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Categorical flexibility in children: Distinguishing response flexibility from conceptual flexibility
The protracted development of taxonomic representations

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Running title: Flexibility and taxonomic representations

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ABSTRACT

This research explored the development of children's use of multiple conceptual organizations (thematic, taxonomic) in sorting sets of pictures. Experiment 1 revealed that between 5 and 9 years, two forms of categorical flexibility can be distinguished: Response and conceptual flexibility. It appeared that children's multiple sorts do not necessarily reflect the use of different conceptual organizations. Such lag was mainly due to a difficulty of access to taxonomic representations, specifically in the younger age groups. Therefore, Experiment 2 investigated the development of taxonomic representations using an original approach requiring participants to decide whether new items could be included into an existing taxonomic sort. This approach showed that taxonomic representations were only gradually differentiated from thematic- and perceptual ones over the 5 to 10 years period. The discussion raises new hypotheses about the interaction between developing executive control (specifically, increasing resistance to interference of irrelevant information) and increasing conceptual knowledge in accounting for the development of conceptual flexibility.

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Categorization is considered as a fundamental component of cognition and as a highly powerful tool to organize the otherwise chaotic world with limited processing capacities; it is often restricted to taxonomic categorization. Yet, other forms (perceptual or thematic) of categorization do exist and adaptive categorization can imply switching between these different forms depending on one's current goal. A ball has to be considered as a round thing if the point is to pack everything before moving to a new house, but as a thing that "goes with" a tee shirt and sport shoes (thematic grouping) if the goal is to play a football game (Barsalou, 1983). Although, recent empirical research (see below) suggests that early on, children can sort objects on a thematic or taxonomic basis, little is known about the development of categorical flexibility per se ,i.e. the ability to switch between different categorical groupings of the same set of elements. Moreover, the extent to which switching between categorical responses (i.e. sorts) reflects the actual activation of diverse types of categorical representations is an entirely open question.

According to recent empirical studies, several ways of categorizing objects are available from the preschool period and even in infancy (Bauer & Mandler, 1989; Fenson, Vella & Kennedy, 1989; Walsh, Richardson & Faulkner, 1993; Dunham & Dunham, 1995; Houdé & Milhet, 1997; Waxman & Namy, 1997, Nguyen & Murphy, 2003) to adulthood (Lin & Murphy, 2001; Murphy, 2001; Ross & Murphy, 1999; Vallée-Tourangeau, Anthony & Austin, 1998). We will focus here on two forms of conceptual categorization: thematic and taxonomic. Thematic categories involve heterogeneous members belonging to a common event or scene, and thus organized in spatial and/or temporal relations of contiguity (Mandler, 1984; Nelson, 1983, 1986). In taxonomic categories, elements are linked together because they share common properties; they are the "same sort" of thing (Mandler, 1993).

Categorical flexibility

The tendency to organize objects thematically or taxonomically depends on various contextual variables such as labeling of the target in the match-to-sample task (Markman & Hutchinson, 1984), type of task (verbal vs. nonverbal; Nelson, 1988), instructions, or stimulus medium (Waxman & Namy, 1997). Although such data suggest that children do have several ways of categorizing objects, they do not address categorical flexibility per se because the availability of thematic and taxonomic organizations is inferred from the comparison of independent groups of participants. (Deak, 2003; Deak, Ray & Pick, 2004; Nguyen & Murphy, 2003, exp. 3). Categorical flexibility is a within-subject variable corresponding to the ability to switch successively between different representations of a given object (or set of objects). Thus, the same target object (e.g., an apple) must be cross-classified, being considered as a member of a taxonomic category (e.g., a fruit), a perceptual category (e.g., a round thing) and a thematic category (e.g., a thing that goes in a school bag with school books; Blaye & Bonthoux, 2001; Deak, 2003).

The little amount of research that exists on the development of categorical flexibility has mainly used variants of the match-to-sample task (e.g. Blaye & Bonthoux, 2001; Deak, 2000; Deak, Ray & Pick, 2004, Nguyen & Murphy, 2003). Participants first must choose among several pictures the best match to a target picture and then they must choose other possible matches, each having a specific relation to the target (either thematic, perceptual, taxonomic, or no relation). At about 4 years, children are able to associate different matches to the same picture when given contrasted instructions (same shape, same material, same part; Deak, 2000) or without any hints when each associate is paired with a non associate (Nguyen & Murphy, 2003). Two successive matches have also been produced to a certain extent by preschoolers when a taxonomic choice was contrasted with a thematic choice (Smiley & Brown, 1979; Blaye & Bonthoux, 2001) or with a perceptual one (Melot & Houdé, 1998).

From multiple matching to conceptual flexibility

An issue that has not yet been addressed concerns the extent to which multiple matchings correspond to “conceptual” flexibility involving children’s knowledge of the different types of relations underlying their responses. Although thematic and taxonomic organizations can easily be distinguished on the basis of children’s overt sorting responses, one might wonder whether they are conceived as truly different in children's mind. In fact, children can produce a taxonomic match on the basis of spatial and/or temporal contiguities (e.g., grouping of a tiger and a fish may be done on the basis of the taxonomic category "animal", but it may also be done by children on the basis that "a tiger can eat a fish"; Blaye & Bonthoux, 2001). Moreover, Nelson (1986) has established that an intermediate level of categorization between script-based categories and superordinate taxonomic ones, - namely "slot-filler" categories - corresponds to groupings of the same sort of objects (thus, looking like taxonomic categories) but still contextualized in a given schema (e.g., animals of the zoo, Lucariello & Nelson, 1985). Hence, what appears to be a taxonomic grouping may well be a grouping organized by reference to event-based representations. In the matching task, when verbal justifications are required, most children younger than 4 years of age are unable to justify two matchings of the same target (Greenfield & Scott, 1986; Lucariello , Kyratzis, & Nelson, 1992; Smiley & Brown, 1979; Tversky, 1985).

We consider that it might be worth distinguishing two forms of categorical flexibility: multiple categorical responses corresponding to response flexibility (estimated through children’s sorts) and conceptual flexibility corresponding to a switch between two differentiated representations of the organizations (thematic or taxonomic) underlying the same set of pictures. This last form is expected to develop later than the first one.

Match-to-sample task vs. free sorting

The use of the match-to-sample task to study the development of multiple categorizations might not be the most appropriate for at least two reasons. Matching performance might be a poor indicator of true taxonomic categorization because, as already suggested, pairs of elements of a same kind could be sorted on the basis of other representations. Moreover, in requiring that children reason about pairs of pictures instead of larger samples, the match-to-sample task might underestimate taxonomical performance (Blaye, Bernard-Peyron, & Bonthoux, 2000). For example, studies on category-based inductions (Gutheil & Gelman, 1997) have shown that children make use of information concerning sample size (larger samples are a stronger basis of inference than smaller samples) and sample diversity (more diverse samples are better than more homogeneous samples) in their inferences. Restricting the number of elements to two as in the match-to-sample task might prompt a process of research for thematic links - most of which involve functional relations between precisely two elements (e.g., dog (eats) bone; thread (goes through) needle) unlike taxonomic relations. Recent research has clearly established the critical role of comparison in abstracting common properties between elements (Gentner & Namy, 1999; Namy & Gentner, 2002). Blaye et al., (2000) have provided data supporting this hypothesis, suggesting that free sorting of? numerous pictures is a better context for revealing taxonomic abilities in younger children than the match-to-sample task.

Hence, categorical flexibility was investigated in the present research using a free sorting task. A large set of pictures (18), which could be sorted taxonomically, thematically, or using slot-filler categories, was used. The participants were first required to sort this set in successive different ways. Then, underlying representations were assessed using children's labels for the different subsets resulting after each free sort in Experiment 1. Data revealed that taxonomic representations were less differentiated in young children. Thus, Experiment 2 was conducted to further examine the development of these representations and their progressive differentiation from perceptual and thematic representations. After having produced a taxonomic sort, participants were presented with additional pictures, half of which were perceptually similar to members of the sort already achieved, and half were actual members of the two schemas organizing the set of pictures already sorted. Participants had to decide whether these new items could be inserted into the taxonomic sortings they had just produced. Half of these pictures were “true intruders” and should therefore not be accepted while the other half were “potential members”.

EXPERIMENT 1

The first objective of Experiment 1 was to sketch the developmental path of categorical flexibility across childhood using a free sorting task in which children were asked to re-categorize items. A group of adults was also included in the study to determine how they do on this task. The second objective was to determine whether response flexibility, assessed through the number of different sorts performed on a same set of elements, followed the same developmental time course as conceptual flexibility, purported to underlie children’s overt responses. It was hypothesized that conceptual flexibility develops later than response flexibility because superordinate taxonomic representations appear to be partly organized through contextual similarities during early childhood (e.g. Lucariello & Nelson, 1985; Sell, 1992) and hence remain largely thematic. Labels provided by participants to qualify their sorts were taken as indicators of the representations underlying their responses. Our expectation was that discrepancies between the two forms of flexibility might be highest during the preschool years and then gradually disappear with the development of more decontextualized taxonomic representations later in childhood.

Method

Participants

One hundred and twenty children of average socio-economic level participated in the experiment. They were assigned to four groups of age: thirty 4-year-old children (mean age = 4;6, range = 4;4 - 5;1), thirty 5-year-old children (mean age = 5;8, range = 5;5 – 6;2), thirty 6-year-old children (mean age = 6;11, range = 6;7 – 7;1) and thirty 9-year-old children (mean age = 9;8, range = 9;5 – 10;2). A sample of 15 adults (first year psychology students) also took part in this experiment.

Material

The material was composed of two sets (M1 and M2) of 18 colored drawings (each one on a square cardboard of 5.5 cm by 5.5 cm). Each set was constructed so that it could be sorted on the basis of three different organizations: (a) thematic: in each set, objects could be distributed into two situational schemas (e.g., farm and beach in M1, circus and forest in M2; see Appendix A for a list of the specific items), (b) taxonomic: three superordinate categories could be contrasted in each set (e.g., animals, vehicles, and people for M1; animals, tools, and people for M2), and (c) slot-filler: each schema involved three slots corresponding to the three taxonomic categories (e.g., animals of the farm). The participants were given A4 sheets of paper that could be used as support for sorting.

Familiarity with the schemas presented was tested by asking a separate group of twenty 5-year-olds (mean age = 5;3, range = 4;11 – 5;8) to name the different thematic groupings of pictures. The schemas "beach", "farm", "circus" and "forest" were retained because they were recognized by at least 75% of the children. The taxonomic categories involved (people, vehicles, animals, and tools) are those traditionally used in this age range.

Procedure

Participants received only one set of items (M1 or M2). They first had to name the drawings which were successively presented to them. When they failed to do so, they were told the name used by the majority of their peers. The experimenter then placed the drawings on the table one at a time and asked participants to sort them: "*You see these drawings* (the experimenter showed the 18 drawings*), they are all mixed up. I want you to put together the drawings that go well together. In order to do this, you can take the number of sheets you want. On each sheet, you will put together the drawings that go well together. There are several ways of putting together the drawings that go well together."*

Participants were then asked to label each subset of pictures*: "How do you name this group?*"

The experimenter repeated the question for each subset. If children did not answer or only labelled one or more drawings, the question was asked differently: *"Why did you put all these drawings together?"*

Participants were then given 18 new copies of the same set of pictures and were asked: *"Can you find a new way to sort these drawings, another way of putting together the drawings which go well together?"* If a new way was found, a third request for a different way to sort was made. A label for each produced groups was also asked for these two new sorts.

Two measures were used: (a) the number of correct[1] sorts produced on the same set of pictures and (b) the number of correct sorts correctly labelled, (i.e., labels produced were congruent with the observable organization; (e.g., taxonomic labels for taxonomic sorts). Response flexibility corresponds to the production of more than one correct sort on a given set of items (maximum being 3). Conceptual flexibility requires moreover at least two of the correct sorts being correctly labelled.

Coding of labels

Participants had to name the different subsets that constituted their sort (3 groups for the taxonomic sort for instance). A first criterion used to consider a sort as correctly labelled was that the same kind of relation (thematic, taxonomic, or slot-filler) was used to describe the different constitutive groups; this criterion was respected by all the participants. Labels were coded into three categories: thematic, taxonomic, and slot-filler.

A sample of 20% of participants' labels of their sorts was coded independently by two coders who had agreed beforehand on the following criteria. Inter-coder agreement reached 92%. Disagreements were solved through discussion. Labels accepted for the thematic sort were the names of the schemas. Several utterances were accepted (sea or beach, farm or countryside, for M1; circus or spectacle, forest or wood, for M2). For the slot-filler sorts, the accepted labels were the names of the subcategories. Here too, several utterances were accepted (e.g., animals of the sea or fishes, vehicles that go on the sea or boats, sailors, farmers). Some ambiguous cases appeared like "animals of the ground" for "animals of the farm"; they were accepted if the other categories of the sort were correctly and unambiguously labeled. For the taxonomic categories, two kinds of labels were accepted: a generic term (animals, people, vehicles or means of transport) or labels referring to potentially defining properties (example: "things which advance" for the vehicles).

Results

The development of flexibility was studied from an age (4 years) at which children are generally able to accept different matches in a match-to-sample task (see Introduction). However, 43% of the 4-year-old children did not manage to carry out a sort with an identifiable underlying organization and all the others (except two) produced only one grouping. Consequently, this age group was not further considered in the analyses. Moreover, in none of the analyses did the type of material (M1 vs M2) significantly affect performance or interact with other factors. Hence, performances on the two sets were not distinguished.

Results of the first sort revealed that, at all ages, the three expected kinds of organizations (thematic, superordinate taxonomic, and slot-filler) were produced (see Table 1); incomplete or mixed sorts never exceeded 30% of the productions of an age group. This confirms the coexistence of several organizations, at least at a group level, from 5 years onwards. No significant changes associated with age were found in the order (1^{st}, 2^{nd} or 3^{rd} sort) and distribution of the different sorts.

INSERT TABLE 1 ABOUT HERE

Measures of categorical flexibility

Two different analyses were done focusing respectively on sorting responses and labeling of the correct sorts achieved. In order to discuss the development of both forms of flexibility, the analyses focused on the number of participants producing more than one sort on a given set of items.

INSERT TABLE 2 ABOUT HERE

Let us consider first response flexibility (see Table2a). Adults showed response flexibility: All but one sorted the material according to the three expected organizations and the last one produced two sorts. Among children, as expected, the number of participants using two or three categorical organizations increased with age. This evolution fell short from significance with 37%, 53% and 67% in 5-, 6-, and 9-year-olds respectively (χ^2_2=5.43 p=.066). Pairwise comparisons revealed that 9 year-olds significantly outperformed 5 year-olds (χ^2_1 =5.41; p = .02).

Turning now to the percentage of participants who produced at least two correctly labelled sorts and hence revealed what we called conceptual flexibility (Table 2b):, data showed that it was optimal in adults, all but one correctly labeling three sorts. Among children, a significant increase was observed between 5 and 9 years (χ^2_2 = 19.38; p < .001). At age 5, only two children (7%) correctly labelled more than one sort. This was the case of 37% of 6-year-olds, and 60% of 9-year-olds. Whereas such results reveal a clear-cut development of conceptual flexibility during childhood, further analysis is required to address the question of a potential lag between response flexibility and conceptual flexibility. Our hypothesis was that conceptual flexibility should develop later during childhood. As expected, no lag at all was observed in adults who correctly labelled all their sorts. Our measures were such that correct labels were considered only for correct sorts; hence conceptual flexibility assessed through labels necessarily implies response flexibility. Response flexibility however can be observed (more than one correct sorts) alone, that is with no conceptual flexibility (i.e. no more than one correctly labelled sort). Among children, there was a significant effect of age group on the distribution of children in these three categories: no flexibility (no more than one sort produced), response flexibility only (more than one correct sort but no more than one correctly labelled sort) and conceptual flexibility (more than one correctly labelled sort): χ^2_4 = 19.91; p < .001, (see Figure 1).

INSERT FIGURE 1 ABOUT HERE

This evolution however is partly due to the increase in response flexibility. Therefore, we now focus on the subset of children who showed response flexibility and assessed the potential increase with age of the proportion of those exhibiting conceptual flexibility. As shown in Figure 1, this proportion increase significantly from 18% among 5 year-olds to 69% among 6 year-olds and 90% in 9-year-olds thus revealing the expected reduction of the lag between the two forms of flexibility across childhood ($\chi^2_2 = 16.38$; $p < .001$). Pairwise comparisons revealed a significant increase between the two younger groups ($\chi^2_2 = 6.68$; $p < .01$) and between 5- and 9-year-olds ($\chi^2_2 = 15.99$; $p < .001$).

Differences between sorting responses and underlying representations assessed through labeling varied as a function of the type of sort. While thematic organizations were correctly labeled at all ages (> 90%), as expected, the percentage of taxonomic sorts correctly labeled increased with age (48%, 67%, and 92% in 5-, 6-, and 9-year-olds, respectively; $\chi^2_2 = 10.65$; $p = .01$). Moreover, among 5 year-olds, 57% of incorrect labels for taxonomic sorts referred to schemas, thus revealing an underlying thematic representation[2] (this percentage dropped to 40% in 6-year-olds).

Discussion

The procedure used in this experiment required participants to produce several successive sorts of the same set of pictures, using different kinds of categorical organizations, and then to label each subset of their sorts. Results support the distinction between two forms of flexibility: **response flexibility** measured through the number of different sorts produced on a given set of pictures and **conceptual flexibility** which involves the activation of alternative representations based on different categorical organizations (these representations were assessed using participants' labels for their sorts). Although both forms improve throughout childhood to reach ceiling levels in adults, they developed at different rates. As expected, the developmental lag between the two forms was highest among 5- and 6-year-olds (4-year-olds were at floor on both tasks) and tended to disappear in 9-year-olds.

Further analysis of labels revealed that the lag observed in 5- and 6-year-olds between the two forms of flexibility might largely be due to a deficit in representation of superordinate taxonomic categories specifically, whereas thematic groupings were correctly labelled from 5 years onwards. This is congruent with Sell's results (1992) showing that young children asked to explain different matches tended to offer event-based explanations for taxonomic pairs (see also Lucariello, Nelson & Kyratsis, 1992, exp. 3).

Hence, Experiment 2 was conducted to further investigate the development of taxonomic representations across childhood. After having produced a taxonomic sort, participants were presented with additional pictures. They had to decide whether these new items could be inserted into the taxonomic categories of the sort they had just produced. Half of these pictures were "true intruders" (TI) and should therefore not be accepted while the other half were "potential members" (PM). The goal of this manipulation was to highlight the progressive differentiation of taxonomic representations from representations based on perceptual similarity and/or thematic relatedness. Conflicts between categorical organizations generally regarded as preferred by young children (i.e., thematic and perceptual) and the taxonomic organization were thus created. It is worth noting that this new procedure allowed us to assess whether children might rely on implicit taxonomic representations, in an age range in which taxonomic representations are not always explicit enough to be verbally told.

EXPERIMENT 2

Experiment 2 assessed children's representations of taxonomic categories by giving participants new candidates (new drawings) to add to a set of stimuli previously sorted into taxonomic categories. Half of these new drawings were potential members (PM) that could correctly be integrated into the existing sort and thus, should be accepted, whereas the other half were true intruders (TI) and should be refused. Moreover, perceptual similarity and schematic membership were conjointly manipulated for both types of candidates. Half of the candidates of each type had low perceptual resemblance with all the members of the already-built categories, whereas the other half were highly similar to at least some member of the target categories (see Appendix 2 and the “stimuli selection” section). Finally, for the low and high perceptually similar items, half were selected to be members of one of the two schemas constitutive of the material (cf. Exp.1) while the other half were nonmembers. Manipulation of these two relations (perceptual similarity and schematic membership) allowed a specific examination of children's developing understanding of the intension of taxonomic categories. The rationale for this manipulation was based on the hypothesis that these two relations might interfere with true taxonomic decisions in younger children. This is a particularly critical issue because stimuli used in many empirical studies do not control for their influence. Many examples suggest a potential confounding of perceptual and/or thematic and taxonomic relatedness: *carrot* and *tomato* are often considered superordinate taxonomic associates; they can however be considered as being perceptually related because both are red or/and thematically related because they are both bought in a given store.

Membership to a common schema and perceptual similarity were expected to influence younger participants' decisions through increasing the proportion of acceptances of both intruders and true exemplars into the taxonomic categories. On the one hand, the early work of Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976) and research on infant categorization have clearly established the perceptual basis of early taxonomic categorization (e.g., Baldwin 1992; Fenson, Cameron, & Kennedy, 1988; Mareschal, French, & Quinn, 2000; Quinn & Eimas, 1996). Melkman, Tversky, and Baratz (1981) have demonstrated the relative importance of shape similarity over superordinate taxonomic membership in a match-to-sample task in 4 and 5-year-olds, but not in 9-year-olds. On the other hand, Nelson's theory suggests that taxonomic representations very gradually emerge from event-based and highly contextualized categories (Nelson, 1983, 1986; see also Mandler, 2000, 2003). Lucariello et al. (1992) showed for instance that 4-year-old children who were instructed to produce all the instances of a superordinate taxonomic category that they could think of, tended to produce one developed slot-filler category within each superordinate one, that is, they produced clusters of items that could be substituted in the same slot as a given schema. This tendency decreased in 7-year-olds. Such data suggest that common schematic membership can be used in certain conditions as a support in activating or using taxonomically-organized knowledge. It does not, however, address the extent to which children and adults can ignore a thematic organization when it interferes with accurate taxonomic decisions.

In the present experimental setting, perceptual similarity and schematic membership could either help a true taxonomic decision (when their presence reinforced a decision of taxonomic acceptance or when their absence facilitated rejection of true intruders), or conflict with these decisions when their consideration suggested a response that was different from a true taxonomic decision. In other words, correct rejection of true intruders was expected to be optimized when no other default criteria of relatedness could be relied upon, that is in the case of low perceptual similarity and no schematic membership of the intruders. For potential members, candidates with low perceptual similarity and no schematic membership were expected to be the least helpful because correct acceptance could only be done on the basis of taxonomic membership. In contrast, potential members with high perceptual similarity and schematic membership of candidates were expected to be the most favorable in enhancing acceptance into the correct taxonomic category because participants could rely interchangeably on three criteria to support this correct response. However, this configuration was supposed to be the most detrimental to correct rejection of true intruders because participants had to resist responding according to these two interfering pseudo “good reasons” to insert the new candidate into the category. No specific predictions were made concerning intermediate conditions involving only one of the two extra-taxonomic criteria, except that they should both induce more acceptances than the strict taxonomic condition.

Finally, an interaction between condition and age was expected: Taxonomic representations, based on a less fragile definition of category intensions in older children and adults should weaken the influence of both perceptual similarity and common schema membership compared to younger participants leading to fewer incorrect acceptances of true intruders or incorrect rejections of potential members.

Method

Participants

Only participants having produced or accepted a taxonomic sort in a pre-experimental session (see procedure) were selected for this new study. Hence 80 children from four age groups were finally involved: Twenty 5-year-old (mean age = 4;11, range = 4;7 - 5;4), twenty 6-year-old (mean age = 5;10, range = 5;6 - 6;3), twenty 7-year-old (mean age = 6;11, range = 6;6 - 7;4) and twenty 10-year-old children (mean age = 9;11, range = 9;6 - 10;5). A sample of 20 adults (first-year psychology students) also took part in this experiment.

Material

The material was composed of the two sets of drawings (M1 and M2) used in Experiment 1. Each set could be sorted into two schemas or into three taxonomic categories. For each set, 24 new drawings were added: 12 true intruders (TIs) and 12 potential members (PMs). Among the 12 members of each group, half had been judged highly perceptually similar to members of the target categories and half presented low perceptual similarity (see the next section). In each of these subsets, three candidates actually belonged to one of the two schemas organizing the initial set and three did not (see Appendix 2)

Stimuli selection

The degree of perceptual similarity between the additional drawings and members of the taxonomic categories was established using judgments from 10 adults. For each of the three taxonomic categories in each set, participants were presented successively with 24 new drawings in a random order (12 potential members and 12 intruders). They were instructed (and familiarized with two examples) to rate perceptual similarity between the new drawing and members of each of the three taxonomic categories. A 7-point scale was used from 1 (weak perceptual similarity) to 7 (strong perceptual similarity). The highest score obtained for each drawing was used as its degree of perceptual similarity with existing members of the categories. Systematic comparisons between scores for intended perceptually similar drawings and their non similar counterparts all revealed statistically significant (t tests, $ps<.001$).

Another group of 10 adult judges were presented successively with schematic sorts for each material set (M1 and M2). For each candidate drawing, adults were asked whether or not it was a member of one of the two schemas (i.e., beach or farm for M1 and circus/forest for M2). No statistical analyses were conducted because there was almost no variance between participants' responses, thus confirming our pre-selection.

Procedure

In a pre-experimental session, participants received one set of drawings (either M1 or M2). They had to sort the pictures only once (see Exp. 1 for instructions). Then, if they had not produced a taxonomic sort, they were presented one introduced as having been produced by one of their peers. They were asked to examine each subset carefully in order to decide whether drawings in each set really went well together. Only participants having constructed or accepted[3] the taxonomic sort were introduced to the new drawings. They had to decide whether each new drawing could be accepted as a member of one of the three taxonomic categories. The drawings were presented in a different random order for each participant. The instructions were: "*Now, I just want to know your opinion about other drawings. I will show you drawings one at a time and for each of them, you will tell me if it can go on one of these sheets. Look at each of the three groups we've made and tell me if the drawing goes well in one of them. OK? What do you see on this drawing? (If the child did not know,* *he/she was given the correct name). What do you think about this drawing? Does it go on one of these sheets?*

Results

Whereas the number of correct decisions both for true intruders and potential members appear to be the most straightforward dependent variable, it is irrelevant here since it would conceal the effects of perceptual similarity and schematic membership. Note that each of these two variables is expected to increase correct responses (i.e., acceptances) on potential members and simultaneously decrease correct responses (i.e., refusals) on true intruders. Hence, participants' responses were analyzed in terms of the number of acceptances of the new drawings into the target taxonomic category. Acceptance was a correct response in the case of potential members (henceforth PMs) and an error in the case of true intruders (TIs).

Whatever the age, the type of material (M1 vs. M2) had no significant effect on performance and was thus not further considered in the analyses. In addition, in accordance with our predictions, adults' representations of the target taxonomic categories correctly excluded all true intruders and accepted all potential members. Hence, adults' performance was maximal for both types of candidates and revealed no influence of perceptual similarity or schematic membership; consequently they were not included in the following analyses.

The data were subjected to a four-way analysis of variance with age (5-, 6-, 7-, vs. 10-year-olds) as a between subject factor and type of candidate (TIs vs. PMs), schematic membership (schematic member vs. not) and perceptual similarity (high vs. low) as within subject factors. Given that participants were presented with 24 candidate drawings, the scores for each subtype (type of candidate $_2$ * schematic membership $_2$ * perceptual similarity $_2$) varied between 0 and 3.

A correct representation of taxonomic categories should produce acceptances of PMs and refusals of TIs. Hence, using acceptance as a dependent variable, a significant effect of the type of candidate was expected, PMs being accepted more often than TIs. In addition, this variable should interact with age. As predicted, children accepted a mean of 2.50 potential members and 1.29 of true intruders, $F(1, 76) = 73.63$; $Mse = 3.16$; $p < .0001$, suggesting that the task was at least globally adequate for assessing taxonomic representations. There was also a main effect of age ($F(3,76) = 2.75$; $Mse = 1.06$; $p < .05$) and a significant interaction between age and type of candidate ($F(3.76) = 14.40$; $Mse = 3.16$; $p < .0001$) as illustrated in Figure 2.

INSERT FIGURE 2 ABOUT HERE

Figure 2 clearly shows the lack of differentiation between true intruders and potential members in the younger group who accepted almost equally often both types of candidates. Planned comparisons support this analysis revealing no significant effect of type of candidates at 5 years ($p > .75$) , a strong tendency at 6 years ($F(1, 76) = 3.83$; $Mse = 3.16$; $p < .054$), and a significant effect among 7- and 10-year-olds (respectively, $F(1, 76) = 41.56$; $Mse = 3.16$; $p< .0001$ and $F(1,76) = 71.35$; $Mse = 3.16$; $p < .0001$). In fact, 10-year-olds' performance was near ceiling for both TIs and PMs suggesting taxonomic representations similar to those of adults.

Overall, both perceptual similarity and schematic membership had significant effects on the proportion of acceptances (respectively, $F(1,76) = 113.12$; $Mse = .68$; $p < .0001$ and $F(1,76) = 61.03$; $Mse = .46$; $p < .0001$). Candidates (be they PMs or TIs) that belonged to one of the schemas were accepted more often than those that did not ($M = 2.10$ and $M = 1.69$, respectively). At the same time, perceptually similar candidates to members of the target categories were also accepted more often than candidates with low similarity ($M = 2.24$ and $M = 1.55$). Perceptual similarity and schematic membership also interacted with one another ($F(1, 76) = 19.13$; $Mse = .55$; $p < .0001$), each being more influential on decisions when the other one was low or absent (cf. Figure 3). In addition, only perceptual similarity interacted with type of candidate ($F(1, 76) = 5.43$; $Mse = .51$ $p < .025$) revealing a stronger influence of similarity on decisions about TIs ($M=1.71$ vs. $M=.88$ between high and low perceptual similarity candidates) than about PMs (M=2.78 vs. M=2.22).

INSERT FIGURE 3 ABOUT HERE

As age interacted significantly with perceptual similarity and schematic membership (respectively, $F(1, 76) = 4.16$; $Mse = .068$; $p < .008$ and $F(1, 76) = 8.88$; $Mse = .46$ $p<.0001$), independent ANOVAS for each age group were conducted to provide a clearer picture of the influence of these two variables across development. Appendix 3 provides graphical representations of the four groups' mean acceptance level for each type of candidates. As expected, both perceptual similarity and schematic membership influenced acceptance in a highly significant way for the two younger groups' decisions (all p's < .0001), increasing the level of acceptance of both potential members and true intruders (no significant interaction with the type of candidate). Seven- and 10-year-olds were influenced significantly only by perceptual similarity (both p's <.03).

Individual patterns

The influence of nontaxonomic cues on taxonomic decisions was confirmed through the analysis of individual patterns of performance. A criterion of success based on 2 out of 3 correct responses for both TIs and PMs was adopted. More precisely, we contrasted responses between the two extreme conditions, those providing either no alternative criteria supporting insertions of new candidates (low perceptual similarity and no schematic membership) and those providing both alternative criteria (high perceptual similarity and schematic membership). Figure 4 reveals that performance in one or the other condition supports two rather different developmental stories for taxonomic performance. That is, when nontaxonomic criteria converged with the correct taxonomic responses, they suggest that taxonomic representations are already well elaborated from 5 years onwards with a majority of children succeeding in our decision task. No significant development occurs between 5 and 10. However, when these criteria conflicted with participants' decisions to include new items into taxonomic categories and children had to ignore them to reject true taxonomic intruders or when perceptual or schematic relations could not be used as a basis for making decisions about potential members, taxonomic performance was at floor at 5 years and progressed very gradually until age 10 when adult patterns of categorization were beginning to emerge ($\chi^2_3 = 27.45$; $p < .0001$).

Discussion

The results of this experiment were consistent with the preceding study in that young children's taxonomic representations are different from those of adults'. Whereas adults' decisions were not influenced by the two nontaxonomic cues, young children's representations were more fragile and appeared to be highly susceptible to schematic and perceptual similarities. Correct acceptances of members and correct refusals of intruders in the taxonomic categories were both significantly affected: Perceptual similarity and schematic membership increased significantly the proportion of acceptances and, conversely, their absence produced the rejection of almost half of the potential members for the youngest children. The interference of schematic membership appears however less long-lasting than the perceptual one, affecting only 5- and 6-year-olds' performances while the influence of perceptual similarity was still present in 7- and 10-year-olds' decisions.

Such results challenge the overoptimistic view that suggests that taxonomic representations are fully developed by the end of the preschool years. The reliance on match-to-sample tasks may be responsible for this optimistic picture of taxonomic understanding in children. We suggest that too many studies examining the development of children's taxonomic categories have not systematically controlled for the presence of other possible nontaxonomic sources of taxonomic decision making that children might use to make their judgments. The examination of the individual patterns of responses in the two most extreme conditions clearly highlights how critical these nontaxonomic criteria might be in young children's decision making.

In fact, the results of the current experiment suggest a possible way for reconciling findings from recent empirical findings revealing early taxonomic responses (e.g. Bauer & Mandler, 1989; Baldwin, 1992; Fenson, Vella, & Kennedy, 1989) with more traditional theoretical accounts of the development of categorization (Piaget & Inhelder, 1959; Nelson, 1988) that have both (in their own way) emphasized the late development of taxonomic categories. That is, young children might be able to associate pictures in ways that look like they are using taxonomic representations to do so, but their overt behavior may not be supported by underlying stable taxonomic representations.

GENERAL DISCUSSION

The first goal of this research was to examine the developmental course of categorical flexibility in children and more specifically to ask to what extent does response flexibility and conceptual flexibility overlap. A second goal was to explore the underlying representations that children use to form taxonomic groupings at different ages. The results of both studies revealed that the development of stable superordinate taxonomic representations follows a protracted development even when taxonomic groupings can be observed very early in childhood.

Specifically, flexibility was assessed in Experiment 1 by asking participants to sort a given set of pictures several times using different types of conceptual organizations. Data revealed significant increases in both conceptual and response flexibility across childhood. More importantly, a discrepancy was observed between the ability to organize the set of pictures in different ways (what we called response flexibility) and the successive activation of different conceptual representations (conceptual flexibility between thematic, taxonomic, or slot-filler representations) in young children. The results clearly show that conceptual flexibility lags behind response flexibility. However, they also reveal that this discrepancy decreases across childhood and disappears by adulthood.

The recent literature has emphasized the development of cognitive flexibility but in such setting conditions that it missed this important differentiation between these two forms of flexibility. The recent interest in cognitive flexibility has been primarily focused on debates around the interpretation of children's performance in an experimental task designed by Frye and Zelazo (Frye, Zelazo, & Palfai, 1995), the Dimensional Change Card Sorting Task (DCCS). This task requires children to switch between two perceptual rules for categorizing items (namely, shape and color). Examination of this literature lets one suppose that (a) preschool years are a critical period going from perseveration to flexibility and (b) despite numerous debates, failures in executive control considered either as a default of inhibition or attentional inertia are often described as critical (but see Jacques, Zelazo, Kirkham, & Semcesen, 1999). Our data cast serious doubts on these two points.

Using an inductive categorization task in which children have to generate multiple categorization criteria, we clearly demonstrated that the path to categorical flexibility does not end with the end of preschool years. This result in itself suggests that executive control probably does not tell the entire story behind the development of cognitive flexibility. Investigations studying the respective contributions of executive development and conceptual understanding in explaining flexibility between semantic representations support this hypothesis (Blaye, Paour, Perret, 2002; Blaye, Jacques, Bonthoux, & Cannard, 2003). It is tempting to assimilate children's lack of flexibility to a perseverative bias interpreted as attentional inertia (Kirkham, Cruess, & Diamond, 2003) or insufficient inhibition (Bjorklund & Harnishfegger, 1990). However, our data revealed that younger children's inability to produce several organizations of the material did correspond to a reproduction of their first sort (i.e. perseveration) on less than one third of times, both at 5 and 6 years. Perseveration is hence not necessarily the only manifestation of lack of flexibility (Deak, 2003). The focus on perseveration as the only alternative to response flexibility has led Jacques et al. (1999) to draw a distinction between a difficulty in response control and a lack of representational flexibility to account for such perseverative responses. In using an error-detection design that eliminated the need for response control, these authors showed that representational flexibility is critical: young children failed to use the post-switch rules in the DCCS task because of a failure in selecting the correct pair of rules although they knew both pairs of rules. Data of our first study suggest that in a free sorting task, older children are able to produce flexible responses but are rarely able to switch between contrasted conceptual organizations. One can wonder whether this lag could be interpreted as a difficulty to select a new organization (as in Jacques et al.'s study) or as a default of knowledge of taxonomic organizations. Results of Experiment 2 support, although indirectly, the latter hypothesis in showing that the development of conceptual flexibility seems to follow the same path as the conceptual development of superordinate taxonomic categories.

In the second experiment, we examined children's underlying taxonomic representations by giving them a decision test on the membership of new elements to taxonomic categories in order to track the progressive differentiation of taxonomic representations from thematic and perceptual ones. The nonverbal method had the advantage assessing their implicit awareness of taxonomic category membership, a technique that should surely be able to identify their highest level of understanding. However, the data revealed that early taxonomic representations are dependent on (and open to interference from) perceptual similarity and schematic common membership. Clearly, taxonomic representations cannot be described in an all or none fashion. We agree with Lautrey (1998) who stressed the lack of interest for the exact structure of taxonomic representations in most studies. This results in an imprecise definition of children's understanding of taxonomic categorization that might account for disagreements in the literature concerning the age at which children master this form of conceptual organization. A view of the development of taxonomic representations in terms of levels of conceptualization seems the most adequate. Whereas 5- and 6-year-olds' representations seem highly sensitive to both perceptual and schematic similarity, older children's ones seem only influenced by perceptual similarity. This reliance on perceptual similarity is of course highly adaptive because perceptual similarity often underlies deeper structural similarities between members of a common taxonomic category.

However, one could argue that the decreasing influence of nontaxonomic cues on children's taxonomic representations may correspond more to improvements in executive control, namely resistance to interference, rather than to conceptual development itself. Recent developmental literature has emphasized the important development of resistance to interference or inhibition of irrelevant information during the school years period (e.g. Bjorklund & Harnishfegger, 1990; Dempster & Brainerd, 1995; Houdé, 2000). Further investigation will be needed to contrast these interpretations. In a recent experiment, however, we used two isomorphic versions of a same task to compare flexibility between “same shape” and “same colour” relations and flexibility between thematic and taxonomic relations (Blaye & Paour, 2004). Results revealed that flexibility was achieved by more than 80% of children at 6 years for shape and colour and only at 10 years for thematic and taxonomic relations, even though knowledge of the associations between pictures was controlled. As the two versions of the task were isomorphic, these data suggest, at the very least, that the ability to resist to the interference of an irrelevant sorting criterion depends on the level of representation of the criteria at hand (see for instance, Karmiloff-Smith (1992) for a similar proposal of a link between levels of explicitness of representations and cognitive flexibility).

Altogether, the two studies suggest new paths for research in young children’s categorical flexibility. They point to the necessity for examining the development of cognitive flexibility beyond the 3- to 5-year-old period, which has been the period of most investigation in the recent literature. By examining categorical flexibility in the context of switching between complex semantic organizations of a variety of objects, we have had the opportunity to distinguish at least two forms of flexibility: response flexibility, which might be based on representations not yet differentiated and conceptual flexibility based on a representational switching between conceptual organizations. A prerequisite for conceptual flexibility, however, is that all possible forms of conceptual organizations (thematic, taxonomic, slot-filler) be more equally salient in the children’s mind (Scheuner, Bonthoux, Cannard & Blaye, 2004). Our results suggest that differentiated superordinate taxonomic representations may not be fully present early in development. They correspond to representations which are too weak when they are put in competition with the stronger perceptual and thematic representations (Munakata, 2001; Munakata & Yeris, 2001) and hence, prevent conceptual flexibility being achieved.

References

Baldwin, D. A. (1992). Clarifying the role of shape in children's taxonomic assumption. *Journal of Experimental Child Psychology*, *54*, 392-416.

Barsalou, L. W. (1983). Ad hoc categories. *Memory and Cognition*, *11*, 211-227.

Bauer, P.J., & Mandler, J.M. (1989). Taxonomies and triads: Conceptual organization in one-to two-year-olds. *Cognitive Psychology, 21*, 156-184.

Bjorklund, D. F., & Harnishfegger, K. K. (1990). The resources construct in cognitive development: Diverse sources of evidence and a theory of inefficient inhibition. *Developmental Review*, *10,* 48-71.

Blaye, A., Bernard-Peyron, V., & Bonthoux, F. (2000). Au delà des conduites de catégorisation: Le développement des représentations catégorielles entre 5 et 9 ans. *Archives de Psychologie*, *68*, 59-82.

Blaye, A., & Bonthoux, F. (2001). Thematic and taxonomic relations in preschoolers: The development of flexibility in categorization choices. *British Journal of Developmental Psychology, 19*, 395-412.

Blaye, A., Jacques, S., Bonthoux, F., & Cannard, C. (2003, Août). Switching between thematic and taxonomic relations in preschoolers: Is there more than cognitive flexibility*?* Paper presented at the *XIth European Conference on Developmental Psychology*, Milan, Italy.

Blaye, A., & Paour, J.L. (2004). The development of categorical flexibility in childhood. An interaction between conceptual development and the development of executive control. Paper presented at the *18th Biennal conference of the International Society of Behavioral Development*, Ghent, Belgium.

Blaye, A., Paour, J.L., & Perret, P. (2002). Categorical flexibility and levels of representation in children: A developmental perspective. Paper presented at the *British Psychological Society Developmental section Conference*, Brighton, UK.

Deak, G.O. (2000). The growth of flexible problem solving: Preschool children use changing verbal cues to infer multiple word meanings. *Journal of Cognition and Development*, *1,* 157-191.

Deak, G. O. (2003). The development of cognitive flexibility and language abilities. In R. Vasta and R. Kail (Eds.), *Advances in child development and behavior* (Vol. 31, pp. 271-327). San Diego: Academic Press.

Deak, G. O., Ray, S. D., & Pick, A. D. (2004). Effects of age, reminders, and task difficulty on young children's rule-switching flexibility. *Cognitive Development*, *19,* 385-400.

Dempster, F. N., & Brainerd, C. J. (1995). *Interference and inhibition in cognition*. San Diego: Academic Press.

Dunham, P., & Dunham, F. (1995). Developmental antecedents of taxonomic and thematic strategies at 3 years of age. *Developmental Psychology, 3,* 483-493.

Fenson, L., Cameron, L.S., & Kennedy, M. (1988). Role of perceptual and conceptual similarity in category matching at age two years. *Child Development, 59,* 897-907.

Fenson, L., Vella, D., & Kennedy, M. (1989). Children's knowledge of thematic and taxonomic relations at two years of age. *Child Development*, *60*, 911-919.

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive Development*, *10*, 483-527.

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

Greenfield, D.B., & Scott, M.S. (1986). Young children's preference for complementary pairs: Evidence against a shift to a taxonomic preference. *Developmental Psychology, 22*, 19-21.

Gutheil, G., & Gelman, S. A. (1997). Children's use of sample size and diversity information within basic-level categories. *Journal of Experimental Child Psychology*, *64*, 159-174.

Houdé, O., & Milhet, S. (1997). Polymorphisme de la catégorisation chez le bébé de douze à dix-huit mois: contiguïté et substituabilité. *Archives de Psychologie, 65,* 273-278.

Houdé, O. (2000). Inhibition and cognitive development. *Cognitive Development*, *15*, 63-73.

Jacques, S., Zelazo, P. D., Kirkham, N. Z., & Semcesen, T. K. (1999). Rule selection versus rule execution in preschoolers: An error detection approach. *Developmental Psychology, 35*, 770-780.

Karmiloff-Smith, A. (1992). *Beyond Modularity: a developmental perspective on cognitive science.* Cambridge, MA: MIT Press.

Kirkham, N. Z., Cruess, L., & Diamond, A. (2003). Helping children apply their knowledge to their behavior on a dimension-switching task. *Developmental Science, 6*, 449-476.

Lautrey, J. (1998). La catégorisation après Piaget. In C. Meljac & R. Voyazopoulos (Eds.). *Piaget après Piaget.* Grenoble: La pensée sauvage.

Lucariello, J., Kyratzis, A., & Nelson, K. (1992). Taxonomic knowledge: What kind and when? *Child Development, 63*, 978-998.

Lucariello, J., & Nelson, K. (1985). Slot-filler catégories as memory organizers for young children. *Developmental Psychology, 21*, 272-282.

Lin, E. L, & Murphy, G. L. (2001). Thematic relations in adults' concepts. *Journal of Experimental Psychology: General*, *130,* 3-28.

Mandler, J. M. (1984). *Stories, scripts and scenes.* Hillsdale, NJ: Erlbaum.

Mandler, J. M. (1993). On concepts. *Cognitive Development, 8,* 141-148.

Mandler, J. M. (2000). Perceptual and conceptual processes in infancy. *Journal of Cognition and Development*, *1,* 3-36.

Mandler, J. M. (2003). Conceptual categorization. In D. H. Rakison & L. M. Oakes (Eds.), *Early category and concept development. Making sense of the blooming buzzing confusion.* (pp.103-131). Oxford: University Press.

Mareschal, D., French, R. M., & Quinn, P. C. (2000). A connectionist account of asymmetric category learning in early infancy. *Developmental Psychology, 36,* 635-645.

Markman, E.M., & Hutchinson, J.E. (1984). Children's sensitivity to constraints on word meaning: Taxonomic vs. thematic relations. *Cognitive Psychology, 16,* 1-27.

Melkman, R., Tversky, B., & Baratz, D. (1981). Developmental trends in the use of perceptual and conceptual attributes in grouping, clustering, and retrieval. *Journal of Experimental Child Psychology, 31*, 470-486.

Melot, A.M., & Houdé, O. (1998). Categorization and theories of mind: The case of the appearance/reality distinction. *Current Psychology of Cognition, 17,* 71-93.

Munakata, Y. (2001). Graded representations in behavioral dissociations. *Trends in Cognitive Sciences*, *5*, 309-315.

Munakata, Y., & Yeris, E. (2001). All together now: When dissociations between knowledge and action disappear. *Psychological Science*, *12,* 335-337.

Murphy, G.L. (2001). Causes of taxonomic sorting by adults: A test of the thematic-to-taxonomic shift. *Psychonomic Bulletin & Review, 8,* 814-839.

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.

Nelson, K. (1983). The derivation of concepts and categories from event representations. In E. K. Scholnick (Ed.), *New trends in conceptual representations: Challenges to Piaget's theory ?* (pp.129-149). Hillsdale, N.J.: Erlbaum.

Nelson, K. (1986). *Event knowledge: structure and function in development.* Hillsdale, NJ: Erlbaum.

Nelson, K. (1988). Where do taxonomic categories come from? *Human Development, 31,* 3-10.

NGuyen, S. P., & Murphy, G. L. (2003). An apple is more than just a fruit: cross classification in children's concepts. *Child Development*, *74*, 1783-1806.

Piaget, J., & Inhelder, B. (1959). *La genèse des structures logiques élémentaires.* Neuchâtel: Delachaux et Niestlé.

Quinn, P. C., & Eimas, P. D. (1996). Perceptual cues that permit categorical differentiation of animal species by infants. *Journal of Experimental Child Psychology, 63,* 189-211.

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

Ross, B.H., & Murphy, G.L. (1999). Food for thought: Cross-classification and category organization in a complex real-world domain. *Cognitive Psychology, 38,* 495-553.

Scheuner, N., Bonthoux, F., Cannard, C., & Blaye, A. (2004). The role of associative strengths and conceptual relations in 4- and 6-year olds children. *International Journal of Psychology, 39,* 4, 290-304

Sell, M. A. (1992). The development of children's knowledge structures: Events, slots, and taxonomies. *Journal of Child Language*, *19*, 659-676.

Smiley, S.A., & Brown, A.L. (1979). Conceptual preference for thematic or taxonomic relations: A nonmonotonic age trend from preschool to old age. *Journal of Experimental Child Psychology, 28,* 249-257.

Tversky, B. (1985). Development of taxonomic organization of named and pictured categories. *Developmental Psychology, 21,* 1111-1119.

Vallée-Tourangeau, F., Anthony, S.H., & Austin, N.G. (1998). Strategies for generating multiple instances of common and ad hoc categories. *Memory, 6,* 555-592.

Walsh, M., Richardson, K., & Faulkner, D. (1993). Perceptual, thematic and taxonomic relations in children's mental representations: Responses to triads. *European Journal of Psychology of Education, 8,* 85-102.

Waxman, S.R., & Namy, L.R. (1997). Challenging the notion of a thematic preference in young children. *Developmental Psychology, 33,* 555-567.

TABLE 1

Distribution across the different kinds of sort for each age-group (1st sort)

Age	Thematic	Slot-filler	Taxonomic	Other[1]
5 y.o. (n=30)	11	3	10	6
6 y.o. (n=30)	8	7	9	6
9 y.o. (n=30)	13	4	4	9
Adults (n=15)	7	2	5	1

1. This category refers to sorts that involve the composition of two categorical organizations or where no organization was identified.

TABLE 2

Distribution of responses as a function of age

2a. Number of correct sorts

	0	**1**	**2**	**3**
5 y.o.	1	18	6	5
6 y.o.	0	14	13	3
9 y.o.	1	9	11	9
Adults	0	0	1	14

2b. Number of correctly labelled sorts

	0	**1**	**2**	**3**
5 y.o.	1	27	2	0
6 y.o.	0	19	9	2
9 y.o.	1	11	10	8
Adults	0	0	1	14

Figures captions.

Figure 1. Percentages of participants showing either no flexibility, only response flexibility or conceptual flexibility, as a function of age.

Figure 2. Mean percentages of accepted new candidate (potential members and true intruders, respectively) as a function of age.

Figure 3. Mean number of acceptances of candidates as a function of perceptual similarity and schematic membership.

Figure 4. Proportion of children producing at least two (out of 3) correct insertions of potential members and two (out of 3) correct rejections of true intruders in the two extreme conditions.
Note**: The "lenient criterion"** refers to the conditions in which participants can make the right decision for "wrong" reasons: for PMs, it corresponds to the presence of the two nontaxonomic criteria for insertion (i.e., high perceptual similarity and schematic membership). By contrast, it corresponds to low perceptual similarity and no schematic membership for TIs. The **"stringent criterion"** refers to the conditions in which children's correct decisions had to be based exclusively on a taxonomic criterion: for PMs, it involves low perceptual similarity and no schematic membership; for TIs, it involves high perceptual similarity and schematic membership.

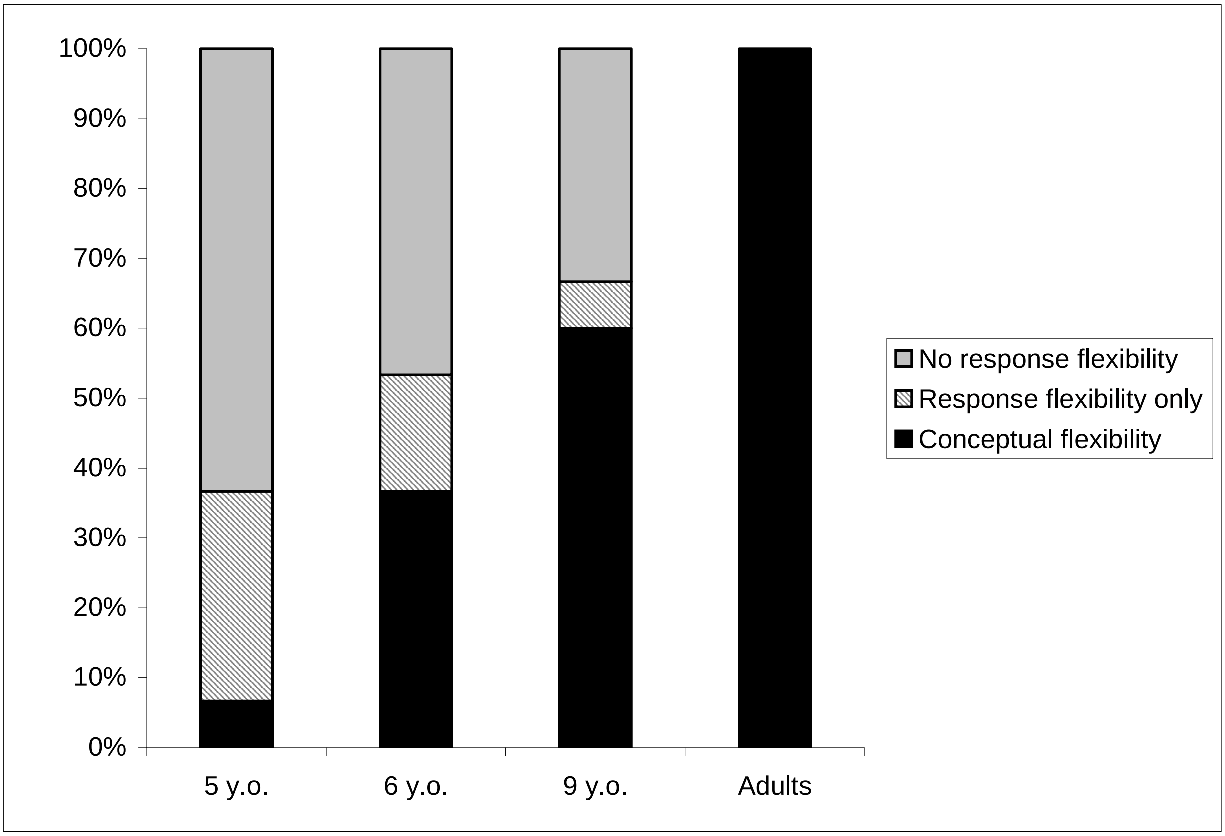

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5 y.o.
6 y.o.
9 y.o.
Adults
No response flexibility
Response flexibility only
Conceptual flexibility

Figure 1.

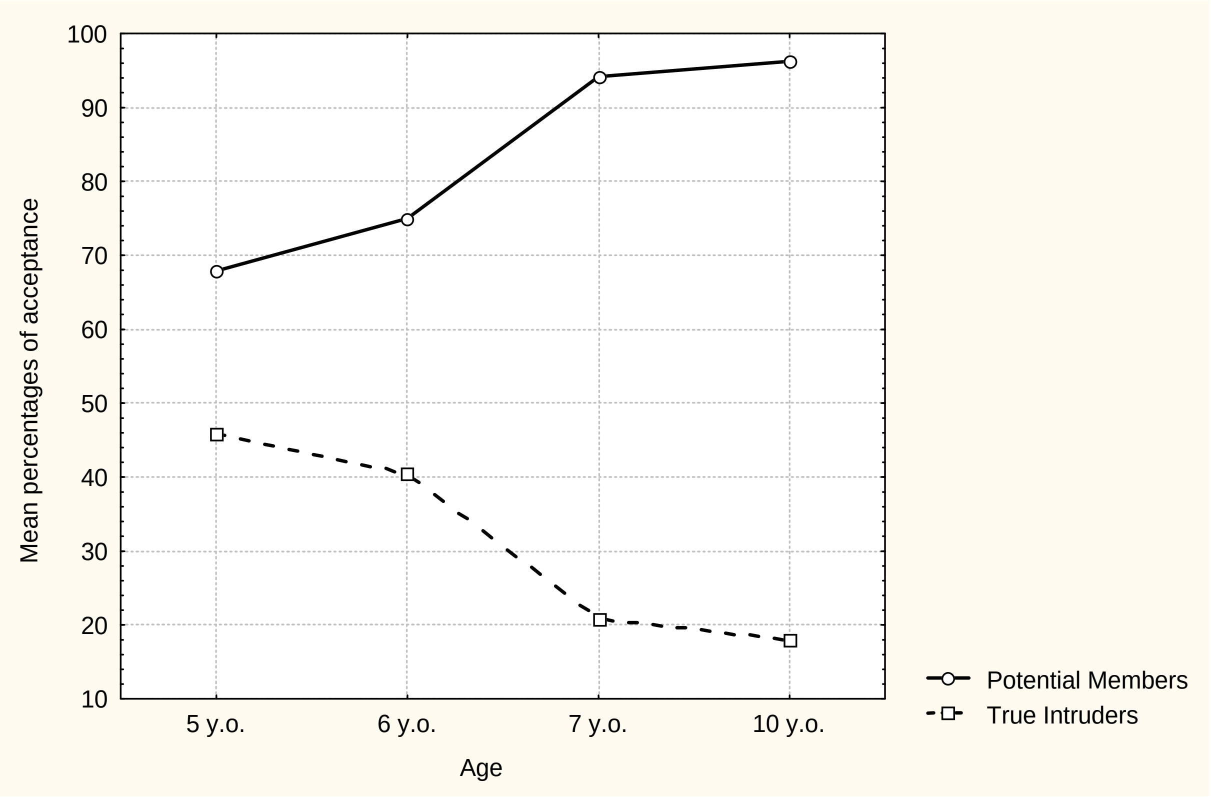

100
90
80
70
60
50
40
30
20
10
Mean percentages of acceptance
5 y.o.
6 y.o.
7 y.o.
10 y.o.
Age
Potential Members
True Intruders

Figure 2.

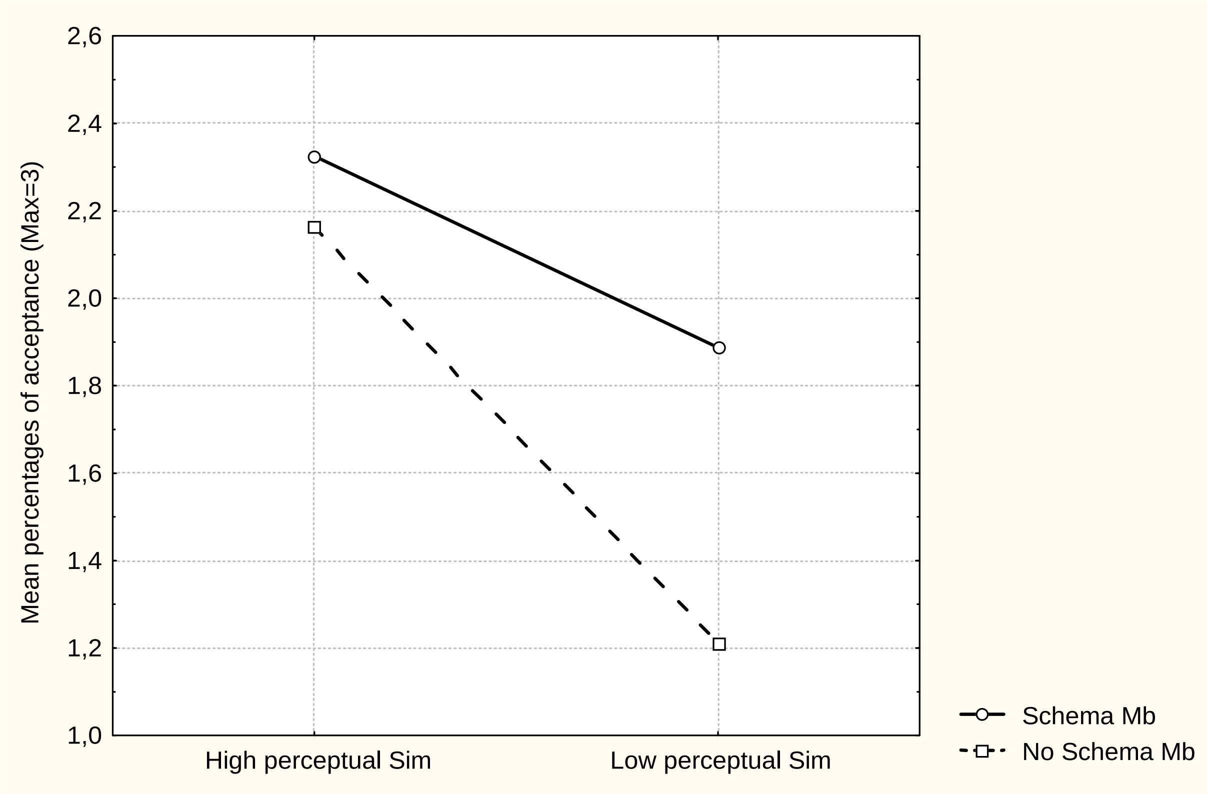
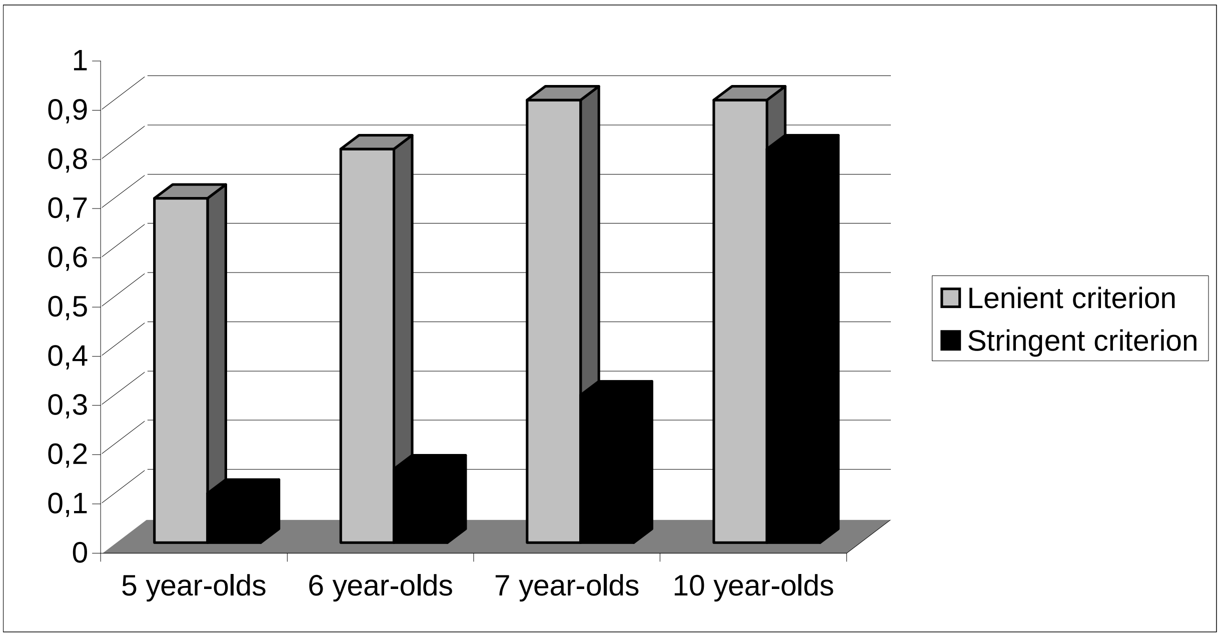

2,6
2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
Mean percentages of acceptance (Max=3)
High perceptual Sim
Low perceptual Sim
Schema Mb
No Schema Mb

Figure 3.



1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
5 year-olds
6 year-olds
7 year-olds
10 year-olds
Lenient criterion
Stringent criterion

Figure 4.

LIST OF APPENDIXES

APPENDIX 1

M1	Beach	people	animals	vehicles
		girl in a swimming costume	crab	boat
		woman in a swimming costume	dolphin	canoe
		diver	fish	windsurf
	Farm	people	animals	vehicles
		farmer	cow	cattle dray
		woman farmer	sheep	tractor
		boy farmer	chicken	hay dray
M2	Circus	people	animals	tools
		clown	elephant	skittle
		juggler	lion	whip
		tamer	horse	bike
	Forest	people	animals	tools
		woodcutter	rabbit	power saw
		walker	owl	wood saw
		girl with walking shoes	squirrel	axe

APPENDIX 2

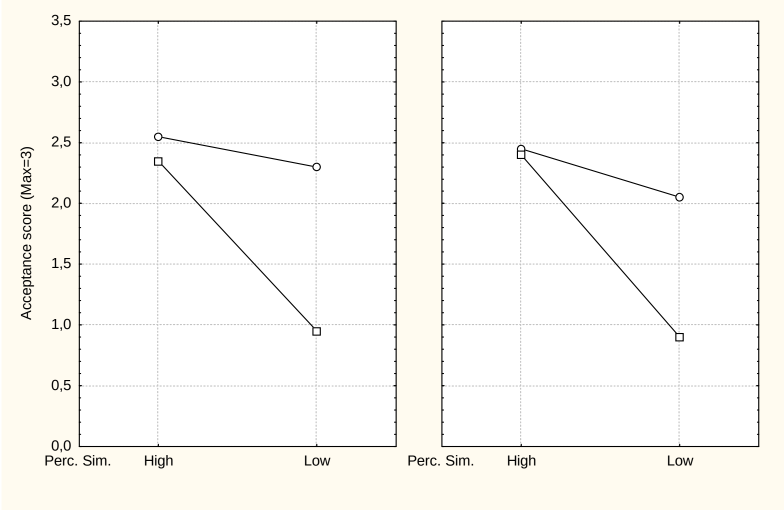
	Potential members			
	Schematic member *High percept.sim.*	*Schematic member* *Low percept.sim.*	*No schematic mb.* *High percept.sim.*	*No schematic mb.* *Low percept.sim.*
M1 Animals/People/Vehicles (Beach/Farm)	Horse	Seagull	Tiger	Monkey
	Boy in a swimming costume	Diver	Dancer	Clown
	Milk van	Pedal boat	Ambulance	Plane
M2 Animals/People/Tools (Circus/Forest)	Tiger	Butterfly	Cow	Fish
	Little Red Riding Hood	Contortionist	Mechanic	Diver
	Circus bike	Lions' block	Shovel	Stethoscope

	True intruders			
	Schematic member *High percept.sim.*	*Schematic member* *Low percept.sim.*	*No schematic mb.* *High percept.sim.*	*No schematic mb.* *Low percept.sim.*
M1	Scarecrow	Beach pail	Rocking horse	String of pearls
	Duck shape rubber ring	Cherry tree	Doll	stethoscope
	Lorry shaped mould for sand pie	Beach towel	Helping walk dray	Banana
M2	Puppet	Tent (circus)	Teddy bear	City bus
	Wild Flower	Tree	Scarecrow	Dressing gown
	Roadsign « Take care the stags »	Mushroom	Ladle	Book

APPENDIX 3

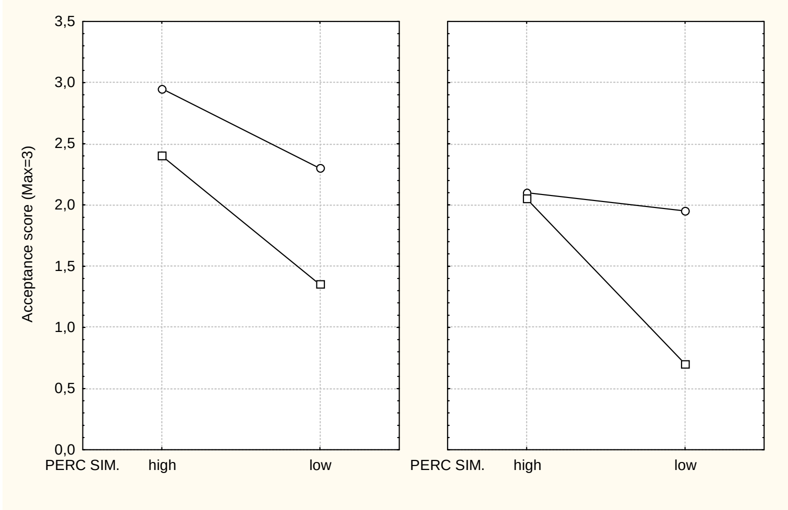
5 year-olds

Potential members | True intruders



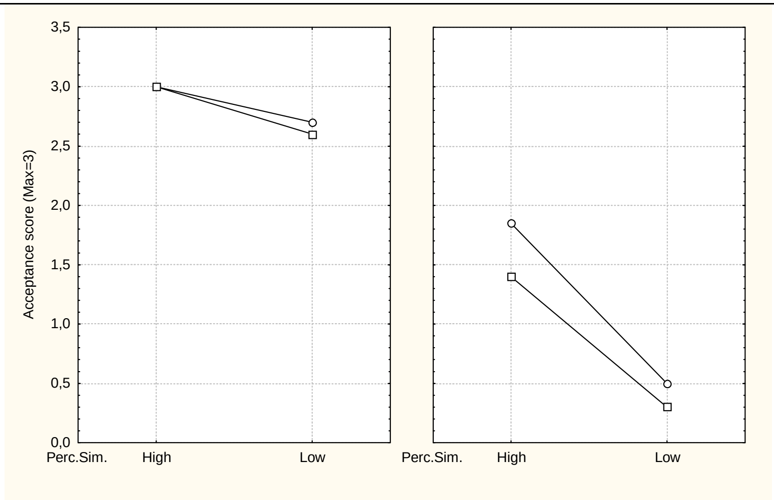
6 year-olds

Potential members | True intruders



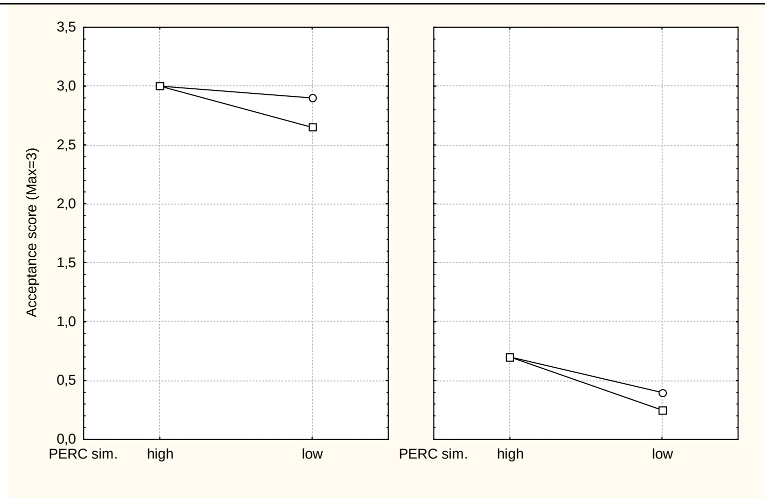
7 year-olds

Potential members | True intruders



10 year-olds

Potential members | True intruders



——— schematic membership -----No schematic membership

NOTES

[1] "Correct sorts" refer to sorts that could be unambiguously identified as either taxonomic, thematic or slot-filler based on the principles of construction of the material. The coding of sorts was made independently of the produced labels.

[2] Children did so by "ignoring" some elements of the taxonomic group; animals were for instance labeled "animals of the circus" or even "the circus"

[3] The proportions of participants having produced or accepted a taxonomic sort were similar across the four children age groups and did not significantly relate to performance ($p>.36$ in all age groups). It was then not considered in the analyses.