Generalizing novel names in comparison settings: Role of conceptual distance during learning and at test

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Abstract

In a comparison setting (two stimuli), we tested 4- and 6-year-old children's generalization of novel names for objects. We manipulated the semantic distance between the two learning items (e.g., two bracelets versus a bracelet and a watch), and the semantic distance between the learning items and the test items (e.g., a pendant versus a bow tie). We tested whether smaller semantic distance between learning items would lead to more taxonomic (vs. perceptual) choices at test, than broader semantic distance during learning, especially in the case of distant test stimuli. Results revealed main effects of learning distance, of generalization distance and that only children aged 6 years benefited from broader semantic during learning at test. Four year-old children failed to generalize to far test stimuli even with semantically distant learning items. We discuss how conceptual distance during learning differentially affects generalization performance across age groups.

Keywords: Comparison, Distinctiveness, Conceptual development, Executive Functions.

Introduction

When learning novel concepts for objects, children have to capture which object dimensions are important to define the corresponding concept and neglect idiosyncratic aspects, particularly irrelevant perceptual dimensions (e.g., Murphy, 2002, for a discussion). Indeed, in many cases perceptual similarities (e.g., objects from different categories displaying the same texture and/or the same color) or differences are more salient than variations along the relevant features.

Do children spontaneously generalize novel names according to perceptual similarities such as shape similarities or do they use deeper core knowledge? On one hand, there is large evidence showing that children's early words refer to deep conceptual properties. This has been shown in triad selection tasks, in which young children are shown a standard object and are later asked to choose between a categorically related object and a thematic match. —"This [standard] is a dax. Can you find another dax?". Children usually select the categorically related object (Markman, 1989, see Imai, Gentner, & Uchida 1994, for evidence that children generalize on the basis of shape in this paradigm). On the other hand, there is evidence that, early in development, children often generalize object novel names to perceptually similar objects, especially "shape-similar objects" (Landau, Smith, & Jones, 1988; Smith, Jones, & Landau, 1992).

In many cases, perceptual similarities between the standard and the test object are conceptually irrelevant. It has been shown that ignoring these salient irrelevant perceptual similarities can be challenging for young children (e.g., Augier & Thibaut, 2013; Gentner & Namy, 1999). Hence, understanding what situations promote nonobvious over salient properties is a crucial issue for cognitive science and concept learning. There is now considerable evidence that comparison learning situations promote generalization based on deeper conceptual properties than classical learning situations in which children are provided with only one learning exemplar.

A large body of research in both children and adults shows that comparison can highlight nonobvious shared properties. For example, Gentner and Namy (1999) used pictures of objects from familiar taxonomic categories (e.g. fruits) to teach a novel name and tested 4-year-olds novel names extensions to other referents. In a one-standard condition (e.g. an apple introduced as a *blicket*) children preferred to extend the new label to a perceptually similar object (e.g. a balloon) rather than to a taxonomically-related-but-perceptually-dissimilar object (e.g. a banana). This preference was reversed when children had the opportunity to compare two standards (e.g. an apple and an orange, introduced as *blickets*).

The benefits of comparison have been demonstrated for object names (e.g., Gentner & Namy, 1999; Augier & Thibaut, 2013), adjectives (e.g., Waxman & Klibanoff, 2000), action verbs (e.g., Childers & Paik, 2009), names for parts (Gentner, Loewenstein, & Hung, 2007), relational nouns (Gentner, Anggoro, & Klibanoff, 2011; Thibaut & Witt, 2015) and perceptual categories (e.g., Hammer, Diesendruck, Weinshall, & Hochstein, 2009). Augier and Thibaut (2013) also obtained this positive effect of comparison with unfamiliar objects. Four- and 6-year-olds were randomly assigned to a no-comparison (one object) condition or to a comparison condition (two objects). In both conditions, the same two posttest objects were used. In the no-comparison condition, the standard – training - item had the same texture but not the same shape as one of two test objects. The standard also shared its shape but not its texture with the other test object. In the comparison condition, they pitted an unfamiliar test object displaying a perceptually non-salient dimension (texture) that was shared with both training items against another unfamiliar object that shared a perceptually salient dimension (shape) with one of the two training standards only. In the no-comparison condition, a majority of children extended the new label to the same-shape test object. By contrast, in the comparison condition, a majority of children extended the novel name to the same-texture match rather than to a stimulus that had the same shape as one of the two standards. Taken together, these results show that comparison situations are a powerful tool for conceptually-based rather than superficially based novel name learning in children.

However, a growing body of research shows that comparisons generate cognitive costs. Recent studies on semantic analogies (Richland, Morrison, & Holyoak, 2006; Thibaut, French, & Vezneva, 2010a) or perceptual analogies (Thibaut, French, & Vezneva, 2010b) (see also Richland & Burchinal, 2013) support this cognitive costs hypothesis. In these studies, irrelevant perceptual features or semantic distractors explained part of children's performance. The hypothesis was that these experimental conditions required inhibition and flexibility. Thus, finding out nonobvious relevant relations requires inhibiting superficial irrelevant dimensions and integrating more difficult dimensions.

In this context, Augier and Thibaut (2013) manipulated the number of items to-be-compared in 4-year-old and 6-year-old children. According to the authors, introducing more evidence in favor of the target dimension (texture) also means more comparisons and more information to integrate, generating more executive costs. They included age as a factor. They hypothesized that the younger group might not benefit from increasing the number of items in the same way. Results showed that both groups benefited from the two-standard condition. However, only the older group benefited from an increased number of standards (four standards versus two standards).

In the same executive control framework, Thibaut and Witt (2015) studied relational categories with 42-month-old children. Relational categories are defined by relations between objects rather than by the intrinsic properties of the objects involved in these relations (e.g., neighbor). In this experiment, they used relational categories such as "the knife is the *dax* for the apple" (Gentner, Anggoro, & Klibanoff, 2011). They manipulated the number of pairs of pictures of objects used in the training phase to illustrate a relational category (2, 3 or 4 pairs such as an apple and a knife for "the knife is the *dax* for the apple") and the distance between the domains depicting the relation. For example, a knife with an apple and another knife with an orange come from close domains whereas a knife with an apple and a log with a saw come from more remote conceptual domains. In the transfer phase, results revealed that three learning pairs were better than two or four and that learning pairs from remote domains were led to better generalization than learning pairs from close domains. These results suggest that increasing the quantity of relevant information might interfere with young children's ability to abstract relevant dimensions in this type of task. More generally, they suggest that there is an optimal number of information that can be integrated in such comparison situations. It is likely that this optimal number increases with age. The distance between domain effect suggests that a broader conceptual distance between learning exemplars helped participants abstracting the relevant relation between objects. A smaller distance between domains might have led participants to constrain the semantic domains around very similar entities (e.g., fruits) and similar operators (e.g., knifes).

Goals of the present experiment

We examined the effect of learning and transfer distance in a comparison of real objects task (e.g., two apples, or two fruits, see Gentner & Namy, 1999). Most former studies with real object categories contrasted no-comparison and comparison conditions. We will focus on comparison conditions and study in which condition(s) comparison leads to better conceptual generalization in a novel name learning task. A closer look at the stimuli in former studies reveals that the objects in the learning pairs come from semantic domains the semantic distance of which is not well controlled for. The same is true for the conceptually related transfer item. In other words, the distance between semantic domains in the learning items, and the distance between the learning items and the transfer items (i.e. the conceptually related target) has not been controlled as independent variables. However, it can be argued that the "width" of learning and generalization depends on the learning exemplars. There is a large body of literature showing to what extent generalization depends on the nature of the training items (Son, Landy, & Goldstone, 2008), on the one side, and factors affecting the generalization width on the other side (e.g., Klahr & Chen, 2011). Thus, knowing at which distance children generalize is a main issue in the study of the ontogeny of categories, subordinate, basic, and superordinate categories.

In the following experiment, we manipulated the semantic distances between both the learning items and the test items (in the generalization phase). Further, we compared two age groups (4- and 6- year-olds) in order to study cognitive resources might interact with these distances. Indeed, children of different ages might not benefit from comparison situations in the same way as a function of the distance between learning instances and the distance between learning and transfer instances. For example, it might well be that both age groups would generalize similarly in the close learning and close generalization case, whereas younger participants might encounter more difficulties to capture conceptual similarities in the case of more distant learning items and or to apply them to more distant domains.

Methods

Participants One hundred French speaking preschoolers were tested individually in a quiet room at their school. Two age groups were recruited. The younger group was composed of 48 children (mean age =4 years, 9 months; SD = 6.7 months; range: 50 - 65 months) and the older group was composed of 52 children (mean age = 6 years, 8 months, SD = 3.8 months, range: 74– 87 months) were randomly assigned to one of the two experimental conditions with 52 (close learning items) or 48 (far learning items) children per condition. Informed consent was obtained from their school and their parents.

Design Four and six-year-old children were compared. This factor was crossed with learning distance (Close vs. Far learning, between subject factor) and Generalization (Close vs. Far generalization, within subject factor).

Materials Seven sets of six objects were created for each distance condition (close or far) (See Table 1). Each picture was displayed on a 8cm by 8cm piece of cardboard. Each set corresponded to one category of objects (e.g., clothing accessories, food, tools, etc.). The learning pair was composed of one learning object and either a close training object (close learning condition), or a more distant training object (far learning condition) (see Figure 1). Thus, we

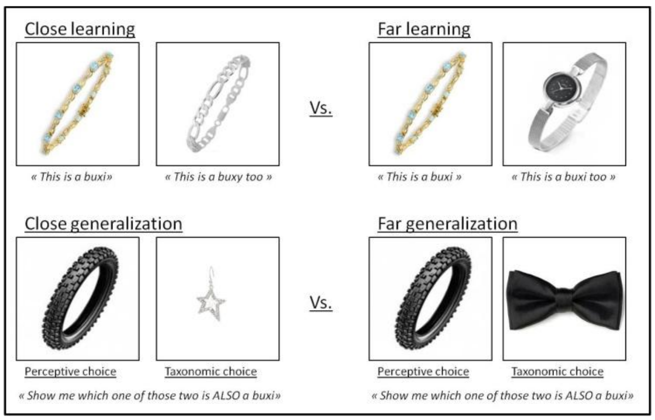

Figure 1: Example of a stimulus set and instructions adapted for the four experimental conditions crossing the learning distance (Close vs. Far learning) and Generalization (Close vs. Far generalization) factors.

manipulated the conceptual distance between the two training objects that were compared in each learning condition (Close or Far) in our comparison paradigm. For each object category (e.g., clothing accessories), the close learning objects were composed of perceptually and semantically close items (e.g., a bracelet - a curb chain), while the far pairs were composed of perceptually similar but conceptually more distant items (e.g., a bracelet – a watch) (see Table 1). The two test pictures consisted of two objects in both the close and the far generalization conditions: an item that was perceptually similar but semantically unrelated to the two training items (e.g., a tire in our bracelet case) and a taxonomic choice. As a function of the generalization condition, close or far, the taxonomic choice was semantically close or more distant to the learning items (e.g., a jewel pendant in the close generalization case, or a bow tie in the far generalization case). Figure 1 depicts the objects used to instantiate the close and far learning distance and the close and far generalization conditions for the "clothing accessories" object category.

Table 1: List of items for the close and far conditions

	Learning			Generalization		
	Initial item	close item	far item	percetive	close taxonomic	far taxonomic
SET 1						
"clothing accessories"	bracelet	curb chain	watch	tire	pendant	bow tie
"tools"	hamer1	hamer2	axe	ostrich head	pair of pincers	chainsaw
"clothing"	sock1	sock2	jeans	pipe	sweater	hat
"food"	apple1	apple2	cherry	bulb	banana	beefsteak
"animals"	ladybird1	ladybird2	beetle	ball	butterfly	duck
"music player"	guitar1	guitar2	cello	bottle	keybord	hi-fi
"game/toy"	ball1	ball2	cuddly toy	orange	Lego	video game
Set2						
"food"	pear1	pear2	strawberry	candle	pineapple	fry
"food2"	pumpkin1	pumpkin2	tomato	ball	cucumber	grilled chicken
"house tools/appliances"	broom1	broom2	feather duster	bush	vacuum	blender
"animals"	snake1	snake2	lizard	rope	alligator	bird
"vehicle"	bike1	bike2	scooter	glasses	rollerblade	boat
"office items"	pencil1	pencil2	ruler	candy cane	scissors	laptop
"clothing accesorries"	knit cap1	knit cap2	hardhat	turtle	crown	boots

Independent similarity ratings from 54 students confirmed that the close learning object condition were conceptually closer one to the other than the objects composing the far learning pairs, $t(26) = 3.98$, $p < .001$, and that close generalization stimuli were semantically more similar to the two learning stimuli than far generalization stimuli, $t(26) = 6.86$, $p < .001$. For the purpose of our experiment it is crucial that semantically related generalization items are perceptually less similar to the learning items than the perceptually similar lures. Perceptual similarity ratings revealed that the perceptual choices were perceptually more similar to the learning items than the semantically related choices (taxonomic choices) in both the close and the far conditions, $t(26) = 14.03$, $p < .001$ and $t(26) = 18.49$, $p < .001$. Importantly, we also performed perceptual similarity and conceptual similarity ratings between the close learning stimuli (e.g., two apples) and the far learning stimuli (e.g., an apple and a cherry) on the one side and the taxonomically related generalization item. They showed that overall the generalization stimuli were equally distant to both types of learning items. This was true for both types of generalization items: close generalization items, perceptual distance, $t(26) = .70$, $p = .46$, semantic distance, $t(26) = 1.21$, $p = .41$; far generalization: perceptual distance, $t(26) = .24$, $p = .65$, semantic distance, $t(26) = .43$, $p = .89$. This is central because we want to avoid that performance differences between close and far generalization items to be due to perceptual but also semantic similarity differences between learning items. We included semantic similarity differences in order to keep only taxonomic distance influence. For example, if we get a difference between close and far generalization items (e.g. between jewel pendent and bow tie) we do not want it to be due to other semantic information (e.g., the fact that the jewel pendent would be more thematically related to bracelet than the bow tie) than the taxonomic distance.

Each learning pair was randomly associated with one out of 14 two-syllable novel names (e.g., *youma*, *buxi*, *dajo*, *zatu*, *sepon*, *xanto*, *vira*, *etc.*) (see procedure).

Procedure

The experiment started with two practice trials. They were followed by fourteen experimental trials presented in a random order. Each standard learning stimulus was introduced with a novel count noun (Landau, Smith & Jones, 1988) (e.g. "this is a *buxi*" and "this is a *buxi* TOO" for the other standard). A puppet named Yoshi was used in order to make the task more attractive for children and to make the use of non-words to refer to known objects more meaningful with the following instructions: "In this game we are going to learn the language of Yoshi. Yoshi is living far away from here". The objects were presented sequentially and were left in view during the entire trial. The two learning stimuli were presented in a row and their location was determined randomly. The forced-choice test phase was identical in all conditions. The two test objects (i.e., the perceptual and the taxonomic matches) were introduced and the child was asked to point to the one which was also a member of the category (e.g., "Show me which one of these two is ALSO a *buxi*").

Results

We performed a 2 Age (4 vs. 6-year-olds) x 2 Training distance (Close vs. Far distance) x 2 Generalization (Close vs. Far) ANOVA on the percentage of taxonomic choices (see Figure 2). Age and Training distance were between-subject factors and Generalization a within-subject factor. There were significantly more taxonomic choices in the Far training condition (M = 64.4%; SD = 22.74) than in the Close training condition (M = 51.3%; SD = 28.73), $F(1, 96) = 6.06$, $p = .016$, $\eta^2_P = .06$. The main effect of Age was not significant, $F(1, 96) = 1.14$, $p = .29$, $\eta^2_P = .01$ (4-years: M = 54.9% ; 6-years: M = 60%) and Training distance did not interact with Age, $F < 1$. In addition, children performed better in the Close Generalization condition (M = 64.79%; SD = 29.69) than in the Far Generalization condition (M = 51.4%; SD = 28.42), $F(1, 96) = 29.79$, $p < .001$, $\eta^2_P = .24$, but the Generalization effect did not interact neither with Age, $F < 1$, nor with Training distance, $F < 1$, and the triple Generalization x Age x Training distance interaction effect did not reach significance, $F < 1$.

When comparisons with chance were run, student-t tests for independent groups with Bonferroni correction for multiple comparisons revealed that children performed above chance in the Close generalization condition, in the Far learning condition only, (respectively, 4 years: $t(23) = 3.49$, $p = .002$; 6 years: $t(25) = 6.82$, $p < .001$) but not when the learning items were conceptually close (respectively, 4 years: $t(23) = 1.09$, $p = .28$; 6 years: $t(23) = 1.04$, $p = .30$). Interestingly, in the Far Generalization condition, only the 6-year-old children performed significantly above chance, $t(25) = 3.29$, $p < .0125$, while the performance of the younger children did not differ from chance, $t(23) = .63$, $p = .53$.

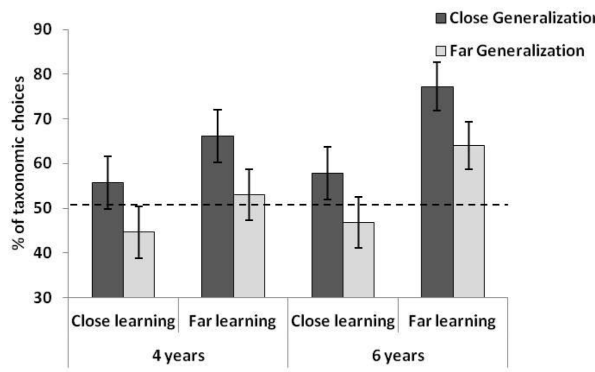

Figure 2: Percentage of Taxonomic choices as a function of the conceptual distance between during learning (close vs. far learning distance) and at test (close vs. far generalization). The error bars correspond to one standard error and the dashed line represents chance level (50%).

Taken together these findings show a clear impact of conceptual distance in our comparison framework, the Far learning condition giving more taxonomic choices than the Close learning condition. Our results also show that the Close generalization is easier than the Far generalization condition. Even though our results revealed no main effect of Age effect and interaction of this factor with learning distance, comparisons with chance confirm the beneficial role of conceptual distance between the learning items and suggested that in Far Generalization contexts only the older children may benefit of comparison between conceptually distant learning items.

Discussion

As mentioned in the introduction, there is a large body of studies showing that young children generalize novel names according to shape when only one standard stimulus is introduced in the learning phase. Our study capitalized on the idea that comparison situations during lexical learning favor deeper generalizations based on less obvious features that will, as a result, favor taxonomic generalization. However, Augier and Thibaut (2013) showed that comparison situations generated cognitive costs that might prevent younger children from using all the available information. This result suggested that the effect of comparison on generalization depends on the ease of processing dimensional similarities and differences. Our rationale was that the deep commonalities in close learning items can easily be accessed because of many conceptual commonalities. However, this situation might have provided little information regarding conceptual similarities subtending generalizations to broader categories. On the contrary, comparisons between distant learning items may be more difficult to unify conceptually because conceptual similarities would be more difficult to abstract. By contrast, comparisons might provide more abstract knowledge supporting broader generalizations. Because younger children might encounter more difficulties to capture conceptual similarities in the case of distant learning items and or to apply them to distant domains, we hypothesized that conceptual distance during learning and at test might differentially impact benefits of comparison across groups of age. World knowledge might also contribute to the difference between age groups, since older children have more knowledge regarding the objects than younger children.

Our results showed that both age groups benefited from broader inter-item conceptual distance during the learning phase since they perform better in the far learning case than in the close one. However, close generalization was better than the far generalization. Taken together, these two results suggest that broader learning range lead to better close generalization. The fact that only the older children performed above chance in the far generalization condition in the far learning case suggests a development from, first, a better performance in the case of broad learning distance to, second, a progressively better performance in the generalization width. This last result suggests that if all age groups were able to benefit from conceptual distance during the learning phase, the benefit is probably qualitatively different across age groups. We think that far learning allowed both groups to defocus from perceptual similarities and to access basic conceptual similarities ("is a jewel"), while far learning would help older children to abstract superordinate properties ("is a clothing accessory"), making the former able to perform correct taxonomic choices only in the close generalization condition ("the pendant is a jewel too"), while the latter were able to generalize in the close as well as in the far condition (" the pendant and the bow tie are clothing accessories too").

Importantly, this pattern of results backs up the classical result in developmental psychology that superordinate categories are more difficult to learn than basic level categories (Mervis & Rosch, 1981; Murphy, 2002) and decomposes the sources of this difficulty. Children might have more difficulties to generalize to broad categories rather than to abstract from broad conceptual distances during learning. Here, we used a perceptual lure. It should be interesting to study how participants abstract categories that are less grounded in perceptually similar instances of the same category.

To conclude, our study suggests that making appropriate use of comparison might entirely depends on tiny differences along the properties of what is compared and on executive capacity to process them. This finding has important implication about the role comparison plays in learning. Indeed, the executive constraints on comparison processing might explain under which conditions comparison can or cannot be fruitful.

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