The importance of differentiation in young children's acquisition of expertise

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A B S T R A C T

In a short-term longitudinal study, stories told about novel creatures conveyed information varying in its capability for differentiating. Depending on the context, a bodily feature could be functionally undifferentiated (FUF), meaning that its subtypes (e.g., eyes of two forms) shared a generic function (“seeing”), or functionally differentiated (FDF), meaning that each subtype’s function was unique to it (e.g., only a “hooded eye” could “see in a sandstorm”). 5- to 6-year-olds who heard 8 stories, but not those who heard only 4, cited FDFs more than FUFs in a pair-justification test of judged similarity; and their delayed recall of specific story events was greater when FDFs rather than FUFs were involved. In the absence of direct instruction, young children show sensitivity to the degree of differentiation afforded by feature-function relations.

1. Introduction

It is commonly accepted that the knowledge of an expert in a domain differs from that of a novice in the differentiation it entails. As familiarity with the entities in a domain grows, so does the tendency to compare and form sub-groupings of those entities, with reference to features that emerge or become increasingly clear in their definition (e.g., Gibson, 1969; Gibson & Gibson, 1955). One way to elucidate the development of expertise is to conceive of changes in memory representations and in perceived similarity as concomitant aspects of progressive differentiation. Learners may treat information (e.g., about property-behavior relations) that supports relatively fine distinctions as more important than otherwise comparable information sufficient only for coarser differentiation. It follows from this that the patterned occurrence of shared properties itself – in other words, the structure of the incoming information – will engender emphasis on differentiating properties in preference to non-differentiating ones. Hammer and Diesendruck (2005) found that children of preschool age do in fact tend to judge according to whichever kind of property (perceptual; or functional) of novel pairs of artifacts is the one that sets them furthest apart, whereas adults are not susceptible to such influences through brief exposure. The insight that incoming information may shape perception and judgments dynamically has been captured by connectionist models (e.g., Rogers & McLelland, 2004); and the view that whether and how knowledge structures will adapt to newly encountered information depends on knowledge consolidated previously is expressed by Schyns and Rodet (1997) as follows: “…the featural analysis of the input is
not perceptually fixed but flexibly adjustable to the experience of the organism” (p. 685). Schyns and Rodet consider their view applicable to both novice-expert and developmental differences in learning and categorization. It is compatible with empirical results from studies of young children's acquisition of expertise (e.g., Johnson & Mervis, 1994).

The study that we report was designed to test the importance of differentiation. Many studies have investigated children's preferential use of certain types of feature-related information in categorization and naming tasks, typically pitting perceptual against functional information. In contrast, our approach was to use the relations between perceptual features and their functions to manipulate the degree of differentiation offered. Placing the focus on information about feature-function relations made it possible to control perceptual resemblance at global and local levels. We used specially-designed dolls whose function-related features, such as eyes and tails, all took one of two forms (e.g., gripper tail or soft tail; hooded eye or eyes-on-stalks). Using story contexts and suitable events taking place in differing environments, the contrasting forms of a feature either were made to share a generic function (e.g., “seeing”), or made to be capable of functioning in ways unique to them (e.g., seeing in a sandstorm, or seeing over tall reeds). The use of artificial stimuli allowed us to make the same physical features differentiating ones for some children and non-differentiating ones for others. This aspect of the design eliminates the risk that any effects obtained might reflect differences in the physical features or their particular functions rather than reflecting the importance of differentiation itself. Furthermore, the use of novel creatures reduces the potential for children's pre-existing knowledge to guide their encoding and responses. We expected feature-function information that enabled children to make fine-grained distinctions between the dolls (features with a unique function) to become more influential, with experience, than otherwise comparable non-differentiating information (features with a shared function) and we reasoned that the emerging change in such influence would be reflected in children's judgments of the dolls' similarity to each other and in their memory of the dolls' activities recounted in the stories.

Our design was founded on three main kinds of evidence from previous studies. The first was evidence indicating that property-behavior relations constitute a form of information to which young children are attuned, making these relations suitable for our manipulation of the degree to which information differentiates. Young children's sensitivity to such relations has been documented both in studies of their acquisition of expertise (e.g., Chi & Koeske, 1983; Gobbo & Chi, 1986; Johnson & Mervis, 1994) and also in studies of their categorization, generalization and naming with respect to animal domains (e.g., Barrett, Abdi, Murphy, & Gallagher, 1993; Greif, Klemmer Nelson, Keil, & Gutierriz, 2006; Kelemen, Widdowson, Posner, Brown, & Casler, 2003; Krascum & Andrews, 1998; McCarrrell & Callanan, 1995; Ward, Becker, Hass, & Vela, 1991). McCarrrell and Callanan (1995) found that children of preschool age not only were sensitive to form-function correspondences when they judged which one of a pair of fanciful animals, depicted in line drawings, could accomplish a particular feat (e.g., see well at night) but also gave weight to such correspondences when they were deciding whether novel creatures would be capable of the same feat. Furthermore, children from 2 to 5 years of age did not relinquish form-function correspondence as a basis for generalizing when a shared label was put in conflict with it. Kelemen et al. (2003) extended these findings by pitting the same kind of implicitly given form-function relations against global perceptual similarity in an induction task involving triads (using a procedure pioneered by Gelman & Markman, 1986). They found that 3-, 4- and 5-year-olds were more likely to base inferences about the behavior of unfamiliar (and unlabeled) animals on shared functional attributes than on overall similarity and that the consistency with which this preference was shown increased from 3 to 4 years of age. However, when 3- and 4-year-olds were tested using the same procedure on inferences about a novel category name instead of a behavioral propensity, the basis of their inferences changed from functional characteristics to overall perceptual similarity. When the task is to extend a newly learned label, apparently children bring to bear knowledge about language (count nouns, in particular) that leads them to rely heavily on overall perceptual similarity. Evidence that 4- to 5-year-old children tend sometimes to attend to morphological shape and at other times to rely mainly on body parts (of presumed functional importance) when they make generalizations about the category membership of novel creatures also was obtained by Ward et al. (1991). One broad point established by these and other studies of categorization and/or naming is that young children are flexible in how they decide what aspects of items to focus upon and use (cf., e.g., Deak, Ray, & Pick, 2002; Diesendruck, Hammer & Catz, 2003; Hammer & Diesendruck, 2005; Jones, Smith, & Landau, 1991; Livingstone & Andrews, 2005). In summary, there is considerable evidence establishing that young children use property-behavior relations and that, at least in situations where labels (or other pointers to shape-based basic-level discriminations) are not the principal focus of attention, such relations take precedence over global perceptual similarity.

The second and third relevant bodies of evidence are linked to a considerable degree. They document the fact that gaining expertise in a domain brings about changes of two main kinds, the first being changes in memory. Children who are expert players of a game such as chess, baseball, or soccer, or who have extensive knowledge of a particular field, such as the life of dinosaurs, or of birds, differ from less expert children and indeed from non-expert adults in their memory of information pertaining to their area of expertise (e.g., Bjorklund, Muir-Broadus, & Schneider, 1990; Chi, 1978; Chi & Koeske, 1983; Schneider, Gruber, Gold, & Opwis, 1993; Schneider, Korkel, & Weinert, 1989; Spilich, Vesonder, Chiesi, & Voss, 1979). The second kind of change linked with growing expertise involves the structuring or organization of knowledge in a particular domain (e.g., Carey, 1985; Gobbo & Chi, 1986; Johnson & Mervis, 1994; Johnson, Mervis, & Boster, 1992; Solomon, 1997). Chi and her colleagues (e.g., Chi & Koeske, 1983; Gobbo & Chi, 1986) documented the increasingly efficient semantic structure formed once a young child becomes at-
tuned not just to explicitly given but also to implicit properties of the entities in a domain. Chi and Koeske (1983) studied a 4 1/2-year-old child who had better knowledge of one set of dinosaurs than of another. For the better known but not the lesser known set, dinosaurs within subgroups had more direct linkages with each other and also more indirect linkages, via properties such as diet, defense mechanisms, and locomotion, than did dinosaurs from different subgroups. Johnson and Mervis (1994) drew similar conclusions from their study of 4- and 5-year-old children’s acquisition of expertise regarding shorebirds. They obtained contrasting findings for a group of 5-year-olds, on the one hand, who were novices with respect to all sub-domains of birds at the outset of the study, and for a single 4-year-old, on the other hand, who began the study already an expert in the sub-domain of passerines. The younger child with expertise in a neighboring sub-domain assimilated and recalled new information about the sub-domain of shorebirds more effectively than the older children with no such parallel body of expertise. Most importantly for the design of our study, they also found that the basis of similarity judgments was different for the 4-year-old and 5-year-olds. The expert 4-year-old’s similarity judgments in the new sub-domain were based on subtle features that were of functional significance (e.g., webbed feet that enabled birds to walk on lily pads to find food), whereas the novice 5-year-olds relied primarily on overall morphological resemblances.

The foregoing reasoning and evidence led us to test whether the degree to which feature-function relations provide a means of differentiating novel creatures would affect 5- to 6-year-olds’ memory and their similarity judgments, and would do so increasingly as their familiarity with the novel information increased. No previous studies have examined the importance of differentiation using a direct manipulation of this sort. Another difference between our study and some related, earlier work is that we gave children no direct instruction regarding the feature-function relations. Johnson and Mervis (1994), in their study of expertise concerning shorebirds, made various property-behavior relations explicit for children by saying, for example: “That’s a turnstone/wrybill. It has a very strong bill. You know why? That’s so it can dig underneath rocks to find crabs to eat”. (Table 3, p. 424) Instead of explaining the functional information in a way that emphasizes its importance, we sought to simulate everyday ways of gaining experience. We made it possible for children to extract and consolidate information from stories in which imaginary activities took place. Because children as young as 4–6 years of age had been shown to be capable of acquiring expertise with relatively explicit instruction, it seemed likely that they also could decide for themselves which particular property-behavior relations help to differentiate in a domain and which do not. Our storytelling did not contain direct statements about such relations, but instead provided instances of them, varying from story to story, that would permit comparisons to be made and inferences to be drawn by the children themselves.

The stories all were similar in structure, conveying sequences of events about which children could be questioned later. However, there was no exact repetition of events from one story to another. The activities described were tailored to the particular setting and theme for each story. This storytelling procedure can be likened to the carefully structured series of occurrences (in which children themselves participate) often used in studies of children’s event memories (e.g., Connolly & Lindsay, 2001; Quas et al., 2007; Roberts & Powell, 2005, 2007). Although the empirical evidence available is not entirely consistent, young children’s memory for events experienced in such series tends to be better (and more resistant to misleading suggestion) when the details of what they experience remain fixed (i.e., do not vary across occurrences) than when the details vary (e.g., when the specific nature of something done as a magic trick changes, when an event occurs in a series of different places, or when something such as a puzzle to be solved differs from occasion to occasion in its subject-matter) (e.g., Powell, Roberts, Ceci, & Hembrooke, 1999; Roberts & Powell, 2007). Our storytelling procedure incorporated even more variation in detail across occasions than the series of occurrences typically used to study children’s event memory, implying that the memory task we gave to children could be expected to be difficult. We surmised that potential effects of differentiation might emerge most clearly if the demands made on integration and memory were high.

The differentiating and comparable non-differentiating information to which 5–6-year-olds were exposed concerned features of novel creatures (dolls) whose exploits were described in the stories. There were five features (one of which was a control feature, not related to any function) each of which could take two forms. With the exception of the control feature, the two forms of a feature either had the same function, for example, eyes of both kinds simply were used to see (a functionally undifferentiated feature, FUF), or they each had specific and exclusive capabilities, for example, only a hooded eye could see in a sandstorm, whereas only eyes-on-stalks could see over tall reeds (a functionally differentiated feature, FDF). If, having heard about a variety of events in stories, children were to rely on FDFs more than FUFs as a basis for similarity judgments, and/or were to show an FDF advantage in memory performance, those tendencies could not reflect a bias to use functional information per se, as the features in both cases were linked with functions. It would mean, instead, that children are sensitive to whether or not property-behavior linkages afford a means of differentiating groups of creatures. Moreover, if the tendency toward better memory of and greater reliance (in judging similarity) on FDFs, as compared with FUFs, were to increase with increased exposure to information, this would be consistent with the idea that with growing expertise comes greater differentiation.

In general terms, variations in children’s memory arising from focused attention could be expected to appear in immediate recall, whereas variations arising from distinctiveness in memory would be manifest after a delay. Children were given immediate and delayed tests of recall, together with tasks tapping the judged similarity of the creatures that were actors in the stories. Because tasks designed to reflect perceived similarity are likely to vary in
sensitivity, we used more than one type of task (cf., Johnson & Mervis, 1994). Two degrees of experience (corresponding to different numbers of stories told) were incorporated into the study’s design.

2. Method

2.1. Participants

Twenty-two children who attended a community-based preschool and kindergarten program participated. They came from predominantly white, middle-class families. There were 12 children (4 M, 8 F; mean age 6:1 range 5:6–6:8) in an 8-story condition and 10 (7 M, 3 F; mean age 5:8, range 5:1–6:6) in a 4-story condition. Within each story condition approximately half of the children were assigned to one set of environments (World TF: 5 8-story, 6 4-story children), the other half to another set (World ES: 7 8-story, 4 4-story). The fact that the sexes were not distributed evenly across the 4-story and 8-story conditions was considered unlikely to pose problems of interpretation, one reason being that care was taken to create materials and stories that would appeal equally to girls and boys, another being that significant sex differences in reasoning about categories and/or similarity have not been found frequently in young children (but see Gelman & Markman, 1986; Hort & Taylor, 1990).

2.2. Materials

Dolls and miniature environments were designed, constructed and used as props in storytelling. The environments were four parks that could be arranged side by side in contrasting pairs to form two different subdivided worlds. Parallel sets of stories were written for the two worlds (World TF and World ES).

2.2.1. Dolls

Dolls made of cloth and stuffed were given five story-relevant features: eyes, “sacks” (sewn in place around the neck), tails, hands/feet, and hair. Each feature could take one of two forms: hooded eye or eyes-on-stalks, water sack or air sack, gripper tail or soft tail, frizzy hair or loopy hair, sticky hands/feet or tough hands/feet. Fig. 1 shows the two forms for each story-relevant feature. Besides varying in the forms of these five features, the dolls also varied in cloth color (blue, green, orange, beige) and size (small, large).

2.2.2. Co-varying pairs of features and the control feature

Two pairs of features co-varied. If a doll had a hooded eye it also had a water sack and if a doll had eyes-on-stalks it also had an air sack. If a doll had a gripper tail it also had sticky hands/feet and if a doll had a soft tail it also had tough hands/feet. The pairs of co-varying features, henceforth termed E/S and T/F features, were linked to particular functions appropriate to particular environments (i.e., “parks”; see Fig. 2). Variations in the fifth feature – hair – had no functional significance. Features of these five kinds figured in events described in the stories. No mention of cloth color or size was made and only the small dolls were used in storytelling. Large dolls were used in parts of the testing.

The set of eight small dolls used in storytelling and in much of the testing is shown in Fig. 2. Except for the pairs of E/S and T/F features that co-varied perfectly there was no systematic relation between the dolls’ features. The set of eight contained all combinations of the two E/S forms, the two T/F forms and two forms of Hair. All four cloth colors were represented once in dolls with E/S features of each form and once in dolls with T/F features of each form. Within a given size (small or large), dolls of the same color had the same form of Hair. The eight small dolls were given consonant-vowel-consonant names, as follows: Juf, Zab, Wev, Vot, Hep, Fom, Kag, and Nud.

2.2.3. Worlds and differentiability of features according to function

There were two worlds each divided into two parks. World TF consisted of a mountainous, rocky terrain with tall, slippery trees (Mountain Tree Park) and a flat terrain overgrown with prickly grass except for a deep crater that had rough, bare walls (Prickly Grass Park). World ES consisted of a hilly terrain through which ran a wide river lined with tall reeds (Reedy River Park) and a desert terrain with large sand dunes and a dry riverbed filled with rocks (Sand Dunes Park). These pairs of parks (shown in Fig. 2) set the stage for events conveying feature-function correspondences. In Mountain Tree Park the mountains could
be climbed only with the help of a gripper tail and the trees could be climbed only using sticky hands and feet. In Prickly Grass Park the grass could be crossed only with the protection offered by tough feet and the crater could be entered only if someone slid down its side on a soft tail. In the world comprising these parks, the co-varying T/F forms were functionally differentiated features (FDFs). In contrast, because there were no aspects of these parks for which it was an advantage to have a particular kind of eye(s) or sack, these were functionally undifferentiated features (FUFs). The reverse was true for the other world: E/S features were FDFs and T/F features were FUFs. In Reedy River Park, the deep river could be crossed only with the help of an air sack and the tall reeds obscured the view unless someone had eyes-on-stalks. In Sand Dunes Park the hot, dry dunes could be crossed only with the help of a water sack and when the wind was blowing sand around it was possible to see only with a hooded eye. There were no aspects of these parks for which it was an advantage to have a particular kind of tail, or hands/feet of a particular kind. For each of the worlds, Fig. 2 shows the division of the set of 8 dolls used in storytelling, according to whichever co-varying pairs of features were FDFs in that world. Although features that were FUFs in a particular world did not have two distinct functions for which their two forms were suited, this did not mean they were entirely unrelated to function. Both forms of an FUF served a general function, and did so equally well.

2.2.4. Stories
For each world eight stories were written, organized in pairs consisting of one story for each park. Besides the critical information about FDFs and FUFs, each story had an opening section that set the theme (e.g., “going on a picnic and flying kites”) and introduced the four characters who would participate. One of the characters was chosen as the leader. The children were told five times during a story who was the leader and leaders’ names were used in delayed recall to cue memory of specific stories about which questions were asked. Each story also had two control events not involving FDFs or FUFs, a comprehension check, and a brief concluding section.

Fig. 2. The top half of the figure shows black-and-white versions of Reedy River Park (Left side) and Sand Dunes Park (Right side), together forming World ES. The bottom half shows Prickly Grass Park (Left side) and Mountain Tree Park (Right side), forming World TF. The dolls are arranged to stand in front of the specific parks for which their features were well suited (i.e., were functionally differentiated). Eyes and sacks were FDFs for those children hearing stories about World ES, whereas Tails and Hands/Feet were FDFs for those hearing stories about World TF. Thus exactly the same set of eight dolls was differentiable in two distinct ways (see the top and bottom halves), according to the world in which stories told about them were set.
Four events in which characters used their FDFs or FUFs to perform a task occurred in each story (e.g., “Juf used his soft tail to slide into the crater and get the sweater”). One such event occurred at the beginning and another at the end for both the FDFs and the FUFs. To help convey the functional differences between FDF forms, one of these events was such that a character lacking the correct form of FDF was unable to perform the necessary task. Then a character possessing the correct form of FDF successfully performed it. This event that served to contrast the functional capabilities of the two forms of an FDF came early in each story. One example of such an event involved a character with eyes on stalks explaining, initially, that she/he could not go looking for a picnic place while the wind was blowing sand into the air, followed by a character who, in this case, possessed the well-adapted form of the FDF (a hooded eye) volunteering to go and look under those conditions. This example comes from the story about “going on a picnic and flying kites” when it was set in Sand Dunes Park of World ES. Full details of this story and of its corresponding version set in Prickly Grass Park of World TF are given in Appendix A. The version for Prickly Grass Park contains another example of an event serving to contrast the functional capabilities of the two forms of an FDF (in this setting, tough hands and feet are well-adapted whereas sticky ones are not). Because both forms of a given FUF served the same generic function, no such contrast was possible in the case of the FUFs.

The stories contained controls of two types, feature controls and event controls (one of each type per story). The feature controls all involved mention of a character’s type of hair in relation to some part of the story (e.g., “The clown had loopy hair, just like Juf’s”). By contrast with the critical features (FDFs and FUFs), the control feature did not serve a function. The event controls were occurrences to which the characters in the story were forced to react in some way (e.g., ants tried to get into the picnic basket, causing the characters to move to another picnic spot) but their reactions did not entail the use of any specific feature(s). These control elements were included essentially as fillers, introducing variety into the stories themselves and the questions asked to test children’s recall. Their inclusion meant that the information conveyed in stories and probed for in tests of recall was not invariably concerned with feature-function links.

To make sure children understood that the FDFs had differentiated functions and knew what the functions were, a comprehension check was embedded in each story. Toward the end of each story, a circumstance arose in which the characters needed some task to be carried out that only the characters with the correct form of FDF could accomplish. After indicating that the character who carried out this task in the first part of the story could not do it again (for a reason unrelated to the FDF), the children were asked to indicate which of the remaining characters could succeed (e.g., “Do you know which of the friends could slide down into the crater and get the tickets?”). Regardless of whether the child chose correctly or incorrectly, the feedback consisted simply of an affirmation of the correct character’s name by the experimenter. The required form of FDF (in this case, a soft tail) was not mentioned during any part of the comprehension check.

Each story concluded with a reiteration of the main events, without any explicit mention of specific tasks for which the characters had used their FDFs or FUFs. There was nothing in the stories to indicate to children that the FDFs were more important than FUFs or even that events involving FDFs and FUFs were more important than the control events or other, incidental events.

The full text for one of the eight stories (with the theme: “going on a picnic and flying kites”) is shown in Appendix A. There are two versions of the story, one for World TF and one for World ES. The text is annotated to indicate the events that involve FDFs or FUFs, the feature and event controls, the comprehension check, and the directions for manipulating dolls to be followed by the storyteller (see Procedure).

2.2.5. Counterbalancing within and across stories and across worlds

Within each story there was one explicit reference to each of the FDFs, one to each of the FUFs, and one to Hair (control feature). Each of these references was to one particular form of a feature (e.g., “hooded eye”: “gripper tail”, “loopy hair”). The ordering of these references with respect to each other and to the comprehension check was FDF, FUF, Hair, FDF, FUF, Comprehension Check (order 1) for half of the stories and FUF, FDF, Hair, FUF, FDF, Comprehension Check (order 2) for the other half. To make the stories flow smoothly it was necessary to vary the place at which the control event occurred (near the beginning, middle, or end) and so it is not listed anywhere in the orderings.

The eight stories were grouped into four pairs and children heard them at the rate of one pair per session. Each pair consisted of one story for each of the two parks in a particular world. Four of the eight characters participated in one story of a pair, the other four in the other story. All the feature types were used once each in each pair of stories, so that if, for example, gripper tails were used in one story of a pair, then soft tails were used in the other. Orders 1 and 2 (above) were used once each in each pair of stories. Across the four pairs, the division of characters into two sets of four varied in such a way as to allow each character to change roles from one story to another. Each individual character was the leader once and all the characters were involved in events using FDFs, FUFs and control features roughly the same number of times.

The eight story themes and their pairings were the same in both worlds. The paired themes were: (Pair 1) “Having a picnic and flying kites” (taking place at Prickly Grass Park in World TF and at Sand Dunes Park in World ES) and “Drawing pictures and getting lost” (at Mountain Tree Park in World TF and at Reedy River Park in World ES); (Pair 2) “Going on a nature study trip and gathering rocks” (at Mountain Tree Park in World TF and at Sand Dunes Park in World ES) and “Cleaning up trash and rescuing monkeys” (at Prickly Grass Park in World TF and at Reedy River Park in World ES); (Pair 3) “Playing hide and seek and dodging a rock slide” (at Mountain Tree Park in World TF and at Reedy River Park in World ES) and “Going to a music concert and finding lost tickets” (at Prickly Grass
2.3. Procedure

Children participated individually in weekly sessions beginning with a pretest and one pair of stories in session 1, followed by either one or three further pairs of stories (1 pair per session), and concluding with two sessions comprising posttests and delayed recall. For a schematic account of the sequences of activities in the sessions, see Table 1. Because of extraordinary cooperation accorded to us by the staff of the school at which the study was conducted, it was possible to schedule sessions that, for any given child, were always seven days apart and at the same time of day each week. Experimenters were assigned to specific times and days and, except for a few substitutions necessitated by unforeseen circumstances, the same experimenter interviewed the same children each week, throughout all of their sessions. Individual sessions lasted approximately 30 min with no break. Structuring sessions so that children switched between passive listening and active answering of questions proved to be an effective way of keeping children engaged.

2.3.1. Pre-test and introduction to materials

A free sorting task and a triad task were used to examine how children would spontaneously group the dolls. The sorting task, included in both the pre-testing and post-testing as one means of assessing children’s notions of similarity, turned out not to yield systematic data at either time of testing. Although we had taken steps to structure this task so as to maximize the likelihood of revealing children’s notions about the relative importance of various features, in practice we obtained much the same high degree of variability both within and across individual children that had been found in some earlier studies for sorting tasks with children of preschool age (e.g., Johnson & Mervis, 1994). For these reasons the results for the sorting task will not be reported and only a brief outline of the method pertaining to this task will be presented.

In the sorting task, the child was presented with the eight small dolls and two bins and told to divide up the dolls into ones that “go together”, so that there would be exactly four in each bin. After the division into groups of four was made, the child was asked to subdivide each of those groups into two groups of two.

In the triad task the child was told: “Now I’m going to ask you some things about these friends. We’ll take just a few at a time. Here are three friends”. The three friends were presented on doll stands in a triangular arrangement such that the two dolls on the outside and further from the child were higher than the middle doll that was closer. This arrangement was chosen to make all the possible pairings equally salient. The child was asked: “Which two of these friends are most alike?” There was a total of four such trials, across which the child had two opportunities to pair according to color, three to pair according to hair, four to pair according to FDFs, and four to pair according to FUFs. Table 2 shows which grounds for pairing were present on each trial.

These two tasks were given in the first part of the first session with each child (see Table 1). The storytelling began in the second part of the first session and to introduce it three steps were taken. Children were told that they would be listening to stories about friends who liked to...

Table 1

| Testing and storytelling sequences within sessions for the 8-story and 4-story conditions. |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Session 1**                  | **Session 2**                  | **Session 3**                  | **Session 4**                  | **Session 5**                  | **Session 6**                  |
| **Eight-story condition**      |                                 |                                 |                                 |                                 |                                 |
| Free sort                      | Feature name recall            | Feature name recall            | Feature name recall            | Feature name recall            | Triads no context              |
| Triads                          | Char. name recall              | Char. name recall              | Char. name recall              | Char. name recall              | Triads park context            |
| Storytelling intro.             | Story 3                        | Story 5                        | Story 7                        | Story 1                        | Triads task context            |
| Feature name recall            | Story 3 recall                 | Story 5 recall                 | Story 7 recall                 | Story 1 recall                 | Pair justification             |
| Story 1                         | Char. name recall              | Char. name recall              | Char. name recall              | Char. name recall              |                                 |
| Story 1 recall                  | Story 4                        | Story 6                        | Story 8                        | Story 8 recall                 |                                 |
| Story 2                         | Story 4 recall                 | Story 6 recall                 |                                 |                                 |                                 |
| Story 2 recall                  |                                 |                                 |                                 |                                 |                                 |
| **Four-story condition**        |                                 |                                 |                                 |                                 |                                 |
| Free sort                      | Feature name recall            | Feature name recall            |                                 |                                 |                                 |
| Triads                          | Char. name recall              |                                 |                                 |                                 |                                 |
| Storytelling intro.             | Story 3                        |                                 |                                 |                                 |                                 |
| Feature name recall            | Story 3 recall                 |                                 |                                 |                                 |                                 |
| Story 1                         | Char. name recall              |                                 |                                 |                                 |                                 |
| Story 1 recall                  | Story 4                        |                                 |                                 |                                 |                                 |
| Story 2                         |                                 |                                 |                                 |                                 |                                 |
| Story 2 recall                  |                                 |                                 |                                 |                                 |                                 |

*Note:* In Session 3 for the 4-story and Session 5 for the 8-story condition the order of testing recall for the stories was counterbalanced across children. The stories that were numbers 3 and 4 for the 4-story condition were the same as stories numbers 7 and 8 for the 8-story condition.
Table 2
Features that match (denoted by “X”) for pairings of dolls in the triad task and the pair justification task.

<table>
<thead>
<tr>
<th>Matching features</th>
<th>FDF</th>
<th>FUF</th>
<th>Hair</th>
<th>Cloth color</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Triad task</td>
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Note: FDF = functionally differentiated feature; FUF = functionally undifferentiated feature. In the triad task, pairs represent the three possible pairs of dolls that could be chosen.

* The matching features shown in the table for triad 3 and 4 are for World TF (see text). For World ES, what the table shows for triad 3 applies to triad 4, and vice versa.

go out together and play games and have adventures in nearby parks. Next, two parks for a particular world were shown to the child, who was helped to notice and name the following: in Mountain Tree Park, the steep rocky mountains and the trees with slippery bark; in Prickly Grass Park, the deep rough craters and the thick prickly grass; in Reedy River Park, the tall reeds and the deep river; and in Sand Dunes Park, the loose sand that blows when it gets windy and the dry waterless landscape. In each case, the demands posed by the environment were pointed out, e.g., for Mountain Tree Park, that “...to climb the mountains someone would need to grip the rocks” and for Sand Dunes Park, that “...to walk a long way, someone would need to take water along to drink.” Finally, children were told about the names of features, beginning with the broad statement: “When you look at these friends you can see they all have...”, and continuing with a listing (and brief descriptions combined with pointing at dolls) of the two forms of each of the five features in turn (hair, sacks, tails, hands/feet, and eyes). This listing served to introduce the names of features to children.

2.3.2. Storytelling and associated memory tests

The stories told to children were preceded by tests of memory for names of the feature forms and, in all sessions except the first, by tests of memory for names of the characters. In every session, the telling of each story was followed immediately by a test of recall of what had happened in that story (see Table 1). There were two storytelling sessions for children in the 4-story condition and four for children in the 8-story condition. Children in the 4-story condition heard only the pairs of stories that were told to children in the 8-story condition in their first and fourth sessions. The order in which pairs of stories were told was Pairs 1, 2, 3, and 4 for half of the children in the 8-story condition and Pairs 4, 3, 2, and 1 for the other half. Similarly, the order was Pairs 1 and 4 for half of the children in the 4-story condition and Pairs 4 and 1 for the other half. (see Stories, above, for the specific themes of the stories belonging to the four pairs).

2.3.3. Recall of names for feature forms and characters

Each telling of a pair of stories was preceded by a test of the child’s memory for the names of all the features. The experimenter pointed to one form of a feature (e.g., loopy hair) and asked the child: “What do you call this?” If a child gave just the name of the feature, for example, “hair”, the follow-up question “What kind of ... (in this case, hair)” was asked. This procedure was followed for all 10 feature forms with the two forms for each feature adjacent in the ordering. The order of testing was counterbalanced across immediate and delayed recall combined, as will be explained in the description of delayed recall.

Testing of children’s memory of the individual characters’ names took place before each individual story, except in Session 1 (because children had not heard any names prior to that). The experimenter placed in a straight row in front of the child the four dolls about whom the upcoming story was to be told and asked, for example, “Which one is Zab?”. The dolls had name-tags, attached to their chests with Velcro, that had to be turned over to reveal the names. After the child made a choice, the name-tag on the correct doll was turned over regardless of whether the child had chosen correctly. As this was done, the child received verbal feedback (confirming or corrective, as necessary, e.g., “Yes, that’s Zab” or “No, here’s Zab”). This procedure continued until the four names were revealed and this meant that the child would always be correct on the fourth and final choice. Across occasions, the positions occupied by dolls with particular features (e.g., a soft tail) and dolls that were about to play particular roles (e.g., leader) in the story were varied. The order of testing also was counterbalanced across occasions. The correct doll for each question (first question, etc.) occupied each spatial position in the row approximately equally often.

2.3.4. Procedure for telling stories

The reading of a story took place with the four participating dolls placed roughly in a straight line in front of the park in which the events took place. When pronouns rather than proper nouns were used in the story, all the dolls were referred to using male pronouns if the participating child was male and using female pronouns if the participating child was female. Once the leader for the story’s events had been established, the child was asked to mark the leader by attaching a special pin to that doll’s chest. The leader was moved forward, relative to the other dolls, when this occurred and moved back into line afterwards. The same procedure of moving a doll forward and then back
into line was followed whenever an event involving an FUF, FDF or Hair occurred. The printed cues telling the experimenter which doll to move forward and back at various points in the story are shown in Appendix A. For the comprehension check, the experimenter set aside the doll not available to perform the required task (see Stories), leaving three dolls, one of them being the leader. The child had to say which one of the two available characters it would make sense for the leader to ask to do the task.

2.3.5. Immediate recall of details from the stories

Following the telling of each story the child was asked six questions that tested recall of what happened in that story. Appendix A contains the sets of questions for the two versions of the story with the theme “going on a picnic and flying kites”. Two questions in each set of six concerned FDFs (one for each FDF – e.g., eyes; and sacks), two concerned FUFs (one for each, similarly), and two were control questions. For FDFs and FUFs, the answer to one of the two questions (a Feature question) was the name of a specific form of feature used in the story to accomplish a task (e.g., “water sack” as the answer to “What did Hep use to help her carry the kites?”). The answer to the other question (an Event question) was an accomplishment for which a character used a specified form of a feature (e.g., “to find a spot to fly kites” as the answer to “What did Hep use her hooded eye to do?”). The questions asking about control details (Hair forms and Control events) could not make reference to feature-function links because there were no such links involved (see Appendix A for details of the wordings of questions).

The immediate recall questions varied systematically across recall sessions. In some sessions (for both stories told in it) the three event questions (one involving an FDF, one an FUF, one Hair) preceded the three feature questions (one FDF, one FUF, one Hair) and in the other sessions it was the reverse. Within both the three event questions and the three feature questions for a given recall session, the ordering was either Hair, FDF, FUF or FUF, FDF, Hair. Across sessions, these two orderings were used approximately equally often. Within the set of questions for a particular story, if the first-mentioned FDF was the subject of a feature question, then the second-mentioned FDF was the subject of an event question (and similarly for FUFs). Across the sets of questions that tested recall of two stories in a particular session, the first/second place assignment of kinds of question was reversed. The degree of systematic variation possible for the 4-story condition was less than that for the 8-story condition.

2.3.6. Post-test and delayed recall

Post-testing and delayed testing of recall took place in two consecutive sessions: Sessions 5 and 6 for children in the 8-story condition, and Sessions 3 and 4 for children in the 4-story condition (see Table 1). The post-tests comprised: (i) two versions of a sorting task, one with no context specified, that was identical to the one given as a pretest, followed by a second version in which a park context was provided; (ii) a triad task in three parts, varying according to context (No context, Park context, Task context with park implied); and (iii) a pair justification task.

2.3.7. Session 1 of 2

The recall of feature names was tested first, in the same way as described earlier for sessions in which stories were told. For children in the 8-story condition, whose recall of feature names was tested five times altogether, the order of testing was varied so that each feature was tested once in each of the five positions. For each particular feature, one feature type (e.g., water sack) was asked about first in three of the five testing sessions (and second in the remaining two), and the reverse was true for the contrasting type (in this case, air sack). Children in the 4-story condition had similar counterbalancing of order insofar as was possible with just three testing sessions. Next, children's recall of the names of all eight characters, grouped into two sets of four, was tested using the procedure described earlier.

Following these tests of recall, children were given two sorting tasks and delayed tests of their recall of details from four stories (those in Pairs 1 and 4). The first sorting task was identical to the one given in Session 1, except that the toy characters presented were the eight big dolls, not the small dolls used throughout all procedures up to this point. Apart from their size, the set of big dolls differed from the set of small ones only in the cloth colors associated with each combination of FUF and FDF feature forms. Because no big doll was identical in all of its characteristics to any small doll, children could not rely on memory of individual small dolls (and/or their names) in this sorting task. The second sorting task differed from the first only in that the parks in which the stories told to children had taken place were invoked as contexts, as follows: “Make it so that four friends you think would go together, to do things in one of the parks, are in this bin (Experimenter points to one bin) and four friends you think would go together, to do things in another one of the parks, are in this bin (points to other bin).” The two relevant parks were visible to children in the background. In an effort to minimize carryover from one sorting to the other, the delayed testing of recall of details from the four stories was interspersed between the sorting tasks.

Delayed recall of story material was tested for the first two and last two stories that children heard (amounting to the entire set for the 4-story condition). As explained earlier, these were the stories constituting exactly the same pairs (Pairs 1 and 4) for all children, because the stories told in the 4-story condition were the first two and last two told to children in the 8-story condition. For half of the children the order in which recall was tested for the four stories was the same as the order in which they had been told and for the other half the order was the reverse of the order of telling. The six recall questions for each story were identical to those asked in the immediate recall test. However, the order of asking the six questions for a given story was, for each child, the reverse of the particular order used for that story and that child in immediate recall.

2.3.8. Session 2 of 2

In the final session children were given two post-tests: a triad task and a pair justification task. The triad task had three parts, each with four trials, the difference between the parts being the instructions given to children. The set of big dolls was used, for the same reason as in the post-
test sorting tasks. For the four trials of part one (No Context triads), the dolls’ features (except for cloth color), their physical arrangements on the table, and the instructions to children were identical to those for the triad task given as a pretest in Session 1. For the second part (Park triads), particular parks were invoked as contexts for choosing two dolls. The two parks for a given world served as the context on two of these trials each. The experimenter said, for example: “If you were the leader, which of these two friends would you take to Prickly Grass Park?” For the third part (Task triads), particular activities requiring the use of FDFs (and thus implying a particular park as context, in each case) were given as grounds for choosing. The child was asked, for example “If you needed two friends to slide into a crater, which two would you choose?” The first part of this task enables a test to be made of whether children’s unguided similarity judgments, made after having heard the stories, reflect greater use of FDFs (as compared with FUFs). The second part focuses on whether the simple mention of a particular park, without specification of any activity, increases the tendency for children to base their choices on FDFs. If it were to do so, that would indicate that children have grasped that FDFs (but not FUFs) can be used to overcome environmental challenges that are park-specific. The third part examines whether, when a specific environmental challenge to be overcome is presented, children choose dolls with the particular form of an FDF appropriate to that challenge indicating that they have understood the function of that FDF.

The pair justification task followed the triad task and consisted of eight trials, the first four using only dolls from the big set and the second four using pairings of one big and one small doll. To pit various matching features against each other (e.g., to offer children a choice of justifying the pairing on the basis of color or FUF type – see Trial 5 of this task, in Table 2), it was necessary to use small dolls alongside big ones. Table 2 shows that the first two trials of the pair justification task offered only hair (the control feature) and color as possible grounds for the match. These trials were placed at the beginning of this task because of the possibility that the immediately preceding third part of the triad task might serve to direct children’s attention to FDFs, creating a response bias that would carry over to this subsequent task. On each trial the child was instructed as follows: “Now I am going to show you some pairs of friends that someone else, who was here with me another time, chose because they are alike. I want you to tell me why you think someone might have picked out these two friends, saying they are alike. What do you think might have been the reason for picking them out and saying that they are alike?” Across the eight trials, the child had six opportunities to justify according to color; two to justify according to FDFs, and four to justify according to FUFs. Table 2 shows which grounds for pair justification were present on each trial.

2.4. Coding of responses to comprehension checks and memory questions

Tape-recordings of storytelling and testing sessions were used to assess children’s responses to the comprehension checks, their recall of individual dolls’ names and of the types of feature, and their recall of events and features entailed in specific stories. For the comprehension checks, assessments (correct/incorrect) made by listening to tapes served to double-check on assessments made during storytelling (see Appendix A). Two coders independently coded all the responses for all 22 children. Appendix B contains the coding schemes for recall. Initially, the scores for two children were used to achieve consensus on how to apply the criteria. The inter-coder reliability was calculated, for the remaining children (10 in each of the 4-story and 8-story conditions), by expressing the total number of agreements as a percentage of agreements plus disagreements. The overall reliabilities (and ranges, across children) were 97% (94–99%) for the 4-story and 98% (95–98%) for the 8-story condition. Disagreements were resolved by discussion.

3. Results and discussion

The main hypothesis to be tested was that the degree of differentiation that a feature provides is likely to influence whether that feature is construed by children as of central or of peripheral importance in a body of knowledge. If two forms of a feature (e.g., eyes on stalks vs a hooded eye) turn out to be adapted equally well to two different environments (FUF), that feature should be accorded less importance than other features that exhibit contrasting adaptations (e.g., tough hands and feet with superior capabilities for acting in one of the environments vs sticky hands and feet with superior capabilities in the other – FDF). Specifically, after children had been exposed to information contained in a series of stories they were expected to show greater attunement, relatively speaking, to features of the story characters that provided the most fine-grained differentiation of them (i.e., to show greater attunement to FDFs). Wherever possible, the key analyses to be reported relied on a direct measure of greater attunement to FDFs that we call the “FDF advantage” score, obtained by subtracting individual children’s scores for FUFs from their corresponding scores for FDFs.

Two main findings supported the primary hypothesis; one pertaining to children’s pair justifications and one to their delayed recall. First we discuss the results for pair justification and other analyses germane to the interpretation of them, including the somewhat less informative results obtained for the triad task, and then proceed to discuss findings for memory. Unless specified otherwise, all the statistical probabilities reported are for 2-tailed tests.

3.1. Evidence from children’s pair justifications and related aspects of the findings

The pair justification task consisted of 8 trials, on each of which the child was presented with two possible grounds for justifying a pairing (see Table 2). An FDF advantage score was created (range: –4 to 4) that was based on children’s first responses on each trial. Note that to be counted a child’s response had to be one that named
a feature shared by the two dolls presented (i.e., a legitimate justification for the pairing). If a child named a feature possessed by only one doll that response was ignored. There were 26 trials out of the total of 176 on which a child's response did not indicate a legitimate basis for the pairing (comprising 1 naming of an FDF on Trial 1, 1 naming of Hair on Trial 4, 10 instances of naming Color on Trial 5 or Trial 6, and 14 instances of naming Color on Trial 7 or Trial 8) and there was one further instance of a child's giving no response at all (on Trial 1). As shown in Table 2, for Trials 1 and 2 the only legitimate justifications were on the basis of color (a feature not mentioned at all in the stories) and Hair (the Control feature). The trials across which a child could accumulate up to 4 justifications naming FDFs were Trials 3, 4, 7 and 8. Similarly, up to 4 justifications naming FUFs could be accumulated on Trials 3, 4, 5 and 6. Because justifications based on an FDF and an FUF were pitted against each other on Trials 3 and 4, a child could not achieve the maximum score of 4 for both FDFs and FUFs. The actual FDF advantage scores (number of FDF responses – number of FUF responses) obtained ranged from −4 to 3 \((M = 0.14, SD = 1.89)\). A 2(Condition: 4-story vs 8-story) X 2(World:TF vs ES) Analysis of Variance was conducted on these scores. The two-way interaction was not significant, neither was the main effect of World. However, there was a significant main effect of Condition, \(F(1,18) = 9.10, p < .01\), and tests against chance expectancy (0) revealed that the average performance of children in the 8-story condition \((M = 1.17)\) represented a significant positive FDF advantage, \(t(11) = 2.75, p < .05\), whereas that of children in the 4-story condition \((M = −1.10)\) did not differ significantly from zero. The significant effect of the number of stories was confirmed using a non-parametric approach, Mann–Whitney \(U(n_1 = 10, n_2 = 12) = 20, p < .05^2\).

Examination of the justifications given on particular pairs of trials helped to pinpoint the circumstances under which children in the 4-story and 8-story conditions did and did not diverge in their responding. Trials 7 and 8 of the pair justification task each pitted an FDF and Hair (Control feature) against each other as legitimate bases for pairing (see Table 2). In the 4-story condition, 4 of 10 children cited the available FDF on both of these trials; and 8 of 12 children in the 8-story condition did so. For these two trials, the association between condition and tendency to cite FDF features consistently (2 times vs fewer than 2 times) was not significant, Fisher's Exact test. Similarly, the association between condition and tendency to cite FUF features consistently (rather than the alternative, Hair, or a non-legitimate basis for pairing) on Trials 5 and 6 was not significant. On these trials, 7 out of 10 children in the 4-story condition and 7 out of 12 children in the 8-story condition cited FUFs both times. These two non-significant associations contrast with what was found for Trials 3 and 4, in which the possibilities of justification based on an FDF and an FUF both were present. Only 1 of the 10 children in the 4-story condition cited an FDF on both of Trials 3 and 4, whereas 7 of the 12 children in the 8-story condition did so, Fisher's Exact \(p < .05\). When children were faced with an FDF and an FUF as the only two viable options, there was a significant, positive relation between the number of stories they had heard and their tendency to justify pairings by appealing consistently to FDFs rather than FUFs. On these particular trials, the mean numbers of FDFs (out of 2) cited by children in the 4-story and 8-story conditions were, respectively, 0.7 and 1.5, \(t(20) = 2.77, p < .05\). Consistently with the non-significant results of Fisher exact tests for pairs of trials other than Trials 3 and 4, reported above, there was no significant difference between the mean numbers of FUFs (out of 2) cited on Trials 5 and 6 by children in the 4-story \((M = 1.6)\) and 8-story \((M = 1.5)\) conditions, and, similarly, no significant difference between the numbers of FDFs (out of 2) cited on Trials 7 and 8 by children in the 4-story \((M = 1.1)\) and 8-story \((M = 1.6)\) conditions, \(t(20) < 1.5, ps > .10\).

In summary, only if they had heard as many as eight stories did children in this study show sensitivity, in a pair justification task, to features' differing capacities for differentiation. When differentiating and comparable non-differentiating features were pitted against each other, children with a greater degree of experience were significantly more likely to select the former, consistently, as grounds for calling two creatures “alike” than were children with less experience.

### 3.1.1. Comprehension check

The effect of differentiation on children's pair justifications led us to compare children in the 4- and 8-story conditions on their grasp of the feature-function links that turned out to exert a greater influence for just those with the more extensive experience. The comprehension check questions, of which there was one asked toward the end of each story, assessed children's understanding of the functional differentiation provided by FDFs (see Stories). For children in the 4-story condition, the mean number of correct answers to comprehension checks (out of 4) was 3.40 (85%; \(SD = 21\%\)), and for children in the 8-story condition, the mean (out of 8) was 6.48 (78%; \(SD = 15\%\)). These levels of success both are significantly above chance expectancy (50%, since in each comprehension check a child had to choose one of two dolls), \(t(4\text{-story}, df = 9) = 5.25, p < .01\), and \(t(8\text{-story}, df = 11) = 6.41, p < .01\). These results show that all participants, regardless of condition, understood the feature-function linkages that constituted the difference between FDFs and FUFs.

### 3.1.2. Responses to the triad tasks

The triad tasks, presented after children had heard all the stories, were of three different types: No Context triads \((N = 4)\), in which the participant was simply asked which two of the three dolls presented were most alike, Park triads \((N = 4)\), for which the participant was given a specific park as a location, and Task triads \((N = 4)\), in which participants were told about a specific task that could only be completed using the appropriate FDF (with this, in turn, 2 Because there were more girls than boys in the 8-story condition and more boys than girls in the 4-story condition, the possibility of a significant effect involving sex was explored. A 2(Condition: 4-story vs 8-story) X 2(Sex: F vs M) Analysis of Variance, conducted on the FDF advantage scores, yielded only a significant main effect of condition. Neither the main effect of Sex nor the two-way interaction approached significance, \(F(1,18) < 0.10\).
simply be the less sensitive measure of children's views of similarity, the triad task doing so more than pair justification. It leaves children open to the influence of perceptual similarity, which might be considered to differ in the degree to which they generate such a pair when faced with a triad involving two other shorebirds that are similar in terms of overall morphology. (p. 427). Perhaps, because a triad task is functionally undifferentiated for children in one condition and functionally undifferentiated for children in the other. This meant that, overall, functionally differentiated and functionally undifferentiated features were equally salient in perceptual terms. Whatever the underlying explanation, our results, like those of Johnson and Mervis (1994), show pair justification to be more sensitive than a triad task as a means of assessing children's use of subtle behavioral functional information.

In summary, the pair justification task yielded evidence of the importance of differentiation in children's use of features, for just those children whose exposure to information extended across as many as eight different stories. Children's responses to the comprehension checks and to the set of triads presented with Task contexts provided no evidence that their basic grasp of the feature-function linkages differed according to whether they had been exposed to information in eight or in just four stories. This means that the difference in performance on pair justification, according to the number of stories heard, cannot be attributed to a simple difference in mastery of the information conveyed. Finally, in contrast to what was found for their pair justifications, children did not rely to a significantly greater extent on functionally differentiated than functionally undifferentiated features in the triad task when given No context, or simply a Park context, without the specification of any particular feature (Task) to be accomplished there.

3.2. Children's recall of information conveyed in stories

The second main question of interest is whether the degree of differentiation offered by features had an impact on children's recall of information. Children's ability simply to recall the names of features would provide a foundation for remembering specific activities and outcomes that they heard described in the stories. The most important tests of children's memory were the questions asking them to name a particular feature that had been involved in a specific activity (Feature questions) and questions asking them to describe a particular event in which a specific feature had been used (Event questions). These two types of question were asked about both FDFs and FUFs. Feature questions also were asked concerning the control feature (Hair), and Event questions were asked concerning the control events (see Procedure and Appendices).

Recall was tested immediately following the telling of each story and there also was a delayed test in which children's recall of information from the first and last pairs of stories that they had heard was probed. Note that there are two ways in which the 4-story and 8-story conditions differed in the delayed testing of recall. They differ both in the number of pairs of stories intervening between the first and last pairs of stories told (0 vs 2 pairs intervening) and also in the length of the interval between the first and...
and last story-telling sessions (1- vs 3-week interval). Because the delayed testing of recall occurred 1 week after the final story-telling session (see Table 1), the stories from which information had to be remembered had been told to children in the 4-story condition in sessions occurring 2 weeks and 1 week prior to the test, whereas they had been told to children in the 8-story condition in sessions occurring 4 weeks and 1 week prior to the test. This means that the short delay is the same for the 4- and 8-story conditions whereas the long delay for the 8-story condition is twice that for the 4-story one. It was expected that differences in children's experience would influence the relative importance accorded to FDFs, as compared with FUFs. It was unclear whether to expect differences in the length of delay before testing to affect memory for FDFs and FUFs comparably or differentially.

### 3.2.1. Delayed recall of function-related information conveyed in stories

The delayed testing of recall of information from stories occurred in a session in which no stories were told to children. As explained earlier, this testing included questions pertaining to the last pair of stories told to the participants (1 week earlier for both the 4- and 8-story conditions) and the very first pair of stories told (2 weeks earlier for the 4-story condition; 4 weeks for the 8-story condition). We compared recall for questions pertaining to FDFs to recall for questions pertaining to FUFs, in order to find out whether the differentiation of a feature according to its functioning might facilitate memory for details of stories in which it was involved. We calculated two different FDF advantage scores, one for Feature questions and one for Event questions, to represent children's recall of stories belonging to the first pair presented to them and, separately, their recall of stories belonging to the last pair presented. This meant that four such scores were derived for each child, each one calculated as the FDF score for one type of question (maximum possible per question = 4, see Appendix B for coding scheme), averaged across stories forming a pair, minus the corresponding averaged FUF score (maximum possible = 4) for the same pair. The FDF advantage scores for recall of story details thus could range from −4 to 4. For pairs of stories, the actual FDF advantage scores obtained covered the full range from −4 to 4 (M = 0.33) for Event Questions and also the full range (−4 to 4, M = −0.33) for Feature Questions (Standard deviations are not reported because each child contributed two scores to the total set for Event questions, one for the first and one for the last pair and, similarly, two for Feature questions).

The FDF advantage scores explained above were entered in a 2(Condition: 4-story vs 8-story) X 2(World: TF vs ES) X 2(Stories: First pair vs Last pair) X 2(Feature Type: Event vs Feature) mixed-design Analysis of Variance, with repeated measures on the last two factors. There was an unanticipated significant difference in the FDF advantage scores for ES as compared with TF features, revealed by a significant main effect of World, F(1, 18) = 30.99, p < .001. The FDF advantage was significantly above zero for World ES (M = .89, t(10) = 4.13, p < .01), whereas it was significantly below zero for World TF (M = −.86, t(10) = −4.23, p < .01). The significant main effect of World on recall of information from the stories was confirmed using a non-parametric approach, Mann–Whitney U(n1 = n2 = 11) = 3, p < .001. This result may reflect, at least in part, the finding (to be reported below) that the names of E/S features themselves turned out to be more memorable, overall, than the names of TF/F features.

The Condition X Question Type interaction also was significant, F(1, 18) = 5.10, p < .05, and this two-way interaction was not qualified by any significant higher-order interaction (all Fs < 1). However, as will be reported below, the possibility of a pattern of differences fitting a higher-order interaction was explored by means of supplementary nonparametric tests, in view of the limited power to detect such higher-order effects in the 4-factor ANOVA. Comparisons of the four relevant mean FDF advantage scores to chance expectancy (0) revealed that children in the 8-story condition showed a significant FDF advantage for Event questions, M = .85, t(11) = 3.22, p < .01, but not for Feature questions, M = −.33, t(11) = −.73. Children in the 4-story condition did not have FDF advantage scores differing significantly from zero, either for Event questions (M = −30) or for Feature questions (M = −.28), t(9) = −.91 and −.59, respectively.

This pattern of findings indicates that children who have accumulated experience of feature-function relations (some of which differentiate whereas others do not) over as many as eight stories are affected, in their recall of events from stories, by the degree of differentiation that the feature-function relations provide. Children who have accumulated experience of the same relations over half as many stories (and weeks) show no such effect. This FDF advantage manifested itself only in responses to questions requiring children to remember the details of a unique event that occurred in a particular story (Appendix B contains examples of questions), and not in responses to questions probing their memory of exactly which feature was used to accomplish a feat.

To complete the analysis of children's recall of information from the stories, a set of nonparametric analyses was conducted, with the aim of confirming and probing further the form of the Condition X Question Type interaction found in the 4-factor ANOVA. The focus was on the differ-

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3 Because girls and boys were represented approximately equally in the groups who heard stories set in the different Worlds (World TF − 5F, 6M; World ES − 6F, 5M), possible sex differences could not offer an alternative account of the main effect of World and supplementary analyses were not conducted.

4 Supplementary analyses were carried out to check for possible effects involving sex, bearing in mind that girls and boys were not distributed evenly across the 4-story and 8-story conditions. Two 2(Condition: 4-story vs 8-story) X 2(World: TF vs ES) X 2(Stories: First pair vs Last pair) X 2(Feature Type: Event vs Feature) mixed-design Analysis of Variance, with repeated measures on the last two factors. There was an unanticipated significant difference in the FDF advantage scores for E/S as compared with TF/F features, revealed by a significant main effect of World, F(1, 18) = 30.99, p < .001. The FDF advantage was significantly above zero for World ES (M = .89, t(10) = 4.13, p < .01), whereas it was significantly below zero for World TF (M = −.86, t(10) = −4.23, p < .01). The significant main effect of World
ence between FDF advantage scores for Event questions and Feature questions. The previously-reported analyses indicated that for children who had heard eight, but not those who had heard only four stories, the FDF advantage score was higher for Event questions than for Feature questions and, relatedly, that the mean FDF advantage score for Event questions in the 8-story condition was the only mean that differed significantly from chance expectancy (0). These effects and findings involve FDF advantage scores combined across the two levels of the Stories factor (First pair and Last pair). However, it was of interest to examine results separately for the first and last pairs, because it could be argued that children’s recall might differ according to the differences (in time, and also in the number of intervening stories, see above) represented by the factor of Stories. As noted earlier, the absence of any significant higher-order interaction effects (most importantly, the 3-way interaction of Condition X Question Type X Stories) in the 4-factor ANOVA might reflect a lack of power to detect higher-order effects. Whereas nonparametric analyses could not test in a direct way for the presence of a significant 3-way interaction, they could be used to examine the difference between FDF advantage scores for Event and Feature questions in the experimental conditions concerned. This was done separately for each of the four Conditions (4-story vs 8-story) X Stories (First pair vs Last pair) combinations.

For the Last pair of stories (i.e., the stories all children had heard 1 week prior to the testing of recall), applications of the Wilcoxon Matched Pairs Signed Ranks Test showed that neither for children in the 4-story condition, nor for children in the 8-story condition was the FDF advantage score for Event questions significantly different from that for Feature questions: $T = 20, N = 9$, for the 4-story condition (1 child had equal scores for the two types of question); $T = 28, N = 12$ for the 8-story condition. The mean FDF advantage scores (SDs) for the Last pair of stories were as follows: 4-story Event questions, $-0.70 (1.01)$; 4-story Feature questions, $-0.25 (1.95)$; 8-story Event questions, $0.79 (1.70)$; and 8-story Feature questions, $-0.33 (2.77)$. In contrast, for the First pair of stories (i.e., those that the children in the 4-story condition had heard 2 weeks prior to the testing of recall, as compared with 4 weeks prior for children in the 8-story condition), the findings differed for the 4-story and 8-story conditions. The FDF advantage scores were significantly higher for Event questions than for Feature questions in the 8-story condition, $T = 6.5, N = 10$ (2 of the 12 children had equal scores for the two types of question), whereas the difference between the FDF advantage scores was not significant for the 4-story condition, $T = 13, N = 8$ (2 of the 10 children had equal scores for the two types of question). The mean FDF advantage scores (SDs) for the First pair of stories were as follows: 4-story Event questions, $0.10 (1.61)$; 4-story Feature questions, $-0.30 (2.21)$; 8-story Event questions, $0.92 (1.22)$; and 8-story Feature questions, $-0.33 (1.64)$. These findings suggest that the effects of the degree of differentiation on memory, found for just the 8-story condition, might also be specific to (or perhaps more pronounced for) the longer of the two intervals (4 weeks) involved in the delayed testing of recall for that condition.

One important question is whether the memory findings are related to encoding or recall. If they reflect enhanced encoding of FDFs, then we should see differences in immediate recall as well. If the differences are due to effects during consolidation or retrieval, or due to the accumulation of knowledge, then we should find that 4 and 8 story children do not differ on tests of immediate recall.

3.2.2. Immediate recall of function-related information conveyed in stories

FDF advantage scores for immediate recall were calculated in the manner described earlier for delayed recall (although each child received only two scores, reflecting responses to questions about the single pair of stories that had been told in the session concerned). The responses for the Last pair of stories were examined first. The Last pair was the pair told in the second session to children in the 4-story condition and the pair told in the fourth session to those in the 8-story condition (see Table 1). Children’s FDF advantage scores (with a possible range from $-4$ to $+4$) were entered in a $2(\text{Condition}: \text{4-story vs 8-story}) \times 2(\text{World}: \text{TF vs ES}) \times 2(\text{Question Type}: \text{Event vs Feature})$ mixed-design Analysis of Variance, with repeated measures on the third factor. There were no significant main or interaction effects for children’s immediate recall of information from the Last pair of stories. However, the lack of any significant effect involving the factor of World in the final testing session for immediate recall turns out to be revealing when it is considered in relation to the results of a parallel analysis of children’s immediate recall for the First pair of stories (i.e., recall at the end of what was the first session for both the 4- and 8-story conditions).

For children’s immediate recall of information from the First pair of stories, tested at a point where the 4-story and 8-story groups had equivalent experience with the features and recounted events, a significant main effect of World was found, $F(1, 18) = 4.98, p < .05$, reflecting a higher FDF advantage for World ES ($M = 0.84$) than for World TF ($M = -0.09$). This effect was not dependent on condition, $F(1, 18) < 1$ for the 2(Condition) X 2(World) interaction. Confirmation of the significant effect of World on FDF advantage scores for immediate recall of the First pair of stories was obtained through a non-parametric analysis, Mann–Whitney $U(n_1 = n_2 = 11) = 32.5, p < .05, 1$-tailed. Comparisons to chance expectancy showed that the mean positive FDF advantage for World ES was significantly different from zero, $t(10) = 3.48, p < .01$, whereas the corresponding negative value for World TF did not differ significantly from zero. These findings of an initial advantage in recall for information relating to World ES, as compared with World TF, are consistent with a more basic result concerning children’s recall of feature names (full details of which can be found in a later section), namely, that the E/S features (FDFs in World ES, FUFs in World TF) had names that were easier to remember than both those for the T/F features and those for Hair (Control feature). At the first point where children were tested on their memory for information conveyed in the stories, the more readily recalled names of E/S features may have contributed to children’s having had a greater degree of success, initially, in remembering aspects of stories in which those
particular features were mentioned and displayed (regardless of their status as FDFs or FUFs). As reported above, when immediate recall for the Last pair of stories was tested, subsequently, there was no longer any significant effect involving World. The results for immediate recall of details from the First and Last pairs of stories, taken together, support the conclusion that the features that were FDFs in World ES and FUFs in World TF (and/or the events involving those features) may have been easier, at first, for children to encode than the other set of features (and/or the events involving them), but that this differential ease of encoding declined as more stories were told.

3.2.3. Interpretation of children’s recall of function-related information

Considering the memory results as a whole, the pattern of findings for delayed recall of function-related information can be seen to reflect the constraints that the function of a feature puts on memory processes, specifically at the delayed point of testing. An FDF advantage was found only for the children who were given a greater amount of experience (8 stories, rather than just 4); and it occurred only for delayed recall of story events (given a subtype of feature as a cue). There also was some evidence (from supplementary analyses) to suggest that this effect held more strongly for the longer (4 weeks) than the shorter (1 week) of the two intervals involved in the testing of delayed recall for the 8-story condition. For both FDFs and FUFs, the feature mentioned in a question had a specific function that it performed, constraining the possible events that might serve as a suitable answer. This served FDFs and FUFs equally well in cases where the question pertained unambiguously to just a single story, as was the case in tests of immediate recall. At delayed testing, on the other hand, there were many possible stories that the question might pertain to, and many possible events that could interfere with recall of the correct information. In the case of FDFs, the feature’s function constrains the possible answers twice as much as it does for FUFs. To see this, consider the question “What did Juf use his hooded eye to do?” If the hooded eye was an FDF, then it was exclusively used to see when the wind was blowing sand into the air. This constrains both the kind of activity it was used for – seeing/searching for something – and also constrains the location (Sand Dunes Park) in which the activity took place, making recall more likely. If the hooded eye was an FUF, on the other hand, it was used simply to see. Because eyes-on-stalks were also used to see, twice as many story events entailed characters using some kind of eye to look for something. Also, the activity occurred equally often in both parks of any given “world”, so events that occurred in another location also potentially could interfere with recall. The additional interference in recall is again doubled when the number of stories doubles from four to eight. As the amount of interfering information in memory is increased, the need for more exclusive connections within this information to constrain the possibilities also increases.

3.3. Children’s recall of names for the characters and features

The most basic kinds of information for which children’s recall was tested were the specific names of dolls and the names of the contrasting forms of the five story-relevant features. Memory of these names was tested in each story-telling session after the first one (i.e., in one session for children in the 4-story and three sessions for those in the 8-story condition) and also in the subsequent delayed recall session for children in both conditions. Children’s recall of character names was coded as the number of correct answers to the sets of questions (“Which one is Kag?”, etc.), out of a possible total of 3 for each set. Recall of two sets of names was tested within each session, making 6 the total possible score per session. The two testing sessions that children in the 4-story and 8-story conditions had in common were the first and the delayed sessions. The scores for these two sessions were analyzed in a 2(Condition: 4-story vs 8-story) X 2(World: TF vs ES) X 2(Session: First vs Delayed) mixed-design Analysis of Variance, with repeated measures on the last factor. There were no significant main effects or interactions. Children’s mean recall of the names in the first testing session was 2.91 and at delayed recall was 3.32 (out of a possible 6.00). Even though both of these means significantly exceeded chance expectancy (2.17 – t(21) = 2.30, p < .05 and 3.69, p < .01, respectively) – there was no significant improvement from the initial to the last session. Children had only modest success in recalling the characters’ names, throughout. This perhaps is not surprising, seeing that, throughout the storytelling procedure, the doll that was acting in the story was always picked out by being pulled forward, out of line with the other characters, thereby removing any necessity for children to identify dolls by name.

Children’s recall of each of the 10 feature names was coded on a scale from 0 to 4 (see Appendix B). We obtained an E/S score by averaging across the four questions for those co-varying features, an analogous T/F score by averaging across the four questions for those co-varying features, and then derived an FDF advantage score as described earlier. FDF advantage scores were analyzed in a 2(Condition: 4-story vs 8-story) X 2(World: TF vs ES) X 2(Session: First vs Delayed) mixed-design Analysis of Variance, with repeated measures on the last factor. The only significant effect was the main effect of World, F(1, 18) = 9.99, p < .01, indicating that the FDF advantage was greater for World ES (M = 0.35) than for World TF (M = –0.45). In fact, as the means indicate, for World TF the FDFs were at a disadvantage in recall, as far as their names were concerned, and tests against 0 showed that this was a significant disadvantage, t(10) = –2.28, p < .05, and also that for World ES the (positive) FDF advantage fell short of significance, t(10) = 2.10, p < .07. This pattern of results suggests that, regardless of which world children heard stories about, they found the names for the E/S features (i.e., the ones that turned out to be FDFs for World ES, FUFs for World TF) easier to remember than those for the T/F features. This was true for both the First and Delayed testing occasions. To explore this finding further, we obtained scores representing children’s mean levels of response (0 to 4 scale, see Appendix B) not just for the E/S and T/F features but also for the control feature (Hair) and conducted a 2(Condition: 4-story vs 8-story) X 2(World: TF vs ES) X 3(Feature Type: E/S, T/F, Hair)
mixed-design Analysis of Variance, with repeated measures on the third factor. It should be noted that these scores were averages across a total of 8 responses for both the E/S and the T/F features (comprising responses to 4 questions in the first and 4 in the delayed session), whereas they were averages across a total of 4 responses for Hair (2 per session). The only significant effect was a main effect of Feature type, $F(2, 36) = 7.45, p < .01$. Scheffé post-hoc tests indicated that the names of E/S features were recalled significantly better than both the names of T/F features and the names of the control feature (Hair) ($M_S = 2.86$ ($SD = 0.54$), $2.46$ ($SD = 0.58$) and $2.43$ ($SD = 0.48$), respectively; maximum possible score = 4.00). These two significant differences were confirmed using the non-parametric Wilcoxon Matched Pairs Signed Ranks test, $T = 36$, $N = 21$, $p < .01$, and $T = 29.5$, $N = 19$, $p < .01$, respectively, for the comparison of recall for E/S and T/F names (1 child had equal scores for these types) and the comparison of recall for E/S and Hair names (3 children had equal scores). This result was somewhat surprising because a considerable amount of piloting conducted with both children and adults gave no indication that the names of E/S features were more memorable than those of the T/F features or Hair. Whether there is a difference in the memorability of the features per se, or whether, for example, something about the way that they were set in story contexts might have led to more effective recall is unclear. It also is possible that children’s background knowledge may have made some features more memorable (e.g., knowledge of camels may have made it relatively easy to remember the name “water sack”). Overall, it can be concluded that children were able to remember a moderately-sized set of feature names that incorporated at least some that could be considered challenging (e.g., “eyes-on-stalks”, “hooded eye”, “gripper tail”). The fact that we chose names in such a way as to capture the perceptually available characteristics of many of the features (e.g., “loopy hair”, “soft tail”) may have aided children in their recall. More broadly, it seems plausible to suggest that 5- to 6-year-old children’s recall in our study is comparable to that shown by similarly-aged children in studies of event memory, although no precise comparisons can be made because of methodological disparities.

4. General discussion

In this study, we used adaptive features of toys, created to represent new animal kinds, to test a specific notion about why some feature-function relations may become more important than others, with accumulated experience, in children’s memory and similarity judgments. We reasoned that a plausible explanation of children’s attunement to function might be given in terms of differentiation. We found that children who heard eight stories, but not those who heard only four, cited functionally differentiated more than functionally undifferentiated features in a pair-justification measure of similarity, and that their memory, after a delay, for details of specific stories was better when they were asked to recall events that had involved the use of functionally differentiated features than when they were asked to recall events that had involved the use of functionally undifferentiated features. The degree of differentiation that features afford appears to exert effects on the acquisition, organization and recall of new information. Young children who have not been given any explicit training in the categorization of novel items show its influence, suggesting that they may have a natural propensity to discern and use whatever information can differentiate.

Because of its short-term longitudinal design, the present study was able to reveal an impact of features’ differentiating capability on children’s memory and similarity judgments that depended critically on the amount of experience: effects of differentiating capability were evident for the 8-story but not the 4-story condition. This was true even though the children in these conditions showed equivalent knowledge in several respects. They showed comparable basic recall of the names of features and characters. Both groups of children chose the functionally appropriate dolls in post-storytelling triads for which a task context (e.g., being in a sandstorm) was set, and both succeeded on the comprehension checks incorporated in the stories, supporting the conclusion that the two groups of children were comparable in their basic understanding of the differentiating feature-function linkages (e.g., hooded eye for seeing in a sandstorm: eyes-on-stalks for seeing over tall reeds). Our overall pattern of findings suggests that, whereas hearing four stories provided a body of information sufficient for children to master the basic facts, most crucially those concerning feature-function linkages, hearing four more stories that elaborated on the preceding ones and/or experiencing the repeated testing of immediate recall brought children to a point of structuring their knowledge in a particular way. Analogous outcomes have been found in other studies and through simulations.

Johnson and Mervis (1994), in their study of young children’s acquisition of expertise, found that, although novice children were able to learn the subtle but informative behavioral attributes of shorebirds (linked with features that differed in their perceptual salience), they, in contrast to a child with a background of directly-relevant expertise, did not tend to favor those informative attributes in their judgments of similarity. Rogers and McClelland’s (2004, Chapter 3) simulations of the acquisition of conceptual knowledge with an artificial neural network showed a similar result. For the network, information that can be used to make fine distinctions in a domain became important after the network had learned to make basic distinctions. For example, activation of the property “has wings” given the input “canary” increased dramatically only after the network had learned to distinguish between plants and animals, and activation of the property “is yellow” given the input “canary” increased only after the model had learned to distinguish between birds and fish. In these contexts, attunement to fine-grained means of differentiating was evident subsequently to, rather than contemporaneously with, the learning of basic information. In general, Rogers and McClelland’s work is supportive of the importance of differentiation. In their words: “Coherent covariation of properties across items and contexts drives conceptual differentiation and determines what properties are central
and what properties are incidental to different concepts” (2004, p. 350). In our study, the degree of differentiation that features afforded can be interpreted as a manipulation of the “coherent covariation of properties”.

Our results can be added to those, arising from a variety of areas of investigation, that indicate that perceived similarity is not simply raw material provided by the senses, but is in fact malleable by and in that sense a product of experience (e.g., Blair & Homa, 2005; Goldstone, 1994a; Lewandowsky, Kalish, & Griffiths, 2000; Livingstone, & Andrews, 2005; Lynch, Coley, & Medin, 2000; Schyns & Rodet, 1997). There are two key points that merit elaboration. The first is that young children and even younger infants, are sensitive to the degrees of differentiation afforded by various aspects of the information to which they are exposed. This has been shown experimentally, for example, in studies of the effects of varying distributional information on infants’ phonetic discrimination (e.g., Maye, Weiss, & Aslin, 2008; Maye, Werker, & Gerken, 2002), in studies of infants’ ability to learn to discriminate between physical events (e.g., Schilling & Clifton, 1998), in studies of the effects of differing contextual domains (animals versus tools) on children’s use of correlated features in category learning (Barrett et al., 1993), and in the Hammer and Diesendruck (2005) study of children’s (and adults’) categorization of artifacts. Somewhat further afield, it has been found that children 7, 5 and even as young as 4 years of age show sensitivity paralleling that of adults to facial distinctiveness, both at the featural and at the second-order, relational level (Gilchrist & McKone, 2003; McKone & Boyer, 2006; but see Mondloch, Dobson, Parsons, & Maurer, 2004). In these and other areas of perceptual and conceptual development, there is mounting evidence of early sensitivity to regularities, such as patterns of intercorrelation, distributional information, and the degrees of differentiation afforded by particular contrasts. Our manipulation of the degree of differentiation offered by feature-function relations, keeping the type of information constant, yielded new evidence that differentiation per se is an influential regularity.

The second point concerns the role of experience in the acquisition and structuring of knowledge, especially that of children early in life. In our study, we sought to simulate the gradual process, involving intermittent exposure to a body of new information, that presumably characterizes children’s everyday experience. The feature-function relations and the contextual settings that determined how much they served to differentiate between toy characters were conveyed in stories, with the help of props. Our procedures did not give children any direct experience of feature-function linkages of the kind they gain during everyday life. Children were not shown the toy characters “in action”, meaning that they had to rely entirely on verbal description to grasp the functions to which reference was made in the stories. The extent to which young children are able to glean functional information from verbal descriptions is not easy to establish. It is plausible to think that early in development they may acquire knowledge most readily about domains in which information conveyed to them through language connects with their direct experience. Evidence to support this reasoning comes from a recent study by Tarlowski (2006), who examined the effects on children’s thinking about biology of two kinds of exposure to information. Tarlowski found that 4- to 5-year-old children’s reasoning differed both according to whether they had had the kind of direct experience of nature afforded by living in a rural setting, as opposed to an urban one, and also according to whether their parents were expert biologists (e.g., zoo-keepers, veterinarians, foresters), as opposed to lay people with respect to biology. A broader, related area of current debate is that of whether there may be differences in young children’s understanding of domains such as cosmology (e.g., Nobes et al., 2003; Samarapungavan, Vosniadou, & Brewer, 1996; Siegal, Butterworth, & Newcombe, 2004), and of origin, purpose and design in nature (e.g., Kelemen, 2003, 2004), reflective of differences in their cultural and/or educational backgrounds. It goes without saying that the limited amounts of experience given to children in our study are dwarfed by what they derive naturally in the course of everyday life. Nevertheless, it is noteworthy that information conveyed through eight stories, told at the rate of two per week, was sufficient to create, for the children who heard those stories and responded to questions about them, views of the story characters that differed according to the feature-function linkages that held for the particular “world” in which the stories they heard were set.

In conclusion, seminal research concerning young children’s acquisition of expertise has documented the contributions of various forms of information, contrasting, for example, the influences of morphological resemblance and behavioral function (e.g., Johnson & Mervis, 1994). The present study focused on a single form of information, feature-function relations, and explored the impact of different degrees of differentiation that any particular feature-function relation might offer. Our findings support the view that the structure of semantic information can be an important determinant of similarity relations and also memory performance. Because of the resemblance of our storytelling procedure to naturally occurring events in a young child’s life, it is plausible to think that sensitivity to differentiation is an important tool that is useful to children from a very early point in their perceptual and cognitive development. If we consider these results in conjunction with those of other work (e.g., Hammer & Diesendruck, 2005; Rogers & McLeod, 2004), it is clear that there are differences in the processing of information to be explored that occur as a function of the previous experience of the learner (c.f. Vosniadou & Brewer, 1987). On a broader scale, there may be related differences in processing linked with differences in socio-cultural and/or educational experiences (e.g., Siegal et al., 2004; Tarlowski, 2006; Van de Wiel, Boshuizen, & Schmidt, 2000). Further exploration of how the influence of the degree of differentiation offered by incoming information may wax and wane, under conditions of various kinds and as the long-term acquisition of knowledge proceeds, seems a promising way to gain new insight into both developmental change and novice-to-expert shifts taking place in adults. Deeper understanding of developmental change and novice-to-expert shifts is an important goal because differences in expertise are implicated in diverse ways in children’s and adults’ judgments and reasoning about categories of objects, living
things, clinical diagnoses, the behavior of bushfires, and even entities grouped in ad hoc ways (Alexander, Johnson, & Schreiber, 2002; Keil, 1994; Lewandowsky & Kirsner, 2000; Little, Lewandowsky, & Heit, 2006; Proffitt, Coley, & Medin, 2000; Shafto & Coley, 2003; Van de Wiel et al., 2000).

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Portions of these findings were presented at the Biennial Meeting of the Society for Research in Child Development in Tampa, Florida, USA in April 2003.

Appendix A

A.1. Story title: “Going on a Picnic and Flying Kites”

A.1.1. Version of story for Sand Dunes Park (one of two parks forming World ES)

One windy day, Zab, Hep, Nud and Wey went out to fly their new kites and have a picnic. [Zab-F] Zab was the leader that day and he decided it would be best to fly them at Sand Dunes Park. So they got their kites and string, gathered all their picnic stuff and went to the park. [Zab-B]

When they got to the park, the wind was starting to blow and Zab, who was the leader asked Nud to look for an open space out in the middle of the sand dunes where there would be plenty of room to fly their kites. [Nud-F] Nud said that it would take him a long time to find a place because he would only be able to see when the wind stopped blowing sand into the air. [Nud-B] [Hep-F] Hep said: “I can do it! I can use my hooded eye to help me look around even when the wind is blowing and find a good spot to fly our kites!” ([Use of FDF for task that FUF cannot accomplish.] So Hep went off across the dunes to find a place. Soon Hep found the perfect spot. He led his friends across the sand to the place he had found and they all started to put together their kites. [Hep-B].

They made their kites swoop and dive like big giant birds. They had so much fun. After a while, Zab asked [Nud-F] Nud to set out the stuff for the picnic by the rocky river bed. Nud said: “I can use my tough hands and feet to help me walk over to the rocky river bed and put everything there for the picnic ([Use of FUF]). He quickly took the picnic stuff right over the sand to the rocky river bed and started to set up the picnic [Nud-B].

The others started to put away their kites, but [Zab-F] Zab got his kite string all knotted up. It was a big mess. First Wey and Hep laughed at him and told him that his string was all knotted up into loops and looked just like his loopy hair! ([Mention of Control Feature]. Then Wey and Hep decided to help untangle it. Because they helped, at last Zab got the string unknotted and Wey, Hep and Zab went to the rocky river bed for their picnic.[Zab-B].

When they got to the place that Nud had chosen for the picnic, Nud said: “Look what’s happened here!. I thought I had chosen a perfect place for our picnic, but as soon as I started to set everything up all these ants came out of the ground. Now they’re running around all over the picnic cloth and trying to get into the picnic basket! Please help me move everything somewhere else, away from these ants!” ([Mention of Control Event] So they picked up all the picnic things very quickly and moved to another spot where there were no ants at all.

They all were hungry and ate up all the sandwiches they brought. After finishing the sandwiches they were still hungry. Wey said: “We’re going to need some more food! It’s good that we brought those cupcakes.” But when they looked in the picnic basket the cupcakes were not there. Nobody knew what happened to them and they were all puzzled. Zab, who was leading the group that day, said that he knew there were some plants, like cactus plants, way over on the other side of Sand Dunes Park that had sweet fruit growing on them. He said they could eat that fruit, if they could get some, instead of the cupcakes. It was very hot, however, and he knew that walking all the way to get the fruit would make them very thirsty as well as hungry. [Hep-F], Hep said: “I can walk across the park and get us some fruit, even though I know it’s hot and doing it will make me thirsty. My water sack is full and I can drink as much as I need to from it while I’m walking!” ([Use of FDF] So Hep walked across the park and came back with a lot of juicy fruit. [Hep-B] When they had eaten it they were ready to take home the kites and everything else.

Everyone started to gather up their kites and soon they set off to go home. As they were walking along beside the rocky river bed, Wey suddenly said: “There are our missing cupcakes! They are down beside that big pile of dry rocks.” He pointed along the rocky river bed. Hep and Nud came over and stood beside Wey and looked along the river bed to where he was pointing. Sure enough, all the cupcakes had fallen out of the picnic basket and were lying beside a big pile of dry rocks. It was going to be hard to pick them all up and carry them. Zab, the leader, said that three
of them should go and get the cupcakes while one of them should stay with the kites. [Nud-F] Nud said: “I can stay here by the rocky river bed and wave my soft tail like a flag to show you where to come back to!” (*Use of FUF) The others thought that was a good idea of Nud’s and when they had picked up the cupcakes they were able to find their way back easily by watching out for Nud waving his tail. [Nud-B].

They ate the cupcakes and then packed up everything that was left and started home. After they had gone across the sand dunes for a while, Zab realized that they had forgotten one of the picnic baskets. Zab would have sent Hep back across the dunes, where the wind was beginning to blow sand around again, but Hep’s hands were full. Then Zab thought to himself: “I know who else I can ask to go back for the basket even though it’s windy and the sand is starting to blow around in the air!”

("Comprehension check question to child): “Do you know who else can go back and find the picnic basket in the wind? [Record child’s answer: _____________________]"

Response, if child is correct:- “Yes, it’s Wev who can go across the dunes even though sand is blowing in the air”.
Or, if incorrect:- “Oh, it’s Wev who can go across the dunes even though sand is blowing in the air”.

Wev went quickly back across the dunes and got the picnic basket that they had left. Soon they were home again and they told all their friends about what fun they had had flying their kites and having a picnic at Sand Dunes Park. Hep, Nud and Wev said that Zab had been a great leader.

A.1.2. Recall questions and answers (for above version of story set in Sand Dunes Park)

Note: The six questions were asked either in the order shown below or in the reverse of that order at Immediate Testing. For each child, the order of asking at Delayed Testing was the reverse of the order that had been used for that child at Immediate Testing.

1. “What did Nud use his tough hands and feet to help him do?” (Answer: “Walk over to the rocky river bed and set up the picnic.” If the child’s answer was “Walk”, the follow-up question asked was: “Where did Nud walk to?”) (*Event Question – i.e., question about an event that entailed the use of a particular FUF feature.)

2. “What did Hep use his water sack to help him do?” (Answer: “Not get thirsty when he was getting some fruit.” If the child’s answer was “Not get thirsty”, the follow-up question asked was: “What was Hep doing when he didn’t want to get thirsty?”) (*Question about event entailing the use of a particular FDF feature.)

3. “What happened to make the friends move their picnic?” (Answer: “Ants tried to get into the picnic basket.” If the child’s answer was “Ants”, the follow-up question asked was: “What did the ants do?”) (*Question about the Control Event.)

4. “What did Nud use to help the others find their way back to the spot by the rocky river bed?” (Answer: “Soft tail.”) (*Question about the use of a particular FUF feature.)

5. “What did Hep use to help him find a good spot to fly the kites?” (Answer: “Hooded eye.”) (*Question about the use of a particular FDF feature.)

6. “What did Zab have that looked like the kite string all knotted up?” (Answer: “Loopy hair.”) (*Question about the Control Feature.)

A.1.3. Version of story for Prickly Grass Park (one of two parks forming World TF)

One windy day, Zab, Hep, Nud, and Wev went out to fly their new kites and have a picnic. [Zab-F] Zab was the leader that day and decided it would be best to fly them at Prickly Grass Park. So they got their kites and string and all their picnic stuff and went to the park. [Zab-B].

When they got to the park, Zab, who was the leader, said that Hep should look for a place where there was no prickly grass to hurt their feet. There were paths that you could walk on all through the park, but they needed a big open space to fly their kites. [Hep-F], Hep said “I can use my hooded eye to help me find a good spot to fly our kites!” (*Use of FUF) and she went off down the paths to find a place. Soon Hep had found a place that was perfect. She led them down the paths to the place she found and they all started to put together their kites. [Hep-B].

They made their kites swoop and dive like big giant birds. They had so much fun. After a while, Zab, who was the leader, asked Nud to go and set out the stuff for the picnic by a big crater.

When the others got to the place that Nud had chosen for the picnic, Nud said: “Look what’s happened here! I thought I had chosen a perfect place for our picnic but as soon as I started to set everything up all these ants came out of the ground. They’re running around all over the picnic cloth and trying to get into the picnic basket!” (*Mention of Control Event). Please help me move everything somewhere else, away from these ants!” So Wev, Nud, Hep and Zab picked up all the picnic things very quickly and moved to another spot where there were no ants at all.

They all were hungry and ate up all the sandwiches they brought. After finishing the sandwiches they were still hungry. Wev said: “We’re going to need some more food! We used up a lot of energy flying the kites and having fun! It’s good that we brought those cupcakes.” But when they looked in the picnic basket the cupcakes were not there. Nobody knew what had happened to them and they were all puzzled. Zab, who was leading the group that day, said that she knew there were some plants, like cactus plants, on the other side of the crater, that had sweet fruit growing on them. Zab asked Hep to get some fruit, but [Hep-F] Hep said that the plants were surrounded by prickly grass and she could not get across. [Hep-B] [Nud-F] Then Nud said: “I can walk across the prickly grass and get us some fruit. My tough hands and feet will protect me from the prickly grass!” (*Use of FDF for task that FUF cannot accomplish) So Nud walked across the prickly grass and came back with a lot of juicy fruit. When they had eaten it they were ready to take home the kites and everything else. [Nud-B].
Everyone started to put away the kites, but Hep got her kite string all knotted up. [HEP-F]It was a big mess. Wev and Zab laughed at her and told her that her string was all knotted up into loops and looked just like her loopy hair! (*Mention of Control Feature) [HEP-B]Hep finally got her string unknotted. Then Wev asked: "How are we going to get these kites home now that they are built? They are too big to be easy to carry!" Zab, who was leading the group that day said, "I know, we can tie them to Hep's water sack". (*Use of FUF) [HEP-F]Hep's water sack can help her carry the kites, so we will have our hands free to carry all the picnic stuff. "We can tie two to the front and the other two to the back" said Wev. They all thought that it would work and set off carrying the kites that way. [HEP-B].

As they were walking along past a crater, Wev suddenly said: "There are our missing cupcakes! They are right down in the crater". She pointed down into the crater. Everyone gathered around the rim of the crater and looked in. Sure enough Wev was right, all the cupcakes had rolled down to the bottom! The only way to get down to the bottom of the crater would be to slide down, but boy would that hurt – ouch! [Nud-F] I can get to the bottom of this crater and get our cupcakes back", said Nud "My soft tail will help me slide down without getting hurt!" So Nud slid down on her soft tail and got the cupcakes back! [Nud-B].

After eating the cupcakes that Nud got, they packed up their picnic stuff and started home. After they had gone down the paths for a while Zab realized they had forgotten one of the picnic baskets. Zab would have sent Nud back down the paths for a while Zab realized they had forgotten their picnic stuff and started home. After they had gone down without getting hurt!" So Nud slid down on her soft tail and got the cupcakes back! [Nud-B].

Wev ran back across the prickly grass and got the picnic basket that they had left. Soon they were home again. Hep, Nud and Wev told Zab that she had been a good leader. The four friends told all their other friends about what a fun day they had had, flying their kites and having a picnic in Prickly Grass Park.

A.1.4. Recall questions and answers (for above version of story set in Prickly Grass Park)

(Note: The order in which questions were asked was counterbalanced, as explained above for the version of the story set in Sand Dunes Park. It can be seen that the questions concerning the control event and control feature are identical to those for the version of this story written for the other park. It also can be seen that any particular feature that was involved as an FUF feature in questioning for one version of the story was involved as an FDF feature for the other version.)

1. "What did Hep use her hooded eye to do?" (Answer: "Find a good spot to fly the kites," If the child's answer was "To look", the follow-up question asked was: "What was Hep looking for?") (*Question about an event that entailed the use of a particular FUF feature.)

2. "What did Nud use her soft tail to do?" (Answer: "Slide into the crater to get cupcakes." If the child's answer was "Slide into crater", the follow-up question asked was: "Why did Nud slide into the crater?") (*Question about event entailing the use of a particular FDF feature.)

3. "What happened to make the friends move their picnic?" (Answer: "Ants tried to get into the picnic basket.") If the child's answer was "Ants", the follow-up question asked was: "What did the ants do?" (*Question about the Control Event.)

4. "What did Hep use to help her carry the kites?" (Answer: "Water sack." (*Question about the use of a particular FUF feature.)

5. "What did Nud use to help her get some fruit?" (Answer: "Tough hands and feet." (*Question about the use of a particular FDF feature.)

6. "What did Zab have that looked like the kite string all knotted up?" (Answer: "Loopy hair." (*Question about the Control Feature.)

Notes: (i) * marks an explanation of the type of feature/event entailed at that place in the story (FDF = functionally differentiated feature; FUF = functionally undifferentiated feature) (ii) expressions such as "Zab-F" and "Hep-B" are differentiated feature; FUF = functionally undifferentiated feature) (ii) expressions such as "Zab-F" and "Hep-B" are printed cues instructing the storyteller to move characters (Zab-F = move the doll named Zab forward; Hep-B = move the doll named Hep back; and so on). (iii) Each child heard only one version of each story. Which versions were told to a particular child depended on the World (ES or TF) to which that child was assigned.

Appendix B

B.1. Coding of recall of names for the Dolls' features

0 (i) no response OR (ii) irrelevant feature OR (iii) wrong feature (i.e., other of relevant pair); 1 correct noun to name the relevant feature but without the correct (or a semantically related) adjective; 2 adjective semantically related to the correct one, either (i) alone OR (ii) with the correct noun; 3 (i) correct adjective alone OR (ii) correct adjective with plausible noun; 4 correct noun to name relevant feature plus correct adjective.

B.2. Coding of recall of features used/cited in relation to particular events in the stories

0 (i) no response OR (ii) irrelevant feature OR (iii) wrong feature (i.e., other of relevant pair); 1 correct noun to name the relevant feature but without the correct (or a semantically related) adjective; 2 adjective semantically related to the correct one, either (i) alone OR (ii) with the correct noun; 3 (i) correct adjective alone OR (ii) correct adjective with plausible noun; 4 correct noun to name relevant feature plus correct adjective.
B.3. Coding of recall of events in which particular features were used or phenomena cited

0 (i) no response OR (ii) irrelevant event/activity (i.e., not occurring in the story) OR (iii) wrong event/activity (i.e., involved in the story but not the event/activity for which the feature was used/cited);
1 correct name of event/activity (closely related or exact wording) but without anything to convey any effect/purpose (right or wrong) of the activity/event;
2 effect/purpose semantically related to the correct one with either (i) no event/activity or (ii) with semantically-related name to indicate event/activity;
3 correct effect/purpose with either (i) no event/activity or (ii) with semantically-related name to indicate event/activity;
4 correct noun to name event/activity plus correct effect/purpose.

References


