Gentner et al., 2011; Thibaut, Stansbury, & Witt, 2018; Thibaut & Witt, 2015). 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, Jerman, Pont, Alberti, & Vianello, 2010), as well as in children with mild to borderline ID (Schuiringa, van Nieuwenhuijzen, Orobio de Castro, & Matthys, 2017). Thus, ID children might benefit less from comparisons situations than TD children.

The case of relational categories (compared to objects) makes the role of cognitive costs of comparisons even 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 needs to pay attention to more objects than for object categories. Therefore, the differences of performance between ID and TD children might be more important for relational than for object categories, especially when the categories are displayed in a comparison setting. Another reason to suspect more difficulties to learn and generalize relational than object categories is that relations are not defined by objects' intrinsic properties. Because conceptual dimensions are more difficult to grasp in these categories, ID children might learn and generalize relational concepts less efficiently than TD children.

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 stimuli which displayed a pair of entities that were defined by relation 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.

2. Material and methods

2.1. Participants.

Ninety-two children participated in the experiment. Forty-six were TD preschoolers (mean age = 5 years, 6 months; range : 4,9 - 6,2) and forty-six were children with mild or moderate ID (mean age = 11,6 ; range : 9,3 - 14,5). For most of the children enrolled in the ID group, ID resulted from severe socio-affective deprivation. None of the ID children was diagnosed for a genetic syndrome (e.g., Down syndrome, Fragile X syndrome or Williams-Beuren syndrome) and children with pervasive development disorders were not included in the

ID group. The ID children attended Medical Educational Institutes or Special Education and Home Care Services. Children with and without ID were matched on mental age with the Raven's Coloured Progressive Matrices (RCPM; Raven, 1965). ID and TD children were divided into two groups on the basis of their Raven score, High or Low score: ID, Mean Low-RCPM = 15 (N = 23) and Mean High-RPCM = 26 (N = 23); TD: Low RCPM = 17 (N = 23); High RCPM = 26 (N= 23). Note that both groups of participants (ID and TD) were evenly split in low and high functioning children so that these two factors could be analyzed as independent factors.

2.2. Materials

2.2.1. Object categories. We built twelve experimental sets (categories) of pictures, each composed of familiar objects. Six sets composed the *close* learning situations and the other six composed 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 Figure 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. Perceptual similarity and distance ratings were obtained from university students with *close* learning items judged to be significantly closer one to the other than the *far* learning items, *near* test items judged to be significantly closer from the learning items than the *distant* test items. Perceptual choices 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).

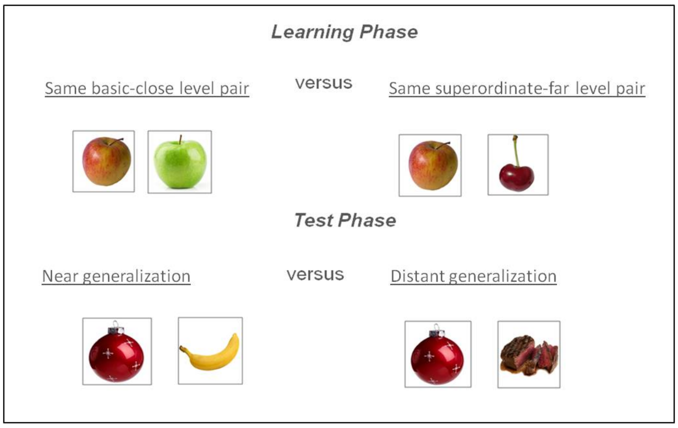

Figure 1. Illustration of the four experimental conditions: 2 learning (same basic-*close* versus same superordinate-*far*) x 2 test (*near* versus *distant*) conditions.

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., knife-watermelon and knife2–orange), while the *far* learning condition was composed of two less conceptually similar pairs of items (e.g., knife1-watermelon, cleaver-piece of meat). The test pictures consisted of 4 pictures for both the *near* and the *distant* conditions: (a) the "entity 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 Figure 2). The twelve sets were counterbalanced across learning and test conditions.

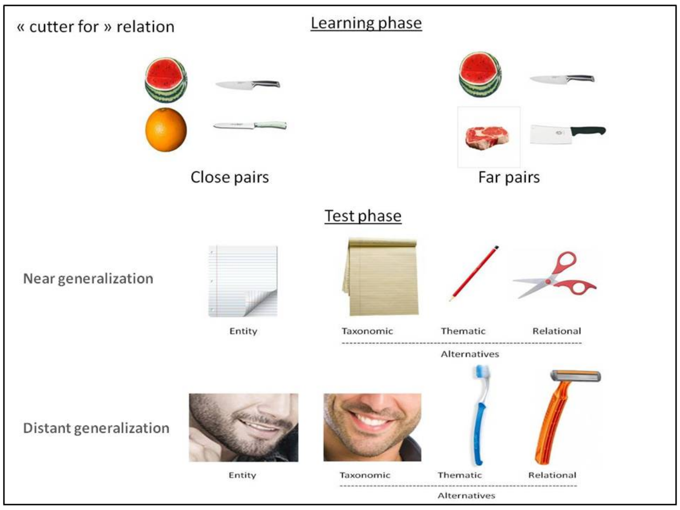

Figure 2. Sample set depicting a *cutter for* relation, in the *close* and *far* learning, and in the *near* and *distant* generalization conditions.

Independent ratings from 54 university students confirmed that the two *close* learning pairs constituting a close trial were significantly conceptually more similar one to the other than the two *far* learning pairs of a far trial, and that the entity and the relational choice (operator) in the *near* generalization condition were conceptually more similar to the corresponding learning pairs than in the *distant* generalization case (all $p_s < .01$, see Thibaut, Stansbury, & Witt, 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. 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 (high or low). Group (TD or ID) and Cognitive functioning (high or low) were crossed with Learning distance (*close* vs. *far* comparison) and Generalization distance (*near* vs. *distant*) as within-subject factors.

3. Calculation

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 one using the comparison paradigm for object and relational names in the context of ID. Also, it is the first to systematically manipulate the role of conceptual distance between learning items and between learning items and generalization items.

One first hypothesis is that ID children should have lower results than TD children because comparison situations involve monitoring costs (Augier & Thibaut, 2013; Thibaut & Witt, 2015) and require executive functions which have been described to be impaired in various 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.

Our second hypothesis was that cognitive costs might also be associated with the level of cognitive functioning defined in terms of an intelligence score. To test this assumption, we divided participants into high- and low-functioning participants on the basis of their Raven's progressive matrices scores (Raven, 1965). A related hypothesis is that the expected difference between high and low performers in far learning or distant generalization might be more important than the difference between ID and TD.

We also hypothesized that differences between TD and ID children, or between low and high cognitive functioning, 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).

However, knowledge development might also lead to the opposite hypotheses. Indeed, 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 Kay-Raining (1991) showed that adolescents with ID (Down-Syndrome) had a better lexical knowledge than MA-matched TD adolescents. Given that categories we manipulate are all 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.

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4. Results

We tested whether ID children were as able as their MA-matched TD counterparts to benefit from comparison situations. We hypothesized that ID children' performance would be lower than TD children' performance, especially in the far learning and distant generalization conditions in which items might be more difficult to unify. This should particularly be the case for relations (rather than for objects) because they require a higher number of comparisons and because they are not stable properties of objects. However, we also hypothesized that the level of performance might be more associated with the level of cognitive functioning (high or low) than with the group (TD or ID children). We thus add this factor in the analyses. 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 Figures 1 & 2). 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).

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

First, we predicted that ID should underperform TD children. Contrary to expectations, the ANOVA revealed that ID children (M = .71) were marginally better than TD children (M = .65), $F(1, 176) = 3.67$, $p = .06$, $\eta_p^2 = .02$. However and as expected, high functioning children (.71) were significantly better than low functioning children (.65), $F(1, 176) = 4.36$, $p < .05$, $\eta_p^2 = .02$. We also presumed that differences between groups should increase for relational concepts compared with objects. Surprisingly, children' performance was higher for relational (M = .76) than for object categories (M = .61), $F(1, 176) = 20.69$, $p < .0001$, $\eta_p^2 = .10$. The Group*Category interaction was also significant, $F(1, 176) = 5.8$, $p < .05$, and revealed that ID children (M = .70) outperformed TD children (M = .53) for object categories, $F(1, 176) = 14.46$, $p < .001$, while the two groups had similar performance for the relational categories (see Figure 3).

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, ($p_s < .001$).

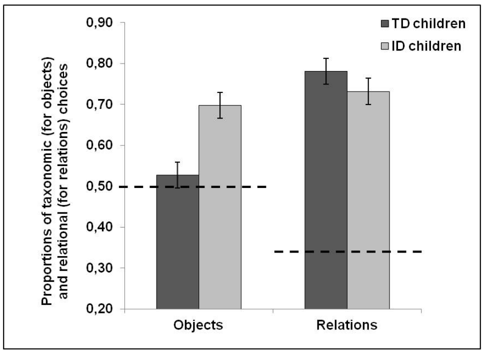

Figure 3. Mean proportions of taxonomic (for objects) and relational (for relations) choices as a function of Group (*TD* vs. *ID* children) and Category to learn and generalize (*Objects* vs. *Relations*). The error bars are standard error of the means. Dashed lines = chance levels (50% in the object case, and 33.33% for relational words).

4.2. Conceptual distance between learning items

Our main interest was to test the effect of conceptual distance and whether TD and ID children (or high and low functioning) would perform at the same level, particularly in the far learning condition.

The results revealed a Learning distance x Cognitive functioning x Category interaction (see Figure 4). This three-way interaction, $F(1, 176) = 5.23$, $p = .02$, η^2_p=.62, showed that high functioning children generalized objects' names better in far ($M = .67$) than in close learning condition ($M = .59$), $F(1, 176) = 5.57$, $p < .05$, but the low functioning children did not ($M_{\text{Close}} = .61$ $M_{\text{Far}} = .57$), $F(1, 176) = 1.39$, $p = .24$. In the far condition, high functioning ($M =.68$) outperformed low functioning children ($M = .57$), $F(1, 176) = 5.09$, $p < .05$, while the two groups did not differ ($M_{\text{High}} = .59$ $M_{\text{Low}} = .61$) in the close condition, $F < 1$. This result fits well with our predictions. 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, $F(1, 176) = 4.14$, $p < .05$, but not in the far learning condition (M_{Low} = .73 M_{Far} = .80), $F(1, 176) = 1.83$, $p = .18$.

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 ($p_s < .0001$).

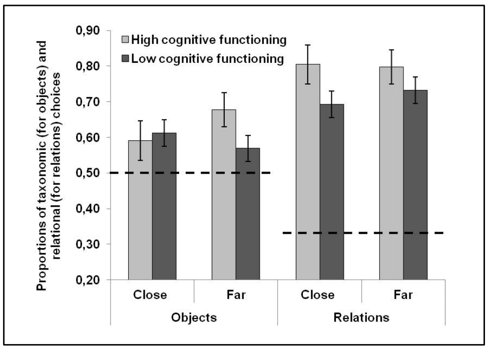

Figure 4. Mean proportions of taxonomic (for objects) and relational (for relations) choices as a function of Learning type (*close* vs. *far*), Cognitive functioning level (*low* vs. *high*) and the Category to learn and generalize (*Objects* vs. *Relations*). Error bars correspond to one standard error and the dashed lines represent chance levels (50% or 33.33%).

4.3. Conceptual distance between learning and generalization items

Finally, we predicted that generalizing novel names to distant targets should be more difficult for ID (or low functioning) than for TD (or high functioning) children. The results showed that performance was significantly higher for near (.72) than for distant (.64) targets, $F(1, 176) = 20.34$, $p < .0001$, $\eta^2_p = .10$. Test distance also interacted marginally with the Group and Category factors, $F(1, 176) = 2.80$, $p = .096$ (see Figure 5). For objects, TD and ID children generalized novel names better for near than for distant targets, (M_{NearTD} = .59 $M_{DistantTD}$ = .47) $F(1, 176) = 12.58$, $p < .001$ and (M_{NearID} = .74 $M_{DistantID}$ = .65) $F(1, 176) = 6.42$, $p < .05$, but contrary to expectations, ID children outperformed TD children in both generalization conditions, near, $F(1, 176) = 9.61$, $p < .01$, and distant, $F(1, 176) = 12.33$, $p < .001$. However the results for relational categories fitted our predictions. The near and distant test conditions did not differ significantly in the TD group (M_{NearTD} = .79 $M_{DistantTD}$ = .77), $F < 1$, whereas ID children generalized novel names significantly better in the near (M = .78) than in the distant test condition (M = .68), $F(1, 176) = 6.94$, $p < .01$. 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, $F(1, 176) = 2.85$, $p = .09$. 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 ($p_s < .00001$).

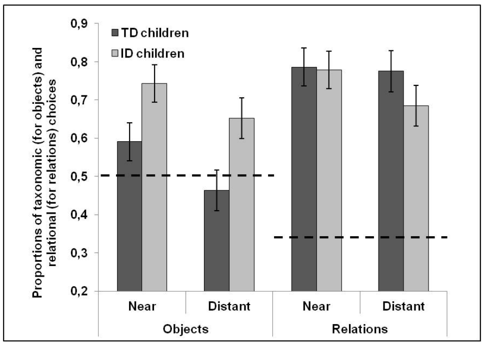

Figure 5. Mean proportions of taxonomic (for objects) and relational (for relations) choices as a function of Group (TD vs. ID children), Test distance (near vs. distant), and the Category to learn and generalize (Objects vs. Relations). The error bars correspond to one standard error and the dashed lines represent chance levels (50% or 33.33%).

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 categories. 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.

5. 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 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. The two groups (TD or ID) were thus divided into high and low cognitive functioning children according to their performance on the RCPM, in order to dissociate the groups (TD or ID) from the level of cognitive functioning (high or low). We predicted that far learning items (compared to close) and distant generalization (compared to near) should benefit to high functioning children but might impede low functioning children. Because, relational concepts are more conceptually 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). These experiments are 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, the importance of which we acknowledge as fundamental.

5.1. 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, Schwartz, and Kay-Raining (1991). 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).

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 related to ID, that is difficulties to conceptualize abstract relational knowledge (Fazio, Jonhston, & Brand, 1993) at a superordinate level of categorization categories (Tager-Flusberg, 1985).

5.2. 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.

5.3. 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. At test, children had to pick the correct item target among two choices for objects: a perceptive choice and a taxonomic (target) choice, while choice was made among three candidates for relations: a thematic, a taxonomic and a relational (target) choice. As a consequence perceptual distractors were used as test stimuli for objects but not 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), and especially shape similarities which 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, the paradigms that were used in previous studies to investigate object or relational categories separately need to be tuned to allow their joint investigation.

Considering now the relational categories alone, Hetzroni, Hessler, and Shalahevich (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, the relational categories themselves (e.g., mirroring) remained less familiar than those we used in the present experiment (e.g., being the cutter for). These conflicting results support our provisional conclusion that ID children's lexical learning and generalization skills probably relied on their more developed world knowledge about familiar categories, like ours, as already described by Chapman, Schwartz, and Kay-Raining (1991), while they underperformed TD children when they faced to 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, Hessler, and Shalahevich (2019) use perceptual choices as distractors in their matching-to-sample task. As evoked earlier, the use of perceptual alternative choices at test may have contributed to globally reduce performance in both groups and to increase inter-groups discrepancy, at the expense of TD children who are more likely to have difficulty to inhibit perceptual distractors as a consequence of impaired executive functions in ID children (Lanfranchi et al., 2010; Schuiringa et al., 2017). Unfortunately, our experiment did not allow to say which of these two hypotheses is more likely to account for the discrepancy

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between the present experiment and previous findings, either the use of familiar vs. unfamiliar categories or the use of different kinds of distractors as test stimuli.

6. 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. Further investigations should integrate a TD children group matched on a vocabulary measure that would tell us more about their level of world knowledge.

Acknowledgements

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Figures captions

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

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

Figure 3. 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).

Fig. 4. 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%).

Fig. 5. 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%).

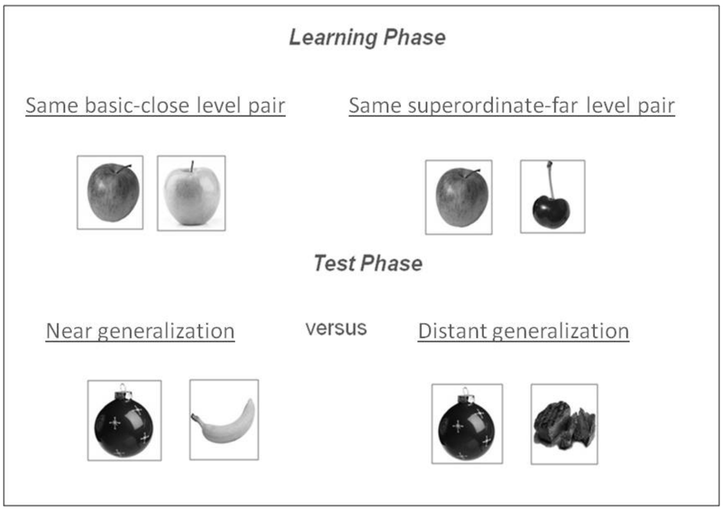
Learning Phase
Same basic-close level pair
Same superordinate-far level pair
Test Phase
Near generalization
versus
Distant generalization

Fig. 1

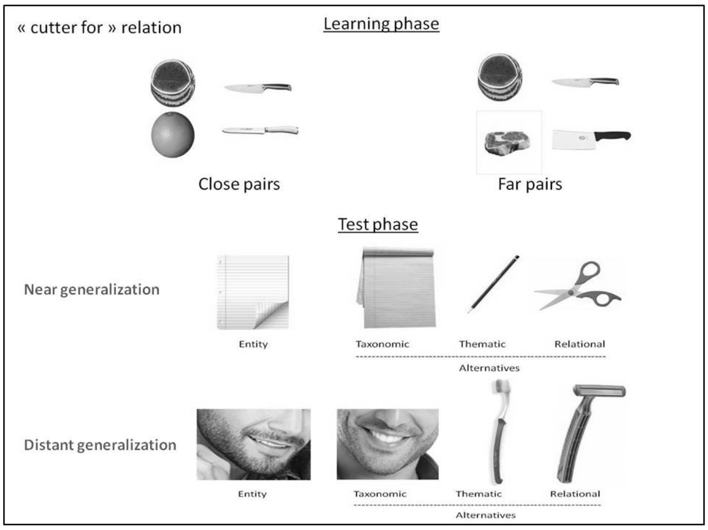
« cutter for » relation
Learning phase
Close pairs
Far pairs
Test phase
Near generalization
Entity
Taxonomic
Thematic
Relational
Alternatives
Distant generalization
Entity
Taxonomic
Thematic
Relational
Alternatives

Fig. 2

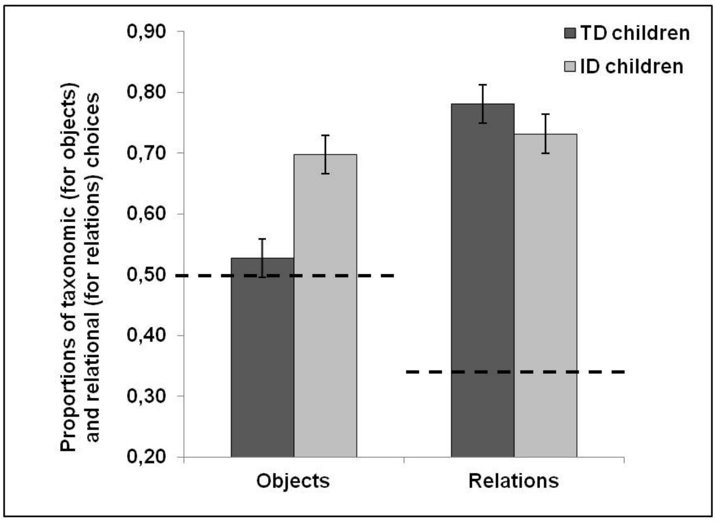
TD children
ID children
Proportions of taxonomic (for objects) and relational (for relations) choices
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
Objects
Relations

Fig. 3

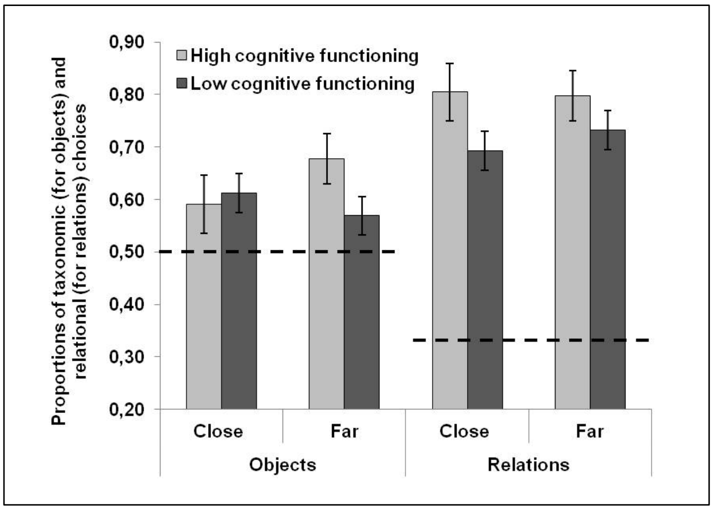
Proportions of taxonomic (for objects) and relational (for relations) choices
High cognitive functioning
Low cognitive functioning
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
Close
Far
Close
Far
Objects
Relations

Fig. 4

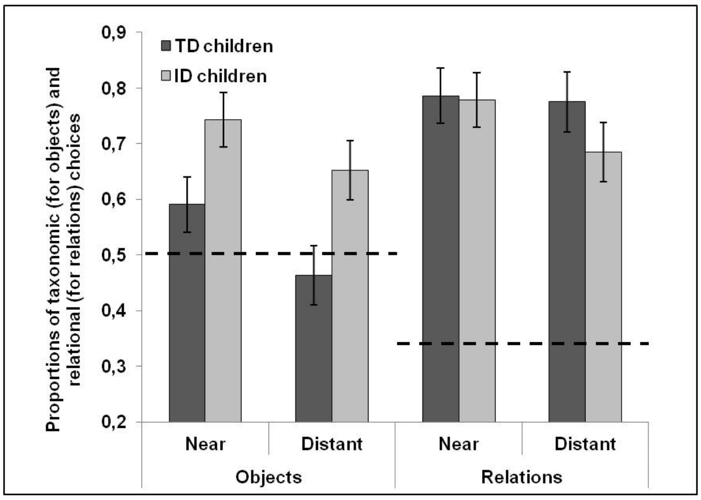
Proportions of taxonomic (for objects) and relational (for relations) choices
TD children
ID children
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
Near
Distant
Near
Distant
Objects
Relations

Fig. 5

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